POSTER PRESENTATIONS

TECHNIQUES AND EQUIPMENT DEVELOPMENT

TE-P1

CHARACTERIZATION OF HMDSO BASED PLASMAS FOR DEPOSITION OF BIOCOMPATIBLE COATINGS

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SiOxCyHz thin films are deposited in a 13.56 MHz RF reactor by plasma enhanced chemical vapour deposition (PECVD) of hexamethyldisiloxane (HMDSO) and oxygen mixtures. The film properties are found to be strongly dependent on the deposition parameters including, RF Power, Oxygen to HMDSO flow ratio, Pressure and pretreatment conditions. The influence of oxygen to HMDSO flow ratio and RF power on the film properties is studied in detail. Fourier transform infra red (FTIR) spectroscopy is carried out to analyze the nature of chemical bonding present in the film. Plasma characteristics such as plasma density, electron temperature, plasma potential, partial pressures of gases and ion fluxes are determined by Langmuir probe, capacitive probe, optical emission spectroscopy and mass spectroscopy.

TE-P2

GENERATION OF ION BEAMS ON A STEEL SURFACE BY LASER RADIATION OF VARIOUS WAVELENGTHS UNDER THE PRESENCE OF AN APPLIED ELECTRIC FIELD

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This paper presents generation of highly stripped steel ions and high current in laser produced plasma. A steel target kept under partial vacuum conditions (10^-3 mbar) irradiated with focused first-four harmonics of a Q-switched Nd:YAG laser radiation at wavelengths of 1064, 532, 355 and 266 nm with pulse duration 7, 6, 7 and 6 ns, respectively. The evaporated ions were detected at a distance of 40 mm away from the target, after having passed through the retarding mesh grid (Cu electrode). The laser radiation with peak intensity between 4 x 10^9 to 1 x 10^11 W/cm2 creates a dense plasma having high ionization state. The velocity distribution function of the plasma cloud which emitted from the steel target flare is investigated by using a Faraday cup technique. The dependence of the current signals on various parameters, such as laser power, laser wavelengths and argon (Ar) pressure, is described. In general, a sharp increase in the plume current was observed as the voltage is increased and is related to arc formation.

TE-P3

DEVELOPMENT OF COMPUTER CONTROLING DOUBLE PROBE AND DIFFERENT DIAMETERS DISCHARGE SYSTEM

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The non-uniform dc glow discharge plasma system is studied by using isolated computer controlled three couples of double probe system (TCDP) in argon gas, simultaneously. The double probe is more applicable than the single probe in diagnostics, especially in plasma reactors which have insulating or semi-insulating walls. TCDP technique has been developed to use for magnetized, unmagnetized, and for low oscillating plasma systems by using optically isolated circuitry to minimize the measurement errors with higher resolution and accuracy .Changing the shapes and diameters of the tube from region to region leads to change the in plasma properties .As the diameter of the tube is decreased at constant discharge currents, the density increases and the electron temperatures decreases.

TE-P4

IRRADIATION EFFECTS OF LIQUID CLUSTER ION BEAMS ON SILICON SURFACES

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A cluster is a tiny particle, which is in a position to a link between atomic state and bulk state. The physical and chemical properties of the cluster are different from those of bulk state. The cluster ion beam process is one of the basic technologies in nanostructure fabrications such as deposition, etching or implantation. However, the cluster ion beam process using liquid source materials has not been investigated, because such cluster ions were not available. We have succeeded in producing liquid clusters such as alcohol and water clusters by an adiabatic expansion phenomenon. The intensity of the cluster ion beams increased with increase of the vapor pressures. In order to investigate the irradiation effects of the liquid cluster ion beams on silicon (Si) surfaces, the fundamental properties such as sputtering depth, surface morphology, irradiation damage were measured. The sputtered depth increased with increase of ion dose and acceleration voltage for the ethanol and water cluster ions. In particular, the ethanol cluster ion irradiation sputtered the Si surfaces with the sputtering yield of approximately 100 times larger than that for argon (Ar) monomer ion irradiation. In addition, the Si surfaces after sputtering had an average roughness less than 1 nm. Furthermore, the RBS channeling measurement showed that the irradiation damage of the Si surfaces by the ethanol and water cluster ions was smaller than that by the Ar monomer ion irradiation. This indicates that the low energy ion irradiation effect is predominant for the liquid cluster ion beams. As an engineering application of the liquid cluster ion beam process, the etching and patterning process was performed on the Si surfaces using metal masks. The mask patterns were formed very swiftly and finely by irradiation of the ethanol and methanol cluster ions. The patterns were 0.5μm in depth at an ion dose of 1x1016 ions/cm2. Thus, liquid cluster ion beams have unique characteristics suitable for surface treatment, such as high sputtering yield and smooth surface at an atomic level.

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TE-P5

INFUSION PROCESSING OF SEMICONDUCTORS USING GAS CLUSTER ION BEAMS

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A Gas Cluster Ion Beam (GCIB) tool can be thought of as a highly energetic (>30 keV), highly directional, reactive beam delivery system. The interaction between substrates and the large, essentially ion free (n/q >5000) clusters results in fundamentally different process effects compared to traditional methods of bombardment by ionized atoms or molecules. The combination of localized large transient thermal spikes, extreme localized pressures, and very low energy per atom (<10 eV) allows for unique material process effects with both inert (e.g., Ar) and chemical beams (e.g., O2, NF3, CH4, etc.). We will show how GCIB surface processing is different from traditional ion implantation, as well as its distinctions from various other methods of thin film deposition, etching, and surface smoothing. Recent work has been focused on exploiting GCIB's infusion mode processing for applications in the manufacturing of Integrated Circuits. GCIB infusion is employed to achieve ultra shallow junctions with no channeling [1], infusion of Ge into a Si surface (and eventually Ge deposition onto the surface) [2], highly controlled deterministic etching of SOI, SSOI, SiGe, and low k materials, pore sealing of porous low-k dielectrics [3], and surface smoothing, among other applications. The nature of the energetic cluster-surface interaction allows us to tailor processes that accomplish these various tasks at room temperature with little or no surface damage.

[1] J. Hautala, J. Borland, M. Tabat, W. Skinner, 2004 Int'l Workshop on Junction Tech. (submitted for publication).
[2] J. Borland, et al, Solid State Tech. (submitted for publication).
[3] B. White, J. Hautala, M. Tabat, 2004 Int'l Interconnect Tech. Conf. (submitted for publication).

TE-P6

LOW DAMAGE SMOOTHING OF MAGNETIC MATERIALS USING OFF-NORMAL GAS CLUSTER ION BEAM IRRADIATION

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Damage-free smoothing process for magnetic materials using gas cluster ion beam (GCIB) has been studied. As increasing areal density of hard disk drives (HDDs), the flying height of magnetic recording head over the disk has been decreasing. In order to further reduce the flying height and improve sensitivity of sensors, damage-free smoothing technology for magnetic materials is extremely required. A GCIB processing has been proposed as a novel smoothing technique for various materials. The GCIB is expected to realize low damage processing, since gas clusters are aggregations of a few to thousands atoms or molecules. In this paper, oblique GCIB irradiation has been studied in order to achieve low damage smoothing of PtMn and NiFe thin films. To avoid ripple formation by one-directional oblique irradiation1), samples were placed on a rotational stage. Surface morphology after GCIB irradiation was observed by scanning electron microscope (SEM) and atomic force microscope (AFM). Quite smooth surface with average roughness less than 1 nm was obtained by using oblique GCIB irradiation. Irradiation damage, such as component ratio fluctuation, was investigated by secondary ion mass spectrometry (SIMS). Damaged layer thickness less than 1.7 nm was achieved by grazing incidence of the GCIB with simultaneous rotation. It was found that the damaged layer thickness was proportional to the cosine of the incident angle.

1) S.Kakuta, et.al, Mater. Res. Soc. Symp. Proc., 843, T5.5, (2005).

TE-P7

ION PROBING FOR EXPLORING OF STRANGE ELECTROMAGNETICS IN CARBON FILMS

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Results of magnetic force microscopy (MFM), dc SQUID magnetization, reversed Josephson effect (RJE), and resistance measurements in thin carbon arc (CA) films are presented. The observation of a RJE induced voltage as well as its rf frequency, input amplitude, and temperature dependence reveals the existence of Josephson Junction arrays. Oscillating behavior of the DC SQUID magnetization reminiscent of the Fraunhofer-like behavior of superconducting (SC) critical current in the range of 10000 Oe has been observed. The dc SQUID magnetization measurement indicates a possible elementary 102 nm SC loop; this is compared to MFM direct observations of magnetic clusters with a median size of 165 nm. All these data are consistent with the existence of a high temperature SC-like phase or fluctuations up to 650 K. It is proposed to expose such CA film to energetic particle (neutron or ion) bombardment to verify this hypothesis. Such bombardment would change both the structure of film and consequently the experimental measurements. In addition such bombardment-induced changes will provide a basis for particle detectors utilizing the Josephson effect.

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TE-P8

NEW METAL ION AND PLASMA SURFACE MODIFICATION METHODS

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The review is devoted to the analysis of the present state-of-the-art and development trends of the new methods and equipment being developed in the NPI for dc vacuum arc-based ion and plasma materials processing. The regularities and advantages are demonstrated for the method of high-concentration implantation with compensation of surface ion sputtering by metal plasma deposition, method of metal plasma deposition under repetitively - pulsed ion mixing with ion beams and plasma flow formed in the "Raduga-5" source, and coating deposition and ion implantation method including an application of filtered dc metal plasma source and high-frequency short-pulsed negative bias voltage with a duty factor in the range 10% - 99%. The regularities of ion implantation and metal plasma deposition for dielectric, semi-conducting and metal samples are presented.

TE-P9

OBSERVATION OF A SPUTTERED Si SURFACE BY AN ION IRRADIATION SYSTEM USING A PROTO-TYPE COMPACT CLUSTER ION SOURCE

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A proto-type compact cluster ion source has been developed using a metal-cluster-complex as a low damage-sputtering source, since cluster are said to be effective for “lateral sputtering”. Using this metal-cluster-complex ion gun the Si surface was successfully sputtered with a high sputtering yield,and yet resulting in smooth surface and no metal implantation.

For seeking the possibility of using a metal cluster complex as an ion beam source, metal cluster complexes such as Os3 (CO)12 and Ir4 (CO)12 have been studied from the view point of their stability in high vacuum and how to ionize them. The metal cluster complexes of Os system were found to have a great potential as a cluster ion source [1].

Using this proto-type compact cluster ion source, an ion beam of the metal cluster complexes of Os3 (CO)12 was generated with the acceleration energy of 10 keV, and the fluences was NCB=5.2x1012particle (Iave=0.050nA, Time=278min). The sputtered Si surface was observed by using AFM (atomic force microscope) and SEM (scanning electron microscope). The sputtered Si part was found to be a truncated (elliptical) cone. From the results of AFM and SEM, the volume of the truncated cone was About 3.2x10-9cm3 , ie Nsi was about 1.6x1014particle. From theses result the sputter yield was about Nsi/NCB =31.

Surface characterization and contamination are investigated by ESCA (electron spectroscopy for chemical analysis) and AES (Auger electron spectroscopy), showing that the Os ions were not implanted in the sputtered Si surface.These results shows that this ion irradiation system using a proto-type compact cluster ion source is capable of a high rate sputtering and no ion implantation at the same time and therefore the cluster ions have low penetration depth leading to low damage sputtering in other words the lateral sputtering due to simultaneous multi-atom bombardment may have been demonstrated using the cluster ions.

The developed ion source is considered to be promising sputtering tool for an application to SIMS (secondary ion mass spectrometry) for nano-region analysis.

[1] Applied Surface Science 231–232 (2004) 945–948

TE-P10

PULSED PLASMA PRODUCTION FOR APPLICATIONS IN PLASMA SOURCE ION IMPLANTATION

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In plasma source ion implantation (PSII), the sample is immersed in a plasma and biased negative with high voltage pulses. During the on time of the pulse, the high voltage negative bias on the sample accelerates the ions which get implanted inside the sample surface; with the implantation depth being controlled by the sample bias characteristics. During the off time of the pulse the sample is at the floating potential and a significant amount of low energy ions bombard the sample surface, and its effects are sometimes undesirable. Simultaneously, in an effort to make PSII process more cost effective, it is desired that the negative pulsed bias can be used for plasma production as well as for implantation of ions from the same plasma. The present investigation focuses on this aspect and characterizes the operating conditions in which such a scheme is functional. The consequences for this is worked out and the results obtained are compared with the well known models used to describe sample current profiles in typical PSII experiments.

TE-P11

SOURCES OF HIGH-DENSITY GASEOUS PLASMA BASED ON A DISCHARGE WITH ELECTRON INJECTION

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A novel technique of high-density gaseous plasma generation was explored, and several plasma sources based on this technique were developed. The sources utilize a DC high-current (up to 35 A) gaseous discharge with electron injection into the cathode region. Electron generation and injection is accomplished by using an additional arc discharge with a cold hollow cathode. Low contamination of plasma is achieved by low discharge voltage (avoidance of sputtering), as well as by special geometric configuration of the emitter discharge electrodes thereby filtering (removing) the erosion products stemming from the emitter cathode.

The devices produce a uniform and stable gaseous plasmas with density up to 1011 cm-3 in a volume of 1 m3, at the pressure of 10-4 Torr and higher. The sources are characterized by high reliability, low3 maintenance and long lifetime. The specific electric power consumption is 140 eV per one generated ion. The sources operate with noble gases, nitrogen, oxygen and hydrocarbons, and can be used for plasma immersion ion implantation and other ion technologies.

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TE-P12

SURFACE PROCESSING WITH HIGH-ENERGY GAS CLUSTER ION BEAMS

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Gas cluster ion beam process has high potential for material processing in nano-technology, such as photonic crystal and MEMS. In order to fabricate the devices, it is needed to etch targets with high-speed, low-damage, and ultra-smooth process. A cluster is an aggregate of a few to several thousands atoms. When many atoms constituting a cluster ion bombard a local area, high-density energy deposition and multiple-collision processes are realized. Because of the interactions, cluster ion beam processes can produce high rate sputtering with low damage in comparison with monomer ion beam processes.

In order to realize the high-speed surface processing, high-energy cluster ion beam irradiation system was developed and high-energy Ar cluster ion beams were generated. Their cluster size distributions were measured using Time-of-Flight (TOF) method and the mean size of Ar cluster was about 2000 atoms. Si substrates were irradiated with the Ar cluster ions at the acceleration energy of 20-80 keV. The sputtering yield was increased with acceleration energy and reached about 87 atoms/ion at 80 keV. This value was about 70 times higher than that of Ar monomer ions. Au films were also irradiated at the acceleration energy of 20-80 keV and the surfaces were observed with Atomic Force Microscope (AFM). The surface roughness was decrease after the high-energy cluster ion irradiation. These results indicate that the high-speed and ultra-smooth surface processing can be realized with the high-energy cluster ion beam. This processing can be applied to fabricate nano-devices.

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TE-P13

THE COULOMB POTENTIAL ENHANCED SPUTTERING OF HIGHLY CHARGED Pbq+ ION ON MOLYBDENUM SURFACE

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Highly charged ion (HCI) has different interacting behaviors with material surface, due to its higher Coulomb potential energy. In this work, the sputtering of Pbq+ ions on molybdenum (Mo) surface is studied versus ion energy, incident angle and charged states of ions. The experiment was performed at an ECR source platfor. The Pbq+ ion beams with a q= 4, 20, 24, 30, 32, 35, 36 have been applied in experiment. A Multichannel Plate (MCP) detector was employed to measure the yield of sputtered positive and neutral particles. The yield of secondary electron has been measured by comparing the beam current measured from target and a Farady-cup. It is found the sputtering yield of HCIs increases more rapidly than that sputtered by ions to the to 75at low charge state, while the incident angle is changed from 15 normal of target surface. The sputtering yield per incident ion is energy dependent and charged state dependent. A strong sputtering enhancement has been observed while the charged state is above 30+. At the same time, the yield increases with the energy evidently in the energy branch from 6q keV to 20q keV, while Pb36+ is used. Therefore HCIs may have some superiority in surface modification.

TE-P14

BY RADIO-FREQUENCY HOLLOW CATHODE DISCHARGE

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Hollow cathode glow discharge has been utilized to nitride stainless steels. The discharge is sustained by a radio-frequency source. The cathode is made of stainless steel with an inner diameter varying from 1 mm to 6 mm. The gas flow rate changes from 5 sccm to 40 sccm. A negatively biased collector is positioned in front of the hollow cathode to measure the ion density. Our experimental results demonstrate that the plasma density depends very much on the inner diameter of the hollow cathode, excitation power, gas flow rate, and so on. The collected ion current increases monotonically with the RF power and inner diameter of the cathode but not with the gas flow rate. The surface microhardness of the treated samples is higher than that of the untreated one demonstrating the effectiveness of the process. The hardness decreases with increasing bias voltage which varies from 100 V to 400 V. Interestingly, the change in the microhardness as a function of the gas flow rate is similar to that of the ion current with the gas flow. To further investigate the mechanism, the surface phase of the treated samples is characterized using glancing-angle X-ray diffraction and the tribological properties are measured using a pin-on-disk tester.

TE-P15

THE IMPACT OF HIGHLY CHARGED Arq+, Pbq+ ION ON ALUMINIUM SURFACE

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Highly charged ion (HCI) produced by an ECR source has not only kinetic energy but also some potential energy. When a HCI impacts on solid surface, both energies may induce surface sputtering. The potential sputtering of HCI on metal surface involved a complicated process and is strongly related to metal property. In this work, the sputtering of Arq+, Pbq+ ions on aluminum (Al) surface is studied correlated to the ion energy, incident angle and charged state of ions. The Arq+ ion beams with q= 1, 8, 9, 10, 11, 13, 15, 16 and the Pbq+ ion beams with q= 4, 20, 24, 30, 32, 35, 36 have been applied in experiments. Neutral and positive particles sputtered by HCIs were measured by a Multi-Channel Plate (MCP) detector, and the total amount of the negative particles has been obtained from the difference of beam currents at targets and in a Farady-cup. The sputtering yield induced by HCIs changes steeply with the incident angle, the change in HCI sputtering is much larger than by ion with limited charges. A significant enhancement of the sputtering yield has been observed, while the q>20, but the curve is not always smoothly increase with the charge state. In case of Pb36+, the sputtering yield increases with the ion energy rapidly. However, no evident energy and charge dependence is observed by using Arq+. It seems to be important for the potential sputtering, whether a hollow ion may be formed before the ion impacts on solid surface.

TE-P16

ADVANCED PLASMA DEVICES FOR ION BEAM MATERIAL MODIFICATION AND PROCESSING APPLICATIONS

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The electrostatic plasma lens is a well developed tool for focusing high current ion beams, where the concern of beam space charge neutralization is critical, and has been used to advantage to focus wide-aperture, heavy metal ion beams such as produced by vacuum arc ion sources, for example for high dose ion implantation [1]. The plasma lens configuration provides a simple method for establishing a stable plasma discharge at low pressure. We have developed some low cost, low maintenance plasma devices based on this approach, for ion cleaning, surface activation, and polishing of substrates prior to film deposition. These devices make use of permanent magnets and possess considerable flexibility with respect to spatial configuration (planar, cylindrical, elliptical). They can be operated as stand-alone instrumentation, for example for liquid crystal alignment on large-area substrates, or as part of an integrated processing system together with magnetron sputtering, for example, for deposition of spectrally-selective coatings on industrial glass. Here we describe the operation of these new plasma devices, and summarize the results of preliminary experiments on their application to ion treatment and coatings deposition.

[1] A. Goncharov, I. Protsenko, G. Yushkov, O. Monteiro, and I.G. Brown, Surf. Coat. Technol. 128–129, 15 (2000).

TE-P17

THE SPUTTERING OF HIGHLY CHARGED Arq+, Pbq+ ION ON WOLFRAM AND GOLDEN SURFACE

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Highly charged ion (HCI) may have few hundreds keV potential energy. When it impacts to a metal surface, the ions may capture electrons from target atoms before it reaches the target surface and becomes a hollow ion. After it impacts into target, it collapse immediately after transmitting a few atomic layers and releases the rest potential energy out. This energy may cause significant sputtering enhancement. In this work, the sputtering of Arq+, Pbq+ ions on golden (Au) and Wolfram (W) surface is studied correlated to the ion energy, incident angle and charged state of ions. Experiments have been performed at a 25KV ECR source platform. The Arq+ ion beams with q= 1, 8, 9, 10, 11, 13, 15, 16 and the Pbq+ ion beams with q= 4, 20, 24, 30, 32, 35, 36 have been applied in experiments. Neutral and positive particles sputtered by HCIs were measured by a Multichannel Plate (MCP) detector, and the total yield of negative particles has been obtained from the difference of beam currents from targets and a Farady-cup. The sputtering yields induced by HCIs are significantly higher than the ion with few charges. The differences depend on charged state, ion energy and also target materials. Arq+, Pbq+ ions show also different behaviors on the same target.

TE-P18

VARIATION OF THE PLASMA DENSITY IN A GLOW DISCHARGE UPON THE APPLICATION OF A HIGH VOLTAGE

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It is emphasized and demonstrated that, during the formation of an ion-matrix sheath in a glow discharge upon the application of a high voltage pulse, the existing neutral plasma density should change as well. An explicit and practical expression for the neutral plasma density in terms of the gas pressure, secondary electron emission coefficient and the applied voltage is derived, so that the consequent sheath behavior can be formulated correctly. The theoretical result is compared with the data of an experiment, particularly designed and performed to test its validity, and found to be in good agreement with the latter.

TE-P19

WEAR BEHAVIOUR OF STEEL MODIFIED BY PULSE PLASMA TECHNIQUE

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In this study, the microstructure and wear behaviour of pulse plasma treated AISI 8620 steel was evaluated. The samples were just annealed. Then, they were carburizing for 2 hours at 900_C. The surfaces of the samples were modified by nitrojen, C3H8 and oxygen gases by using plasma pulse technique. Two different battery capacities of 800 and 1000 μF and, three different sample plasma gun nozzle distances of 60, 80 and 100mm were chosen for surface modification . After that they are exposed to metallographic examination and cross-section observations were obtained by using optical microscope. XRD analysis was done for all specimens and micro-hardness measurements were done to draw hardness profiles.AISI 8620 steels modified by pulse plasma method were exposed to ball-on-disc testing according to ASTM G99 to investigate their wear and friction performances in dry sliding. Then, EDS and SEM photos were obtained and wear behaviour of them were investigated.

TE-P20

THERMOOPTICAL EFFECTS ON RADIATION DEFECTS IN IMPLANTED SILICON

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This work is devoted to investigations of radiation damages in implanted silicon. The method of investigation is thermooptical (thermal wave) technique [1,2]. Implementation of this method can easy control the main parameters of implanted layers and discover new details unknown before: defect annealing at room temperature during long time (structural changes have been observed during several months), influence of measurement procedure on final result from previous treatment of sample (oxidation, thermal treatment, etc).

The method of research based on repeated excitation of free carriers of charge is strongly dependent on the procedure, so the value of signal determines by the number of exciting laser pulses. It was shown that such multiply measurement might lead to changing of measured value. These changes could be either reversible, which is related to recharging of defect centers, or irreversible, which is defined of the defect center annealing during measurement.

For some ions the very unusual peculiarities was observed. The main interesting feature is connected with F+ bombardment. There are unusual increasing of defect signal in comparison with other ions with close value of ion mass. This behavior is related to chemical activity of fluorine atoms.

1. N.N. Gerasimenko (jr.), N.N. Gerasimenko, V.Yu. Troitskiy, Yu.N. Parhomenko // Izvestiya vuzov. Materialy electronnoy tehniki. 2004. İ4. Ò.57-60.
2. F. Buchmann, H.D. Geiler // Nuclear Instruments and Methods in Physics Research. 1995. B 96. p.113-117

TE-P21

CRATER FORMATION ON THE SURFACE OF REFRACTORY ALLOYS DURING HIGH POWER ION BEAM PROCESSING

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The effect of high-power, pulsed ion-beam irradiation and various methods of the preliminary surface treatment on the crater formation process was examined using Auger electron spectroscopy, X-ray diffraction analysis, and scanning electron microscopy. The crater distribution density, sizes and shape, along with their microhardness and chemical composition inside and outside them were determined. As a result of these experiments, the most probable mechanisms of crater formation on the surface of refractory alloys were established. The major conclusions from this study can be summarized as follows:

1) Crater formation process takes place on the surface of solids during irradiation by HPPIB. This phenomenon is due to the cathode material erosion (technological factor) and the nonstability in the physical and chemical state of the irradiated surface.

2) In order to reduce the negative effect of crater formation upon the properties of targets can be proposed: changing the accelerator diode system material; to use the fine polishing when preparing the surface for the irradiation; to carry out the final HPPIB treatment at low ion current density (crater-free irradiation); and to perform the final heavy ion implantation.

TE-P22

THE MATERIAL SCIENCE CERTIFICATION OF ION-BEAM INSTALLATIONS CONTAINING ARC-PULSED SOURCES OF THE RADUGA TYPE

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The objective of the present research is the certification of ion beam installations containing Raduga-2 and Raduga-4 arc-pulsed sources using the material science methods. For realization of this certification the samples were made of bar, produced of the following refractory alloys: VT9, VT8M, VT18U, VT33, EP866sh, and EP718ID with the use of machining. The physical and chemical state of each sample was determined by the following methods: Auger electron spectroscopy, X-ray diffraction analysis, scanning electron microscopy, and microhardness measurements. Ion implantation of Hf, Sm, La and B into these samples was carried out under the following conditions: accelerating voltage – U=30 kV, frequency of irradiation – f=30 Hz, the ion current density in a pulse – j=1-5 mA/cm2, irradiating dose was varied from 1016 to 5H1017 ion/cm2. The various groups of samples (every group contained 6 unites) were irradiated under the various regimes. Furthermore, the irradiation was repeated in a year. After irradiation each sample was studied by the above-mentioned methods.

It was shown that differences of physical and chemical state determined after completing the irradiation under the identical condition were not fixed by these methods for the samples from refractory alloys. The considerable differences were observed only for the samples irradiated in high and low vacuum. A great amount of carbon and oxygen impurities was contained in the surface layer with thickness near 200 nm. The concentrations of these elements were equal to 12 and 8 at. % correspondingly, when the irradiation was carried out at the dose of D=5H1017 ion/cm2 in low vacuum. The effect of irradiating regimes and nonstability of irradiating parameters on the service properties of refractory alloys was discussed.

POSTER PRESENTATIONS

MATERIALS & PROPERTIES

MP-P1

MODIFICATION OF POLYETHYLENE SURFACES IRRADIATED BY THE SIMULTANEOUS USE OF CLUSTER AND MONOMER ION BEAMS

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The predominant properties of the ion beam technology are based on the feasibility to control the kinetic energy by adjusting an acceleration voltage. In addition, atomic, molecular and cluster ions are available, and the interaction of these ions with solid surfaces is different depending on the ion species used. Compared with the monomer (atomic or molecular) ion beams, the cluster ion beams have several advantages, one of which is that equivalently low-energy and high-current ion beams can be realized. On the other hand, the monomer ion irradiations with high-incident energy beams play important roles in production of bond scission, cross linking and / or carbonization on polymer surfaces.

In this article, polyethylene (PE) substrate surfaces were irradiated at dose ranging from 1013 to 2.5x1015 ions/cm2 by the simultaneous use of oxygen cluster and monomer ion beams. The acceleration voltage for the ion beams was changed from 3kV to 10 kV. The FT-IR and XPS measurements showed that hydrophilic groups such as carbonyl, carboxyl and hydroxyl groups were formed for the PE surfaces by the oxygen ion irradiation. Furthermore, the contact angles measured decreased with increase of an acceleration voltage and an ion dose, and it was 10 deg at an acceleration voltage of 7 kV and at a dose of 1x1015 ions/cm2. The contact angle for the uniiradiated surface was 100 deg, and the wettability was much improved by the oxygen ion irradiation. To be compared with the oxygen ion beams, the simultaneous use of argon (Ar) cluster and monomer ion beams was applied, and the minimum contact angle obtained for the PE surfaces was 40 deg. The chemical modification was predominant for the simultaneous use of the oxygen cluster and monomer ion beams. This was occurred due to the supply of the oxygen atoms into the resultant dangling bonds, which were formed based on the bond scission by the irradiation of oxygen monomer ions.

Presenting Author: Masakazu Kawashita

MP-P2

CHARACTERIZATION OF SURFACE LAYER OF SILICON WAFERS IMPLANTED WITH HYDROGEN IONS

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In the present work the Si single crystal wafers were studied grown by the Czochralski-technique (Cz-Si) and implanted with H+ of different dozes. The thermoelectric, optical, structural and mechanical properties of the wafers were studied using the following techniques: high-pressure thermoelectric power measurements, Raman scattering, ultra soft X-ray spectroscopy, nano-indentation and high-pressure compressibility. The following effects have been established: (i) a lowering of the thermopower value of the H+-rich layers in comparison with the as-grown Cz-Si in the region of semiconductor-metal phase transition at high pressure; (ii) dependence of the Raman spectra on H+ implantation; an arising in the spectra of some features of amorphous and porous Si; (iii) dependence of ultra soft X-ray L2,3 spectra on high-pressure treatment and H+ implantation; (iv) an observation of the phase transitions in the wafers by change of compressibility as well as under nano-indentation. The effects observed are discussed in the work. The results obtained are important for manufacture of Si substrates for microelectronics.

The authors are grateful to Dr. I.I. Morozov for H+ implantation and to Dr. V.A. Aksenova for assistance in the X-ray L2,3 spectra measurements. The work was supported by the Russian Foundation for Basic Research – Gr. No. 04-02-16178, and by the INTAS (Nr. 03-55-629)

MP-P3

DLC FILMS FORMATION BY He+ ION BEAM IRRADIATION IN ETHYLENE GAS ATMOSPHERE

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A study has been made of the mechanical properties of diamond-like carbon (DLC) thin films on 304SS substrate. DLC thin films were prepared by the He+ ion beam assisted deposition method, in which the He+ ion irradiation was carried out in a C2H4 gas atmosphere. He+ ions were accelerated at the energy of 5 to 18 keV, and the ion beam current densities were ranged from 10 to 100 micro A/cm2. Atomic concentration and structure of the films were investigated by X-ray photoelectron spectroscopy and Raman spectroscopy respectively. The tribological properties of hardness and friction coefficient were determined using the Knoop hardness tester and the pin-on-disk tribometer. The Raman spectra showed the DLC thin films are amorphous. The Knoop hardness of the films increased with increasing He+ ion current density, and the film prepared at the current density of 60 to 80 micro A/cm2 showed the maximum Knoop hardness value of 1200 kgf/cm2. The friction coefficient of the film prepared at the current density of 40 micro A/cm2 indicated louest value. From these results, it was concluded that the tribological properties and structures of DLC thin films were greatly affected by the He+ ion beam current density.

MP-P4

CRYSTALLINE ZrSi2 FORMATION BY SWIFT HEAVY ION BEAM MIXING

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The effect of swift heavy ion (SHI) irradiation on the interface of a metal-semiconductor system can manifest itself through structural modifications and possibly lead to the desired formation of technologically important metal silicides; which may not be energetically favourable otherwise. This work investigates the SHI beam (120 MeV Au, 10^13 ions/cm2) induced mixing of Zr/Si multilayers, deposited on Si (100) substrates at room temperature by electron beam evaporation.

Grazing incidence x-ray diffraction and simulation of the x-ray reflectivity measurements performed on the SHI irradiated samples indicated complete mixing of the multilayer structure into a single layer of crystalline ZrSi2. The formation of this refractory silicide, known to have excellent properties as a contact material for ULSI devices, directly on Si and without annealing, is of vital importance to device processing techniques.

Mechanism of observed SHI beam mixing in the Zr/Si system is satisfactorily explained by invoking the thermal spike model, wherein SHI induced mixing is considered to be the consequence of interdiffusion at the interface during transient melt phase. Within the framework of this model, the present work establishes a new, experimentally observed threshold (24.4 keV/nm) for defect creation by electronic energy loss in Zr. This value is lower than that reported in literature [1], implying the greater sensitivity of Zr to SHI induced radiation damage.

[1] Z.G. Wang, Ch. Dufour, E. Paumier and M. Toulemonde, J. Phys.: Condens. Matter 6 (1994) 6733.

MP-P5

DAMAGE EFFECTS OF GAMMA AND X-RAYS IN ELECTRETS POLYMERIC FILMS

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Dosimeters produced with electret materials are able to detect g and X-rays, a, b, e- and other charged particles and, with appropriate converters, fast and slow neutrons. To produce and use an electret dosimeter the polymer must be charged in a system able to inject an initial charge into a selected material. After charged the electret can be exposed to ionizing radiation and the difference between the remaning and initial charges is proportional to the absorbed radiation dose.These charges density can be read through an appropriate device. In this work ETFE (Ethylenetetrafluoroethylene) and FEP (Tetrafluoroethylene-hexa-fluoropropylene) polymer films were inicially charged later exposed the to several radiation absorbed doses using gamma (60Co) and conventional X-Rays photons. In order to determine damage that could compromise the use of this materials as dosimeters, the virgin and charged-exposed films were analysed with Optical Absorption Photospectrometry (OAP), Fourier Transform Infrared (FTIR) and micro-RAMAN spectroscopy. The analysis results are shown and from them one can figure out the films damage caused by the expositions from cited radiations sources.

MP-P6

EELS AND XPS STUDIES ON STUCTURE OF CARBON MATERIALS AMORPHIZED BY ION IRRADIATION

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Crystalline-to-amorphous transformation, referred to as “amorphization”, is one of the most important phenomena in the fields of ion beam modification of carbons. The amorphization process of carbon materials has been well studied so far. The structure of amorphized carbon is, however, not well understood yet. The carbon atomic density is a key parameter to characterize the amorphous carbon [1]. Electron-energy-loss spectroscopy (EELS) is a useful tool for examining the density of valence electron, that is, the carbon atomic density. In the present work, the structure of carbons, including highly oriented pyrolytic graphite (HOPG), isotropic graphite, diamond, tetrahedral carbon (ta-C) and glassy carbon (GC), amorphized by 2 keV Ar ions has been investigated by using EELS and x-ray photoelectron spectroscopy (XPS). In the HOPG sample irradiated to 5x1015 cm-2, for example, the energy of sigma+pi plasmon was 25.0 eV, slightly lower than that for un-irradiated sample (25.8 eV). Thus the EELS measurements revealed that the irradiation reduced the atomic density in HOPG due to amorphization. In XPS analysis for the amorphized HOPG, a C 1s line was significantly broadened, indicative of the presence of a dangling bond and/or a bond angle disorder [2]. The structure of amorphized carbons will be discussed in terms of the following two questions; is there any difference in structure among carbons after completely amorphized? Is there any possibility for bond transformation from sp2 to sp3?

[1] R. Haerle et al., Phys. Rev. B 65, 045101 (2001).
[2] K. Takahiro et al., to be published in Nucl. Instr. Meth. B.

MP-P7

ELECTRON SPIN RESONANCE STUDIES ON AGEING AND STABILIZATION OF pp/ps (80/20) BLENDS WITH AND WITHOUT SBS AT 7.5 w% UNDER GAMMA IRRADIATION.

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Electron spin resonance studies on ageing and stabilization of polystyrene / polypropylene (PS/PP) blends with and without Recylostab 811-Ciba commercial antioxidant at 0.1W%, and with and without styrene-butadiene-styrene (SBS) at 7.5w% after 4 years of air storage irradiated with gamma rays from a 60Co source at a dose rate of 4.8 kGy/h and at a integral irradiation doses of 10,25 and 50 kGy in the presence of air and at room temperature (RT) are reported. Dependence of resonance line, Hpp, resonance line shape, K, and radicals concentrations, %S, on degradation integral doses, is investigated. The free radicals concentration, the double integral of the resonance line, %S, has been estimated at room temperature, for a group of single lines characterized by the same giromagnetic, g, value by direct double integration. The nature of the free radicals is discussed. Simple kinetic adjustments were carry out by means of mathematical equations. Not signal is observed at 0 kGy of integral irradiation doses. A maxim value of %S is observed a 10 kGy and a minimum value is observed a 25 kGy of integral irradiation doses. The radicals oobserved in the irradiated blends and irradiated homopolymers are the same (hydroperoxide, phenyl, carbonyl) at the same conditions. For the blends the resonance line parameters (K, Hpp) suggest dipoles interaction among free radicals at 10 kGy and 50 kGy, and exchange interactions at 25 kGy among free radicals.

MP-P8

ELECTRONIC ENERGY LOSS INDUCED DISORDERS IN THE SILICON SURFACE IRRADIATED WITH SWIFT HEAVY IONS

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Crystalline silicon samples were irradiated with 65 MeV oxygen and 65 MeV fluorine ions at different fluences, 1 X 1013 to 1.5 X 1014 ions/cm2. The surface region of each silicon was studied by the Raman spectroscopy, the Optical reflectivity and the Atomic force microscopy techniques. The intensity of the Raman peak at 520 cm-1 and the optical reflectivity of 200 - 700 nm radiation were found to decrease continuously with increasing the fluences of oxygen or fluorine ions. The AFM measurements show that the roughness of the silicon surface has enhanced substantially after ion irradiation. These results reveal that a fraction of the crystalline surface was converted into disordered region after oxygen or fluorine ion-irradiation. Furthermore, at each ion fluence the degree of damage induced by 65 MeV oxygen ions was relatively higher than that induced by 65 MeV fluorine ions, even though the energy deposited through electronic energy loss by 65 MeV fluorine ions (~ 1.284 keV/nm) was greater than that deposited by 65 MeV oxygen ions (~ 0.944 keV/nm). The results of the present study show that the energy deposited through the process of electronic energy loss can induce disorders of appreciable magnitude in the silicon surface. Moreover, in the case of 65 MeV fluorine ion irradiation, it appears that both the processes of inducing defects and annealing out of defects were occurring simultaneously but at different rates.

MP-P9

INFLUENCE OF PLASMA ION-BEAM ASSISTANCE ON THE PROPERTIES OF TiO2 AND MgF2 THIN FILMS DEPOSITED BY PLASMA ION-ASSISTED DEPOSITION

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In an interference optical multilayer filter, a combination of TiO2 and MgF2 thin films is highly desirable because it provides a high index contrast between the two. However, the conventionally evaporated TiO2/MgF2 multilayers often lead to the formation of microcracks in the multilayers, because both TiO2 and MgF2 films used to exhibit the tensile stress. Ion-beam assistance can be helpful in reducing the stress because ion beam at a high dose may modify the microstructure of the films. It is expected that the plasma ion-assisted deposition (PIAD) maybe employed to modify the microstrucrure of TiO2 and MgF2 thin films such that a stable TiO2/MgF2 multi-layer without microcracks and remain mechanically stable after annealing.

In this study, TiO2 and MgF2 thin films were prepared by PIAD as well as conventional e-beam evaporation (CE) and the optical, chemical and structural properties of the as-deposited and annealed films were investigated. Those properties were measured by spectrophotometer, XRD, SEM, AFM and XPS. The stress of the films was measured using a laser scanning method. As an application TiO2/MgF2 narrow band–pass filters were deposited to study the effects of PIAD and annealing on the multilayers. The result shows that TiO2 film deposited by PIAD have a higher refractive index, a lower extinction coefficient, and smoother surface roughness than the CE TiO2 film. Also, the PIAD of TiO2 film induces a transition of tensile stress into compressive one. It is found that the PIAD method for TiO2 films is very helpful in achieving stable TiO2/MgF2 multilayer optical coatings, due to the dense microstructure, high refractive index, low extinction coefficient, smooth surface and compressive stress.

MP-P10

SURFACE MODIFICATION OF POLYOLEFINS BY PHOTOGRAFTING OF ACRYLIC COATINGS

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Film samples of high-density polyethylene (HDPE) and linear-low-density polyethylene (LLDPE) have been surface- modified by two different methods, before and after a pretreatment by wet oxidation (1, 2). The grafting of a mononacrylate monomer is realized on native or oxidized HDPE or LLDPE films under UV irradiation (3) in air atmosphere.

The surface properties of modified films are characterized by contact angle measurements, Infrared spectroscopy (FTIR) and X-ray photoelectron spectroscopy. The water contact angles recorded on coated films without pretreatment increases after Soxhlet extraction in acetone, while, pretreated films are less affected. The FTIR spectroscopy indicates appearance of new peaks (4) with main absorbances at 1160 cm-1, 1250 cm-1, 1536 cm-1, 1726 cm-1 and 3358 cm-1, assigned to polyacrylate.

These results are further supported by XPS data.

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MP-P11

ENERGY LOSSES AND ENERGY LOSS STRAGGLING DATA FOR LIGHT IONS CROSSING THIN POLYMERIC FOILS

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Experimental data of energy loss and energy loss straggling for 1H, 2H and 4He light ions crossing several polymer foils published previously by our group have been summarized and compiled in this study. The details of the experimental procedures are described and discussed. The experimental stopping data have been compared to the calculated values given by SRIM computer code and analyzed with the modified Bethe-Bloch formula, the mean excitation energies I have been then extracted from the data.. The obtained values of energy straggling are compared to those deduced from Bohr and Bethe-Livingston theoretical predictions. This comparison was made by using the famous Bragg's rule as model of calculation over the investigated energy range 0.9 – 3.5 MeV. The experimental straggling data are corrected to consider the roughness effects due to target thickness inhomogeneity.

MP-P12

CHARACTERISTICS OF CURRENT IN THE THIN SILICON OXIDES WITH NANO STRUCTURE

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In this paper, the trap characteristics of thin silicon oxides is investigated in the ULSI implementation with nano structure transistors. The stress and transient currents associated with the on and off time of applied voltage were used to measure the distribution of high voltage stress induced traps in thin silicon oxide films. The stress and transient currents were due to the charging and discharging of traps generated by high stress voltage in the silicon oxides. The transient current was caused by the tunnel charging and discharging of the stress generated traps nearby two interfaces. The stress induced leakage current will affect data retention in electrically erasable programmable read only memories. The oxide current for the thickness dependence of stress current, transient current, and stress induced leakage currents has been measured in oxides with thicknesses between 113.4nm and 814nm, which have the gate area 10-3cm2. The stress induced leakage currents will affect data retention, and the stress current and transient current is used to estimate to fundamental limitations on oxide thicknesses.

MP-P13

FABRICATION OF Ta2O5 THIN FILMS ON Si WAFERS BY REACTIVE ION SPUTTERING

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Being the most powerful candidate to replace SiO2, tantalum pentoxide (Ta2O5) thin films are very important for electronic and optical applications. Among several other methods to prepare Ta2O5 thin films, ion beam sputtering of Ta in an oxidizing ambient is a promising technique to fabricate high quality films. In this work, Ta2O5 thin films were deposited on p-type Si substrates by using reactive oxygen gas as the sputtering agent. A high purity Ta target was bombarded by accelerated oxygen gas with a constant energy of 1000 eV. Different deposition times and substrate temperatures (room temperature, 250 °C, 350 °C, 450 °C) were used to produce thin Ta2O5 films. An ellipsometer was used to measure the thickness and refreactive index of the films. Fourier Transform Infrared Spectroscopy (FTIR) in the region of 400 – 4000 cm-1 was performed to identify tantalum oxide formation. X-ray photoelectron spectroscopy (XPS) with depth profiling feature was performed in order to identify the chemical and structural properties of the deposited oxide layers. The crystal structure of thin films were determined with X-ray diffraction method. FTIR measurements reveal that the spectra have peaks around 650 cm-1 showing the formation of oxidized tantalum layers. From the analysis of Ta 4f doublet peak positions, the chemical structure of the surface region is found to be Ta2O5 with desired stoichiometric composition. Upon etching the surface region with Ar sputtering, new features with lower binding energy emerged in the XPS spectrum. This is attributed to the presence of suboxides with nonstoichiometric ratio in the region close to the interface between Si substrate and the deposited film.

MP-P14

MOSSBAUER AND XRD STUDIES OF SWIFT HEAVY ION IRRADIATED FERROMAGNETIC METALLIC GLASSES

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Modifications in structural properties of ferromagnetic metallic glasses, induced by swift heavy ion irradiation have been investigated. Metallic glasses Fe40Ni38Mo4B18 and Fe78B13Si9 have been irradiated using 100 MeV 127I ions at different doses ranging from 5x1012 to 1x1014 atoms/cm2. Mossbauer spectroscopy and XRD have been used for the structural characterization. Randomization of magnetic anisotropy and reduction in hyperfine magnetic field has been observed. The specimens retain their amorphous structure even after irradiation, as seen from XRD. The change in magnetic anisotropy is believed to be caused by residual stresses introduced by swift heavy ion irradiation. To release these stresses, some of the samples have been annealed at 490 K which is below Tg (~ 550 K) and Tcr (~ 673 K). However, these samples show partial crystallization as indicated by Mossbauer spectroscopy which was not expected. Crystallites of size ~ 15 nm have been found in the specimen, as determined from the XRD. The hyperfine magnetic field has been observed to get shifted towards the value corresponding to a crystalline phase. However magnetic anisotropy doesn't change significantly. Also it has been noticed that, after one year a the irradiated but un-annealed metallic glass samples have shown change in the hyperfine magnetic field indicating the initial stages of nucleation of different crystal structures. This paper will discuss the possible mechanisms of these structural relaxation and modification of magnetic anisotropy.

MP-P15

CORROSION AND OXIDATION RESISTANCE STUDY OF REACTIVE ION BEAM MIXED 316ss

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Corrosion and oxidation resistance behavior of reactive ion beam mixed Al-316SS and Si-316SS has been studied. 28 nm Al and Si films were deposited on 316SS substrates. Ion beam mixing was carried out using 30 keV N2+ ions at different doses ranging from 4x1016 to 2x1017 ions/cm2. Potentiodynamic polarization measurements of the reactive ion beam mixed samples have been carried out in 0.5N H2SO4 electrolyte. Oxidation study was carried out in the air at 800 _C temperature. For the structural characterization GXRD techniques has been used. Both corrosion and oxidation resistances are improved as the dose is increased. For the corrosion measurements done in 0.5N H2SO4 electrolyte it is seen that a passive film is formed which protects the substrate. No such passive film is observed for the Si deposited and ion beam mixed 316SS. In the GXRD spectrum of the samples shows peaks of GXRD plots of the samples of Al -Fe and-Al-oxide, Al, Al-Fe, mixed 316SS using nitrogen ions show peaks of -Fe. Whereas, GXRD plots of Si ion beam mixed 316SS shows peaks of chromium nitride. Comparatively corrosion potential and corrosion current were better for the Al-316SS reactive ion beam mixed sample than for the Si-316SS reactive ion beam mixed samples in 0.5N H2SO4 electrolyte. High temperature oxidation resistance increases as the dose increases.

MP-P16

FABRICATION OF A NEW TYPE OF OPTICAL MEDIUM WITH METALLIC NANOLAYERS BY ION IMPLANTATION TECHNIQUE

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Inorganic crystals with nanosize metallic particles are a promising material for manufacturing of optical switches with the ultra fast response. They have very high non-linear optical third order susceptibility, especially at the frequencies being closed to range of absorption by metallic nanoparticles, which is due to the surface plasmon resonance. In this report we present the first results of development of a new type of optic media based of the alkali halides crystals with an embedded sub-surface metallic nanoparticals. These media have a set of merits, namely: a high light irradiation resistively with respect to light irradiation and low optical losses. Also, a wide set of laser media based on the alkaline-halogen-crystals with the color centers have been developed last years. That suggests they are a promising material for manufacturing of optoelectronic elements such as communication fibers with distributed amplification as well. We used the LiF samples which were implanted with Cu2+ ions. The ion fluencies were 5ı1016 ions per sq. cm and ion energy was about 100 keV. The doping has been realized at the MEVVA ion implanter in HCEI (Tomsk, Russia) by group headed by E.Oks. After ion implantation an absorption F band appears at 250 nm, that suggests the self lattice defects formation as the F-centers. The next stage was annealing of the irradiated crystals up to the near melting temperature. When the temperature increases up to 950°C, a weak absorption band appears at 570 nm. Note, that at such a high temperature all absorption bands disappear in the irradiated crystals, because of disruption of the defects that have been caused by radiation. On the other hand, the recorded location of the absorption band is closed to one, which has been observed earlier for plasmon surface resonance due to nanosized copper particles produced in amorphous silica glasses. Hence, it is naturally to relate the absorption band in our case is due to surface plasmon resonance of the copper nanoparticles. By means of the TEM it was shown that the copper particles distributed throughout the doped layer of the crystal are of a quasi spherical shape with 10– 30 nm in diameter and average inter-particle distance of 50–80 nm. Hence, the present report shows a possibility of manufacture of the nanosize copper particles in LiF crystals.

MP-P17

ION IMPLANTATION TREATED MAGNESIUM

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Attractive mechanical properties of magnesium at low weight offer great potentials in technical applications such as automobile and aerospace fields, albeit its low corrosion resistance often limits this scope. Biomedical application of magnesium and its alloys is not a new concept ever since they were introduced into orthopaedic and trauma surgery in the first half of the last century, particularly owing to the elastic modulus approximate to bone as well as degradable properties, eliminating the need for a second operation for implant removal. However, this approach was stopped when the stainless steel were successfully chosen. The reasons are their too quickly degradation as well as hydrogen gas bubbles accumulated in vivo. Recently, magnesium has gained renewed interests for vascular stents, with the expectation of maintaining the mechanical properties during the first weeks to months after implantation and after this time disappear without the risk of mechanical or chemical irritation, which leads to restenosis. Attempt of modifying Mg to control its corrosion (degradation) properties is therefore of great scientific and technical importance. In this paper, oxygen PIII modified Magnesium with different doses and modifying layer depths were prepared, and investigated the corrosion behaviors in phosphate buffer solution (PBS) with negligible or large chloride ion concentrations (PBS(Cl-1)). Potentiodynamic polarization tests indicate that in PBS the corrosion current density of oxygen ion implanted Mg treated under 20KV bias voltage with oxygen dose more than 5 x 1016 cm-2 was strongly decreased by almost five orders of magnitude compared with untreated Mg, and can withstand more strongly potentials within the anodic scanning range. Decreasing bias voltage to 10KV did not result in intermediate corrosion rate expected. There seems to be a threshold value of the ion dose and depth for the corrosion protection. X-ray photoelectron spectroscopy (XPS) and X-ray diffraction (XRD) measurements show that an oxide layer can be formed on Mg by PIII ion implantation of oxygen, which is highly corrosion protective against a non-NaCl-containing, near neutral buffered solution. In more aggressive PBS(Cl-1) with Cl -1 more than 145mM , there is no significantly improvement of corrosion resistance for the high dose implanted Mg, indicating that the modified layer is still sensitive to highly Cl-1 containing solutions. Scanning electron microscope (SEM) and atom force microscope (AFM) observation were performed to investigate surface morphology of the treated Mg, interpreting influence of surface morphology obtained by PIII on the corrosion protection behavior of the modified layer. Surface of the treated Mg after corrosion were observed by SEM to determine their corrosion characteristics.

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MP-P18

DIRECT OBSERVATION OF STRUCTURE DENSITY VARIATION IN PLANAR NANOSTRUCTURES BY RBS METHOD

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The diagnostics of the size factor influence on the physical and chemical material properties is one of the most problem for nanostructure physics [1] and, in particular, for the planar nanotechnology. It is well known that the thickness reduction of film coating leads to it's material density decreasing. This effect is expected because the film thickness reduction increases the surface energy deposit in the material thermodynamical potential. At the same time the diagnostics of a material density decreasing is not routine task, and it's solution searches are connected with X-ray methods of the material cell parameters determination. But X-ray diagnostics of nanosize structures is very difficult and nonmonosemantic procedure. The direct material density definition can be carried out by using of the ion Rutherford backscattering method. The work presents the attempt for theoretical ground about possibility of real material density determination on base of RBS data. These theoretical evaluations are built on a difference of fast ion energy losses on electrons of atomic cores and on free electrons. These theoretical calculations are confirmed by RBS experimental study of Ag thin film coating for size area 20-100 nm on Si substrates.

Moreover, the great surface energy deposit for thin film coatings can lead to effects when the film material density will depend from the method of the coating preparation and the selection of next modification procedures. The work discusses the RBS experimental data obtained for Al films with thickness near 300 nm on Si substrates. These films were prepared by method of the partial ion assistance and showed the material Cdensity defect near 6%. After thermal treatment in vacuum at temperature 480 during 1 hour the film material density achieved the X-ray value for Al.
[1] Teller C.R., Tosser A.J. Size effects in thin films. New York: Elsevier. 1982. 310 p.

MP-P19

IMPROVEMENT IN CRYSTAL QUALITY OF EPITAXIAL AG FILMS INDUCED BY SELF-ION IRRADATION

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It is well known that thermal annealing, for the Ag/Si and Cu/Si systems, is inapplicable to the improvement in crystal quality of the metallic films because exfoliation as well as inter-diffusion between the film and substrate easily occurs at temperatures as low as 500 _C. We demonstrated that ion irradiation at low temperature (LNT and RT) greatly improved the crystal quality of epitaxially grown Ag [1,2] and Cu [3] films on Si substrates. In the earlier works, 500 keV-Si ions were used to irradiate so that the irradiation-induced vacancies distribute almost uniformly along the depth in epitaxial films. In this case, most of Si ions pass through the film/Si interface, resulting in degrading the crystal quality of Si substrate. In the present work, the epitaxial Ag film of ~300 nm in thickness was irradiated with 300 keV-Ag ions. Under this condition, all of the Ag ions stay within the film. The crystal quality of the epitaxial film was analyzed by Rutherford backscattering spectrometry/channeling (RBS/C) before and after irradiation. The minimum yield at the Ag surface in the RBS/C spectra decreases from 39 % to 13 % after irradiation to 3x1015 cm-2 at RT, indicating that the self-ion irradiation improves the crystal quality. The type of defects remained in the irradiated films was also investigated by the RBS/C technique with 0.5-2.8 MeV He ions. Energy dependence of de-channeling rate suggests the presence of voids in the irradiated film.

[1] K. Takahiro et al., Appl. Phys. Lett. 69, 2828 (1996).
[2] K. Takahiro et al., J. Appl. Phys. 96, 4166 (2004).
[3] K. Takahiro et al., Surf. Coat. Technol. 158/159, 334 (2002).

MP-P20

SURFACE MODIFICATION OF POLYMERIC BLENDS BY NITROGEN PLASMA IMPLATATION

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The surfaces of polymeric blends of poly vinyl chloride and poly ethylene terephthalate have been treated by reactive ($N2^+$) gas plasma to understand the effects of low energy ions on the surface modification of polymeric blends. These effects were studied by microhardness tester, optical microscope, atomic force microscopy (AFM) and FTIR spectroscopy as a function of fluence. DSC studies of pristine and irradiated samples were also reported here. It is observed that hardness of the film increases significantly as fluence increases. The bulk hardness of the film obtained at loads greater than 400 mN. The increase in hardness may be attributed due to cross-linking effect, which is also corroborated with FTIR spectra. The optical micrographs clearly show the surface roughness due to implantation. The atomic force microscopy (AFM) shows that the average roughness (Ra) of the film surface increases from 13.1nm to 78.1nm as fluence increases. The DSC thermograms revealed a quite complex behavior in the temperature range 250- 350 °C, where it is seen that with increase in fluence the DSC exotherm changes into DSC endotherm.

MP-P21

IMPROVEMENT OF INTERFACIAL AND MICROSTRUCTURE PROPERTIES OF HIGH-k ZrO2 THIN FILMS FABRICATED BY FILTERED CATHODIC ARC DEPOSITION USING NITROGEN INCORPORATION

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Advanced gate dielectric materials such as ZrO2 have attracted much interest due to their high-k dielectric properties and excellent thermodynamic stability in contact with silicon. However, the application of ZrO2 thin films in the advanced gate dielectric fields has been seriously restricted by the low crystallization temperature. It may be because of the ionic bonding and high oxygen ion diffusivity in ZrO2 crystal structure. Therefore, crystallization control of ZrO2 thin films is considered to be one of the most challenging issues for good device performance. It is well known that incorporation of nitrogen into ZrO2 can promote the formation of covalent bonding in the thin films. Furthermore, accumulation of nitrogen atoms at the SiO2/Si interface can improve hot carrier resistance, and the use of oxynitride can also suppress boron penetration from the poly-Si gate to Si. Thus, nitrided oxides are attracting a great deal of attention for device applications that include not only flash memories but also standard MOS logic circuits. Recently, there have been several reports on incorporating nitrogen into binary metal oxides to increase the crystallization temperature by high temperature annealing in N2O or NH3 ambient. Unfortunately, the high-k dielectric materials nitrided by NH3 exhibit an increase in the interfacial trapping density and deterioration of mobility due to hydrogen-related traps (-H, -OH, and N-H). Besides, N2O and NH3 are both toxic gases. Therefore, the development of a novel deposition technology that utilizes nitrogen instead of NH3 and N2O is preferred to achieve crystallization control of advanced gate dielectrics for a ‘clean’ ULSI process. In this work, ZrO2 thin films were deposited on n-type Si (100) wafers using a cathodic arc plasma source in the presence of oxygen and nitrogen gases. By introducing nitrogen, ZrO2 thin films with higher crystallization temperature and better microstructures and interfacial characteristics were produced. Our study suggests that cathodic arc deposition by adding nitrogen is an effective nitriding technology to improve the microstructure. It will accelerate the application of alternative high k thin films in advanced gate dielectric fields.

MP-P22

SWIFT HEAVY ION IRRADIATION ON CO-IMPLANTED ZnO THIN FILMS

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ZnO(600nm)/GZO(400nm)/LT-ZnO/Al2O3(1000) was grown by a radical beam assisted molecular beam epitaxy. Undoped ZnO(600nm) thin film has the mobility 101 Vs/cm2 and concentration n<1x10e17/cm3. For the fabrication of dilute magnetic semiconductor, Co ions were implanted at 80 keV and with the fluence of 1x10e16/cm2-1x10e17/cm2. As-implanted ZnCoO showed the diffraction peaks of CoO(311) and Co(111) in x-ray diffraction analysis and the resistivity lay in 20-50 mOhm-cm. And the optical band gap shows the blue-shift as much as 20 -60 meV. Swift heavy ion of Ag+15 were irradiated at 200 MeV and the ion fluence of 1x10e12 ions/cm2 on as-implanted ZnCoO films. After irradiation, the peaks related to Co and CoO disappears in the ZnCoO films implanted up to 5x10e16/cm2, but still are observed in the films irradiated at 1x10e17/cm2. The resistivity is also reduced by the factor 2 and the optical band edge moves to lower energy reversely. Magnetic properties of as-implanted and after swift heavy ion irradiated will be presented.

MP-P23

ELECTRICAL CHARACTERISTIC OF PROTON CONDUCTIVE POLYMER IRRADIATED BY MEV ION BEAMS

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We studied the irradiation effect of proton conductive polymer by MeV ion irradiation, and demonstrated improvement of the electrical conductivity at the low humidity. A perfluorosulphonic polymer membrane is attractive proton-conducting material for polymer electrolyte fuel cells which are promising in automotive and in electrical equipments requiring compact batteries.Because hydrated ions play important role for transporting protons, a limiting factor in the polymer is poor ionic conductivity at low humidity. Recently we found enhancement of electrical conductivity in the proton conductive polymer by gamma-ray irradiation [1]. Ion irradiation offers possibilities for improvement in characteristic of polymers by introducing chemical and structural changes. However, ion beam modification of the proton conductive polymer has never been examined.

Ion beams of H, He and Au with 1 - 2 MeV were irradiated to the commercially available perfluorosulphonic polymer membranes (Aciplex: Asahi Kasei) up to a dose of 1 x 1013 ios/cm2 with a flux of about 1 x 1010 ions/cm2s at room temperature After the ion irradiation, V-I characteristic was measured in the temperature range 295 to 380 K. The electrical conductivity increased with an increase of the irradiation dose of light ions; the maximum conductivity was three orders of magnitude higher than that in an un-irradiated membrane. Temperature dependence of the electrical conductivity indicated that ion irradiation caused a new conduction process with the lower activation energy in comparison with the original one. On the other hand, the low activation energy component disappeared in vacuum circumstance, suggesting that the ion irradiation induced conduction process is also attributed to water. The mechanism of the observed electrical conductive phenomenon will be discussed in connection with structural changes induced by ion irradiation.

[1] T. Adachi, et.al., J. Nucl. Mater., 329-333 (2004) 1499-1502.

MP-P24

THE STRUCTURES AND PROPERTIES OF TITANIUM NITRIDE FILM SYNTHESIZED AT DIFFERENT NITROGEN PRESSURE BY MAGNETRON SPUTTERING

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Titanium nitride films have been widely used in different fields due to its attractive properties such as high hardness, wear and corrosion resistance, low resistivity, etc. Ti-N-O film has been reported that it has good blood compatibility. Those make Ti-N-O film possible to be applied in biomaterial surface modification. In order to study Ti-N-O films, we first synthesized TiN films and then oxidize them to synthesized Ti-N-O films. In this work, titanium nitride films were deposited on Ti6Al4V and Si(111) substrates by DC reactive unbalanced magnetron sputtering deposition. The effects of nitrogen pressure on structures and tribological properties of titanium nitride films were investigated. X-ray diffraction (XRD) results show that the titanium nitride films fabricated at different nitrogen pressure have different structures. Nitrogen pressure increasing, the structures of titanium nitride films change from Ti2N to TiN. The microhardness and wear resistance of titanium nitride films were also studied. The relationship between structures and properties was discussed.

MP-P25

IMPROVEMENT OF SURFACE PROPERTIES OF ORTHOPEDIC NICKEL-TITANIUM SHAPE MEMORY ALLOYS BY NITROGEN PLASMA IMMERSION ION IMPLANTATION

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Our work aims at improving the anti-corrosion capabilities of nickel-titanium (NiTi) shape memory alloys (SMA) used in orthopedics. In spite of the favorable shape memory effects and super-elasticity, NiTi SMAs suffer from the leaching of harmful Ni during prolonged uses inside humans thereby raising safety concerns. In our work, we produced a titanium nitride barrier layer on the NiTi surface by nitrogen plasma immersion ion implantation (PIII). Post-implantation vacuum annealing was carried out to maximize the nitrogen density within the implanted region. Both electrochemical and immersion tests coupled with inductively-coupled plasma mass spectrometry (ICMPS) were conducted to assess the anti-corrosion capability and degree of Ni leaching. Nano-indentation was conducted to compare the mechanical properties of the implanted layers with the untreated control samples surface. X-ray photoelectron spectroscopy (XPS) and X-ray diffraction (XRD) analyses were employed to examine the composition and microstructure of the materials after implantation and annealing. Electrochemical tests show that the N-treated samples possess higher corrosion potential and breakdown potential while lower corrosion current compared to the untreated control sample. It demonstrates the improvements in the corrosion resistance. The ICPMS analysis after the immersion test shows that the amount of Ni leached out from the untreated control sample is at least ten times higher than that from the treated samples. The barrier layer is thus effective in mitigating leaching of Ni from the NiTi substrate. Nano-indentation results show that all the N-treated samples have higher Young's modulus and hardness than the control sample throughout the treated depths. Hence, the treated sample surface is mechanically stronger than the substrate underneath. XPS and XRD analyses show that TiN is the only phase formed after nitrogen implantation and annealing. The XPS depth profiles also demonstrate that the Ni content is suppressed in the implanted region. The possible enhancement mechanisms will also be discussed.

MP-P26

ENHANCED CORROSION RESISTANCE OF AISI H13 STEEL TREATED BY PLASMA IMMERSION ION IMPLANTATION OF NITROGEN

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AISI H13 steel is a high strength steel employed in molds for high temperature manufacturing of industrial components. It is also used in the industries due to its extraordinary shock resistance. Thus, it is important to enhance AISI H13 steel wear and corrosion resistance as well as its hardness by some kind of surface treatment. So far the corrosion behavior of AISI H13 steel by PIII has not yet been studied. The aim of the present work is to study the electrochemical corrosion behavior of AISI H13 steel treated by PIII process in 3.5% (wt) NaCl solution. The electrochemical results are correlated with the surface morphology, nitrogen content and hardness of the nitride layer. Ion implantation of nitrogen into H13 steel was carried out by plasma immersion technique. SEM examination revealed a generalized corrosion and porosity over mall analyzed samples surface. Penetration of nitrogen reaching more than 20 C and hardness as high as 1340HV (factor of 2.7 enhancementwas achieved at 450 over standard H13) was reached by a high power, 9h PIII treatment. The corrosion behavior of the samples was studied by potentiodynamic polarization method using a conventional three-electrode glass cell. AISI H13 steel slices were employed as the working electrode. The noblest corrosion behavior was observed for the C, during 9h. An increase of the corrosionsamples treated by PIII at 450 potential from V (untreated sample) up to about -0.42V (treated=9h) was observed. Anodic branches of polarization curves of PIII processed samples show the passive region associated with the formation of a protective film. The passive region current density of PIII treated H13 samples (3.5x10-6 A/cm2) is about hundred times lower than the one of no treated specimens. This enhanced corrosion behavior is an important factor to H13 industrial applications along with the improvement of hardness and formation of thick N-enriched layer observed by GDOS analysis.

MP-P27

TRIBOLOGICAL TREATMENT OF ALUMINIUM BY OXYGEN PLASMA IMPLANTATION: ASPECTS OF PRACTICAL IMPLEMENTATION

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Aluminium has poor tribological properties that can be vastly improved, however, using oxygen plasma implantation. The optimal treatment requires control of the ion dose and the workpiece temperature, two parameters that are not trivially measurable online in plasma-based implantation (PBI). We have built, calibrated and tested on our PBI device a system to measure the surface temperature and the incident power. It is based on the measurement with a thermopile of the black body radiation emitted from the back of a very thin aluminium plate inserted in the workpiece holder. We also make use of this system to monitor the ion dose. Since secondary electrons, backscattered ions and sputtered particles carry relatively little energy compared to the incident ions (20-30 keV), the incident power is a measure of the ion flux to a good approximation. But since O ions can be atomic or molecular, this brings in an additional uncertainty on the actual oxygen dose. The results show that the ions are mostly molecular in agreement with estimates based on plasma parameters and with XPS measurements of the ion penetration depth. Another important practical aspect is the treatment uniformity achievable on non-planar workpieces. Using a machined workpiece whose faces made different angles theta with the plasma source, we found the O contents to vary as ~cos(theta). The resulting tribological properties were acceptably uniform in the range $0 < \text{theta} < 45°$.

MP-P28

SRTUCTURAL AND TRIBOLOGICAL PROPERTIES OF CARBON STEELS MODIFIED BY PLASMA PULSES CONTAINING THE INERT AND ACTIVE IONS

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Nitrogen and carbon expanded austenite (γN, γC) combines high hardness, good wear and corrosion resistance in austenitic stainless steels. It is generally assumed that conventional stationary process can only form such phases if the system contains Fe, Cr and Ni elements. As was shown in our previous experiments this does not hold the true if the process of transient melting and recrystalisation (TMR) of the near surface layer of the substrate is applied. In such case g$_N$ can be formed even in pure iron. In the present work we performed systematic studies on the structural and tribological properties of carbon steels with carbon content in the range 0 – 4 at.% irradiated with 5 short (ms range), intense (5 – 6 J/cm^2) argon or nitrogen plasma pulses. The retained dose of N after nitrogen pulses was about 1.2x10^{17} N/cm^2. Samples were characterized by: X-ray diffraction analysis (GXRD), conversion electron Mössbauer spectroscopy (CEMS), nuclear reaction analysis (NRA), hardness and wear resistance measurements.

The thermal effects induced by energy pulses of inert gas plasma (argon) leads to formation the γC phase in all samples containing carbon atoms. In the case of active gas plasma (nitrogen) pulses both g$_C$ and g$_N$ phases are formed reaching of about 15 vol.% of the near surface (100 nm) layer. Also some amount of Fe$_3$N nitride are identified by GXRD and CEMS analysis. In spite of the fact that these phases are formed from the initial material distinctly different from the austenitic stainless steels, the values of their hyperfine parameters such as isomeric shift and quadrupole splitting determined by CEMS, are very close to observed by others authors where g$_C$ and g$_N$ were formed by conventional implantation techniques. The presence of these phases in the near surface layer resulted in increase of hardness and wear resistance of our samples by a factor of 2 – 2.5; γN begin more effective in improving the tribological properties.

MP-P29

INTERFACE STRUCTURE OF BETA-FeSi2 THIN FILM FABRICATED ON Si AND SOi SUBSTRATES

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Formation of epitaxially grown beta iron disilicide (beta-FeSi2) layers on Si substrate is important for opto-electronic device fabrication. The ion beam sputter deposition (IBSD) is capable of fabricating a highly oriented beta-FeSi2 film on a Si(100) substrate. Our previous results show that photoluminescence (PL) has been observed up to high as room temperature from IBSD-beta-FeSi2 with sequential annealing [1]. It can be considered that nanostructure at the interface strongly affects the luminescence. In the present study, effect of the substrate/film interface structure and compositional changes at the interface for the luminescence has been investigated by the observation of cross sectional transmission electron microscope (XTEM). Two different substrate, Si(100) and SOI (silicon on insulator) were used in these experiments. The beta-FeSi2 film is fabricated with IBSD method by deposition of Fe on these substrates. Some of the films are sequentially annealed at 1153 K for 24 hours after the film formation. The PL measurement shows that the peak intensity at 0.83 eV drastically increased upon thermal annealing when Si(100) is used as a substrate. Such feature has not been observed with SOI substrate. The XTEM images showed these films have quite difference structures. The beta-FeSi2 films on Si(100) were aggregated, forming beta-FeSi2 particles with the size of around 200 nm. Dislocations and stacking faults were not observed near the interface. Aggregation also occurred to form 20 to 30 nm beta-FeSi2 particles with SOI substrate. However, in the SOI case, diffusion of oxygen from the

MP-P30

PATTERN FORMATION BY SPUTTER EROSION OF Si- AND C-SURFACES

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During the irradiation of solids by energetic ions the interplay of sputtering erosion and surface diffusion can produce self-organized surface patterns. Periodic height modulations (ripples) arise having a characteristic wavelength of 10 to 100 nanometers. These steady state structures can be described by a continuum theory. Nevertheless, they are produced by a large sequence of single ion impacts. The present experiments are carried out to study the evolution of these steady state ripple patterns starting from flat surfaces. Sputter erosion experiments are performed on amorphous carbon, graphite and silicon surfaces. These surfaces are easy to prepare, stable in air and typically flat on an atomic scale. Moreover, since silicon and graphite are amorphized by the ion irradiation, the surfaces are isotropic regarding surface diffusion. Sputter erosion was done by Ar and Xe ion beams with fluences of 10<13> to 10<16> ions/cm2. The transition from single ion impacts to ripple patterns was investigated using AFM and STM.

MP-P31

STUDY OF SURFACE CHARACTERIZATION OF Ti+N AND Zr ION IMPLANTED 316 L SS SAMPLES

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In this study, the polished 316LSS has been implanted with Ti+N and Zr ions at fluence of 2x1017/cm2 and 1x1017/cm2 to investigate the influence of the ions on its structural and mechanical behaviour. Measurements show that after Ti+N implantation; the friction coefficient decreases , the hardness value increases, the wear behaviour decreases, and after Zr implantation; the friction coefficient decreases, the hardness value increases, the wear resistance increased by a factor of ten with respect to an unimplanted sample. Ion charge state distributions of Ti+N and Zr were measured with TOF. The Ti+N and the Zr concentration profiles, that were obtained by RBS. These structural differences and the range distribution of ions in implanted and unimplanted samples were evaluated using stoppo program (1) and the results were compared with the experimental data , which were in good agreement.

[1] S.Selvi, Z.Tek, A.Oztarhan, I.Brown, N.Akbaş 'High fluence effects on ion implantation stopping and range' Nuclear instruments and methods in physics research B 229 (2005) 60-64

MP-P32

SWIFT HEAVY ION INDUCED MODIFICATION IN POLYIMIDE FILMS

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Polyimide (PI) films were irradiated by 80 MeV O^{6+} ions at different fluence of 8.5 x 10^{12} ions/cm^2 , 1.5 x 10^{13} ions/cm^2 and 2.5 x 10^{13} ions/cm^2. The modified films were charcterized by microhardness tester, LCR meter, and FTIR spectroscopy. It is observed that the hardness of the films increases as fluences increases. This may be attributed to the cross-linking effects as corroborated with FTIR spectra. There is an exponential increase in conductivity with log of frequency and the effect of irradiation is siginificant at higher fluences. The dielectric constant/loss are observed to change with fluence.TGA/DSC thermograms give information about the thermal stability and qualitative/quantitative information about physical and chemical changes that involve endothermic (heat absorbed) or exothermic (heat evolved) process in heat capacity.The results will be discussed.

MP-P33

THERMAL DIFFUSION BEHAVIOR OF IMPLANTED GERMANIUM ATOMS IN SILICON DIOXIDE FILM MEASURED BY HIGH-RESOLUTION RBS

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Diffusion properties of implanted germanium atoms in a thin oxide film have been investigated by a high-resolution Rutherford backscattering spectrometry (HR-RBS) and cross-sectional transmit electron microscope (TEM) observation. Distribution of nanoparticles formed in depth is an important factor for developing single electron devices using nanoparticles in a thin oxide film. The depth distribution and size of nanoparticles are closely related to the depth profile of implanted atoms after annealing. Therefore, non-destructive measurement of the depth profile with nanometer scaled resolution is required as alternative method of TEM observation. We implanted Ge atoms into 25-nm-thick SiO2 film on Si by negative ion implantation at 10 keV with 1 x 1015 ions/cm2, and measured depth profiles of Ge atoms after various annealing by HR-RBS (HRBS500, COBELCO, Japan) under measurement conditions: He ions at 450 keV and 30 mC; the incident and detection angles were 49° and 80° from the normal to the surface, respectively. As implanted sample, the depth profile was almost Gaussian and very similar to the calculated one by TRIM-DYN program with a peak fraction and depth of 1.5 at.% and 12 nm, respectively. After annealing at temperatures of 500 and 700 °C in Ar-gas flow, the depth profiles were almost same as that of the as-implanted sample. In the cross-sectional TEM images, nanoparticles with 3-4 nm in diameter were formed around 12 nm in depth. At 900°C, the profile had another peak at 28 nm. This showed that Ge atoms thermally diffused to the Si boundary. Details of HR-RBS and comparison with TEM images will be presented at the conference.

MP-P34

ION IRRADIATION ON THE CONDUCTIVITY AND OPTICAL ABSORPTION OF HEAVILY MgO-DOPED LiNbO3 SINGLE CRYSTALS

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The confirmation of MgNb defects in heavily MgO doped LiNbO3 single crystals were investigated through optical absorption, electrical conductivity measurements, optical spectroscopy with nanosecond time resolution, and Raman spectroscopy technique. An increase in the MgO concentration up to 10 mole% provides an essential change of the luminescence of LiNbO3, the appearance of a supplementary optical absorption band at the 1.1 eV, an alteration of the Raman spectra caused by the formation of MgNb defects, a shift of the edge of the supplementary optical absorption due to ion irradiation toward the shorter wavelength region as the MgO concentration increases. The effect of Ar+ ions irradiation on the conduction of the MgO doped LiNbO3 samples was studied. The important role of reduction in modification of the conducting properties of the ion-irradiated crystals was established. The increase of MgO concentration leads to the decrease of the reduction efficiency.

MP-P35

ION BEAM MODIFICATION OF CERAMIC COMPONENT PRIOR TO FORMATION OF ALN-Cu JOINTS BY DIRECT BONDING PROCESS

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Direct Bonding (DB) process is getting recently increasing interest as a method of producing high quality joints between aluminum nitride (AIN) ceramic and copper. AIN is an attractive substrate material for electronic applications in high power density packing owing to such features as: high thermal conductivity, good electrical insulation, thermal expansion similar to silicon and non-toxicity. The requirement of heat dissipation imposes the need of forming low thermal resistance (thin) joint with a high thermal conductivity metal, preferably copper. In our present approach it is expected that implantation of some additives to ceramic substrates should enhance better wettability between the bonded elements in comparison with conventional processes (oxidation) used thus far. Oxygen ions were implanted in gaseous source implanter. Ti and Cu ions were implanted in MEVVA type implanter. Oxygen dose was 5E17 in 15 keV. Ti and Cu doses ranged between 1E16 and 1E18 in energy 28 and 30 keV adequately. Following the ion implantation, conventional DB process was performed. Junctions were characterized by shear strength, RBS, SEM and XRD techniques. Results obtained show clearly that our presents approach leads to the results several times better with respect to the shear strength as compare to those obtained by the reference conventional method.

MP-P36

ION IRRADIATION EFFECTS ON OPTICAL PROPERTIES OF SILICON NITRIDE FILMS

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Silicon nitride films are of interest in applications such as optically transparent coatings. We have investigated the ion-induced effects on optical properties of Si3N4 films. Si3N4 films were deposited on SiO2 glass at room temperature in N2 gas by using reactive-RF-magnetron sputtering method. According to X-ray diffraction and Rutherford backscattering spectrometry, the films are amorphous and the thickness is ~ 200 nm, respectively. The films were irradiated with 100 keV N ions at room temperature. Optical absorption shows that the films kept transparency in the visible region. Ellipsometry was performed to obtain the refractive index for 380 to 1700 nm. The refractive index decreases with increasing the wavelength. The representative value at 400 nm decreases by ~7% at ~1016/cm2. Si3N4 films which were chemically grown on Si (SPL product) show slight increase of the refractive index by ion irradiation. Experiments on sample dependence, ion and energy dependences are under way and also origins of refractive index modifications by ions are in investigation.

MP-P37

MECHANISMS OF SURFACE MODIFICATION OF RARE-GAS SOLIDS BY ELECTRONIC EXCITATIONS

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The decay of electronic excitations is the final step in energy relaxation during treatment of surfaces by ion beams. The scission of the bonds, stabilizing the ground-state configuration, by transfer of electronic excitation energy to the lattice follows the trapping of the electronic excitations. However the range of materials, which exhibit inelastic processes induced by electronic excitation is limited to specific classes of materials, such as alkali halides, alkali earth fluorides and fused quartz [1]. Recently the rare-gas solids (RGS) manifest themselves as a new class of insulators, which demonstrates pronounced inelastic processes induced by electronic excitations [2]. As a consequence of the closed electronic shells, RGS are the simplest solids known to us with smallest binding energy between atoms in the lattice. On the other hand, solid argon and neon have band-gap energies exceeding that of LiF and may be cited as widest band-gap insulators. Therefore, RGS – well-known model systems in condensed matter physics – are very promising for investigation the mechanisms of inelastic electronically induced processes. Because of strong interaction with phonons the excitons and holes are self-trapped in RGS. Local elastic and inelastic lattice deformation around trapped electronic excitations, population of the antibonding electronic states during relaxation of the molecular-like centers, and excitation of the Rydberg states of guest species are the moving force of point defect formation and desorption of atoms and molecules (DIET) at the surface of RGS. The paper reviews the recent spectroscopic studies of the processes of large-scale atomic displacements at the surface of RGS following electronic excitation, using the complementary advantages of cathodoluminescence and photoluminescence (selective-state excitation by synchrotron radiation at high-flux VUV experimental station SUPERLUMI at HASYLAB, DESY, Hamburg) [3].

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MP-P38

IRRADIATION EFFECTS IN CARBON FIBERS AFTER N+ - ION IRRADIATION

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In order that carbon fiber composite materials have a good interfacial adhesion between matrix and fiber, it is necessary to study the effect of various methods of treatment on changing physico-chemical, physico-mechanical and morphological properties of fiber. Ion beam irradiation is a perspective method of simultaneous treatment of surface and structure of carbon fiber. In this paper we study the changes in morphology (topography) and structure of carbon fiber after ion irradiation.

Carbon fibers were implanted with 40 keV, N+ at the wide range of doses (from 1014 to 1019 cm-2). The specimen's temperature during ion implantation changes from 30 – 40 C at low doses up to 700° – 900 °C at high doses. Ion source of the basis of glow discharge with a hollow cathode was used to generate broad (~ 150 cm2) ion beam with 5 mA/cm2 current density. Pulse periodic mode of treatment was used with pulse duration of 1 ms and pulse repetition rates 3 – 50 1/s.

The structure of carbon fibers and graphite was studied with using RBS, SEM, and XRD. X-Ray studies of structure were made using Cu, K. Comparative crystallite size (L) was determined from the corrected peak width of reflections from two – dimensional turbostratic lattice. Surface wetting of fibers by organic liquids has been studied too, because a value of contact angle depends on the structure of fiber's surface.

Possible mechanisms of changing carbon fibers and graphite structure and properties as result of ion implantation are discussed.

MP-P39

MICRO STRUCTURAL CHARACTERIZATION OF AL DEPOSITION ON CORONA TREATED-POLYETHYLENE FILMS BY ION BEAM AND MAGNETRON SPUTTERING

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Packaging applications require metallization of the polymeric films to improve the barrier properties. The adhesion between the metallic coat and the polymer film is critical to obtain relatively high peeling strength at the interface and durability of the coating during the usage of the package. In order to enhance metal to polymer adhesion, corona treatment of polymers is usually used. Evaporation is commonly employed technique to deposit Al on polyethylene (PE), although adhesion is a vital problem in this method. In this m thick PE filmsstudy, Al thin films have been deposited on corona-treated 30 either by ion beam or magnetron sputtering system in high vacuum region. In an ion beam system, Ar+ ions were accelerated with different energies varying from 1000 to 1400 eV and bombarded a high purity Al target and all samples were grown at room temperature with the fixed deposition times. Al films were also coated onto the PE films at room temperature in magnetron sputtering system. After deposition of Al on PE, strong Al/PE adhesion was observed from the peel tests for both of the deposition techniques. Atomic force microscopy was used to investigate the surface morphology of the Al coated films. Fracture surface Scanning electron microscope images of Al/PE systems were examined to observe the interfacial interactions between Al and PE. The X-ray diffraction method was employed to determine the quality of the deposited films.

MP-P40

MICROSTRUCTURE OF NITROGEN IMPLANTATED STAINLESS STEEL AFTER WEAR EXPERIMENTS

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Outstanding wear resistance of austenitic stainless steel after nitrogen insertion in the temperature range below 420 °C is a well established phenoma. However, detailed information on the wear mechanism present for the modified surfaces are still missing.

In this presentation, results of metallographical investigations on cross sections before and after wear tests are presented. Stainless steel 304 is implanted with nitrogen ions using plasma immersion ion implantation at 10 and 25 kV for different incident fluences up to 5 x 1018 cm-2 at temperatures between 350 and 380 °C. Subsequent reciprocating wear tests were performed in a dry ball-on-disc geometry with a WC counterbody at a contact pressure of 1 GPa and an average speed of 1.5 cm/s. A total wear path of 100 m and more was necessary to reach a depth of 1 – 2 µm, corresponding to about 50% of the nitrogen-rich surface zone as the specific wear was below 10-5 mm3/m. Using these samples, metallographic cross-sections were prepared and investigated by scanning electron microscopy to obtain information on the grain size of the base material and the microstructure of the expanded austenite layer before and after the wear experiments. A correlation of the results with the treatment parameters and the parameters of the wear test allows an insight into the hardening mechanism for the expanded austenite as well as into the modified wear behaviour.

MP-P41

MICRO-SCRATCH TEST OF DLC FILMS ON Si SUBSTRATES PREPARED BY BIPOLAR-TYPE PLASMA BASED ION IMPLANTATION

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Diamond like carbon (DLC) films were prepared by bipolar-type plasma based ion implantation, and the adhesion property was examined as a function of positively and negatively pulsed voltages (Vp and Vn) by micro-scratch tester. Raman spectra were measured for the samples before and after scratched. Cross sectional transmission electron microscopy (TEM) was also done to check the interface between DLC film and Si substrate.

Pulse plasma around the sample was generated by alternating Vp and Vn. The films deposited under different conditions of Vp and Vn in the ranges of +2 to +4 kV and of -5 to -15 kV, respectively. Temperature of the sample during deposition was measured by a chromel-alumel thermocouple. It was changed from 40 to 200 °C, depending on the Vp and Vn. Toluene was used as a source gas and Si wafer was used as a substrate.

The critical load is increased with increasing Vn. On the other hand, the load where the film starts to be deformed is increased up to Vp +3 kV and decreased at further increase of Vp. Raman spectra suggests that graphitic structure is formed as the Vp increased. This indicates that wear resistance property depends on the microstructure of the films which is changed by the Vp. Cross sectional TEM observation reveals that the interface layer between DLC film and Si substrate is presented and the thickness is changed as the Vp and Vn are varied. The relationship between the critical load and the thickness of the interface will be discussed.

MP-P42

MOMENTUM EFFECTS ON ALUMINUM NITRIDE FORMATION IN A LOW-ENERGY ION BEAM ASSISTED DEPOSITION

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Aluminum nitride (AlN) is a promising wide band-gap semiconductor for electronics and optoelectronics device applications. Using a low-energy ion beam assisted deposition system (LEIBAD), the AlN thin films were formed on silicon substrate and we investigated its characteristics and effects of incident ion beam on film formation. The AlN thin films were grown by an electron beam evaporator and a low-energy ion beam. Nitrogen ions were generated in an electron cyclotron resonance (ECR) ion source and accelerated to 25-200 eV. The temperature of Si substrate was kept at 773 K during deposition. The pressure in the deposition chamber was 2x10-4 Pa (background) and 2x10-2 Pa (operating). The crystal structure of AlN thin films was characterized by X-ray diffraction (XRD). The AlN thin films showed c-axis preferred orientation. However, the cubic-AlN was grown by the ion beam bombardment with the energy of 50-100 eV. And the surface morphology of the AlN thin films was observed by atomic force microscope (AFM). The surface roughness was below 1 nm (rms). The AlN thin films formed by LEIBAD showed very smooth surface.

MP-P43

SURFACE CHARACTERIZATION OF SILICON CARBIDE FOLLOWING SHALLOW IMPLANTATION OF PLATINUM IONS

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Silicon carbide is a promising wide-bandgap semiconductor intended for use in fabrication of high temperature, high power, fast switching microelectronics components running without cooling. For hydrogen sensing applications, silicon carbide is generally used in conjunction with either palladium or platinum, both of them being good catalysts for hydrogen. When such a coating is applied on the exposed surface of SiC, the chemical reaction between the catalyst and hydrogen produces a detectable change in the surface chemical potential. Our past work dealt with both palladium coated SiC and palladium implanted SiC sensors. In this work we are investigating the effects of high-fluence, very shallow platinum ion implantation into semi-insulating silicon carbide on the sensing properties of the devices. We used atomic force microscopy (AFM) for monitoring the surface morphology before and after implantation, Rutherford Backscattering Spectrometry (RBS) for measuring the depth profile of the platinum distribution and the amorphisation of the silicon carbide crystalline lattice, and electrical measurements to determine the sensitivity to small hydrogen amounts and ruggedness of the devices when exposed to hot, oxidizing atmosphere. These tests were performed by exposing the sensors to various concentration levels of hydrogen in argon while monitoring the current flow across the p-n junction(s) and also in the surface conductivity mode with respect to time. The sensitivity of each sensor was measured at temperatures between 27°C and 800°C. We will present full surface morphology and electric measurements during this meeting.

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MP-P44

PROPERTIES OF CHROMIUM NITRIDE FILMS PREPARED BY HIGH ENERGY ION BEAM ASSISTED DEPOSITION

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Properties of chromium nitride films allow to use them as protective coatings of various objects, especially tools, against wear and partially also against corrosion. There are many methods by which the chromium nitride films can be prepared. These films were prepared also by Ion Beam Assisted Deposition (IBAD) method but only at low values of ion energy (below 2 keV). At high values of ion energy it would be possible to expect the improvement of adhesion and structural changes of the films. We have prepared the chromium nitride films by high energy (90 keV) IBAD method and investigated their properties. In the dependence on process parameters we have obtained the mixture of two known crystalline phases or amorphous state of the film. Resulting fims were hard and they had very high adhesion to the tool steel substates. Beside mechanical tests also corrosion ones were carried out. The films strongly supressed high temperature oxidation of stainless steel substrates. We also tried several examples of applications of the resulting films.

MP-P45

SILICON BASED COATINGS BY DYNAMIC ION MIXING FOR OXIDATION PROTECTION OF A Ti6242 ALLOY

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Ceramic coatings exhibit unique physicochemical properties for oxidation protection of metallic surfaces however they must fulfil two important requirements: strong adhesion and high density (i.e. low porosity or cracks). By using the dynamic ion mixing technique (DIM) which combines coating deposition and bombardment of the film with a high energy ion beam (100 -300 keV) it is possible to produce dense and adherent ceramic coatings at moderate temperature. We have investigated the influence of SiC and SixNy coatings deposited by DIM on the oxidation properties of a Ti6242 alloy. Amorphous SixCy and SixNy coatings were produced by sputtering SiC and Si3N4 targets with 1,2 keV Ar+ ions and the growing films were bombarded with 120 keV Ar+ ions. The chemical compositions were investigated by RBS and XPS as well as GDOES. The oxidation resistance was measured by thermo gravimetry experiments at 600°C in artificial air (20%O2+80%N2). The structural modifications were investigated by XPS, XRD, SEM. A considerable reduction (~ two orders of magnitude) of the oxidation rate is measured for both coatings. The structural modifications after 100 hours at 600°C are very limited and consist principally in the formation of SiO2 at the surface and Ti-Si compounds at the interface; the crystallisation of SixNy is SiC could exist. The improvementnot detected and for SiC only some traces of of oxidation resistance of Ti6242 is discussed in relation with the intrinsic properties of the coatings and with the interface mixing and ion beam densification.

MP-P46

OPTICAL PROPERTIES OF HIGHLY (1000) ORIENTED TEXTURED ZINC OXIDE FILMS FABRICATED BY METAL CATHODIC ARC AND OXYGEN DUAL PLASMA DEPOSITION

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Zinc oxide (ZnO) films possess many interesting characteristics such as piezoelectric effects, conductive effects, acoustic characteristics, direct band gap (3.3 eV), and absence of toxicity. Highly (1000) oriented ZnO films are fabricated on silicon substrate using a dual plasma deposition process incorporating a metal cathodic arc source and oxygen ambient. In this method, a zinc cathode is triggered to produce the zinc plasma and oxygen gas is simultaneously fed into the chamber. The zinc plasma interacts with oxygen in the vacuum chamber and a dual zinc-oxygen plasma is formed to conduct deposition. The optical properties of a series of ZnO films deposited on quartz using similar conditions are investigated using UV-visible spectrophotometry and the effects on the band gap are evaluated. The absorption of C-exciton resulting in a blue-shift of the band gap at room temperature is observed to be accentuated due to the (1000) orientation (a // n) of the ZnO film. The C-exciton absorption can be quite dominant and induce a blue shift, but the maximal effect should be about 39.3 meV. Therefore, the variation in the band gap may also be affected by the strain induced by the thermal mismatch [a small blue shift for (1000) ZnO film], BM effect (blue shift), and the effects of the positive charges on the donor atoms (red shift) depending on the properties of the ZnO films.

MP-P47

TUNNELING SPECTROSCOPY OF MICRON-SIZED PATTERNED Bi2Sr2CaCu2O8+d MESA ARRAYS

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All high temperature superconductors (HTSC), such as Bi2Sr2CaCu2O8+d (Bi-2212) single crystals, consist of CuO2 planes separated by non-superconducting Bi-O and Sr-O layers along the crystal c-axis, which results in strong anisotropy. Since its structure contains adjacent CuO2 layers with the separation of 1.2 nm, c-axis transport becomes a crucible issue not only in terms of fundamental physics but also the potential new applications such as terahertz radiation sources to bridge the terahertz gap. To see the inherent features of intrinsic Josephson junctions (IJJ) and tunneling characteristics peculiar to HTSC, micron-sized mesa structures have been fabricated on the surfaces of Bi-2212 single crystals using photolithography and Argon ion beam etching techniques. Various mesa heights have been obtained by different etching regimes. The surface topography and heights of the mesas have been examined with atomic force microscopy. I-V curves with multiple branches and temperature dependence of tunneling conductance have been investigated by means of point contact tunneling in a large range of temperatures from 4.2 K to 300 K. The results obtained from SIN single junction and SIS break junction conductances have been compared with IJJ quasiparticle spectra exhibiting no higher bias dip structures; which are reconciled with overheating in the mesa. It has been also discussed how gap voltages change with temperature and the normalized gap voltage versus normalized temperature plot obtained by experimental data have been compared with BCS and various HTSC models.

MP-P48

SYNTHESIZE OF ANATASE TIO2 WITH THE THICKNESS OF SEVERAL TENS OF NANOMETER AND ITS PHOTO-CATALYTIC PROPERTY IMPROVED BY NITROGEN IRRADIATION WITH SEVERAL HUNDRED ELECTRON VOLTS

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RF sputtered titanium thin film with 200-800nm thickness was deposited on Si(100) single crystal substrate. Titanium oxide films were synthesized by annealing in oxygen at the temperature of 350 °C. Crystal structure and stoichiometric ratio of titanium oxides were estimated by X-ray diffraction (XRD) measurements irradiating by 12kW Cu Kα. Compositions and chemical binding state of titanium oxides layer are analyzed by X-ray photoelectron spectroscopy (XPS). Careful analyses of XPS and XRD indicate that it is able to control the crystallization of titanium oxides such as anatase, brookite and rutile. The photo-catalytic property of Titanium oxide was evaluated by the bleaching method of methylene blue solution with the concentration of 10μmol/l.

Anatase TiO2 was synthesized by thermal oxidation and it was confirmed by analyses of XRD and XPS. The anatase thickness was estimated to be about several tens nm. After the irradiation of UV light (365nm, 6mW/cm2) for 3hrs, the anatase TiO2 specimen bleached the solution. When the blue LED (470nm, 1.2mW/cm2) and UV LED (400nm, 0.5mW/cm2) were used as the light source, the bleaching process was not observed at all.

On the other hand, for the specimens which nitrogen irradiated at the relatively lower energy such as several hundred eV, methylene blue solution was bleached even for the blue and the UV LED light source. The XPS analyses indicated that the N concentration for the specimen was about 10-15at%. It is concluded that anatase TiO2 with several tens nm thickness has the good photo-catalytic property and the nitrogen addition affect on the improvement of the photo-catalytic reaction in the region of visible light.

MP-P49

PHASE AND MICROSTRUCTURE EVOLUTION OF ION IRRADIATED Fe-Pt THIN FILMS

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Considerable interest has been generated in thin film Fe-Pt alloys because of their use in a variety of magnetic-related applications including GMR underlayers and small bit size media. In these applications, control of the granular morphology is critical. When Fe-Pt alloys are sputtered deposited, they adopt a solid solution fcc phase. This requires a subsequent anneal near 600C to order the film into the desired crystallographic phase with its appropriate magnetic properties. Detrimental grain growth often accompanies this annealing process. We have investigated the use of Cu+ and Kr+ irradiation on the grain size, texture, phase and magnetic properties for a series of Fe-Pt alloy thin films. Irradiation could be used to engineer the vacancy defect concentration that could promote ordering at lower annealing temperatures. 'Ex-situ ion irradiation' was conducted using a 2MeV Pelletron accelerator with the films being annealed and characterized post-irradiation. 'In-situ ion irradiation' was performed using a TEM that was directly connected to a beam line allowing real-time characterization during irradiation. When dosages approached 10^12 ions/cm^2, the films experienced mixed texture formation as a result of grain boundary sliding in the film. We have found that the ordering temperature is a strong function of stoichiometry; Fe3Pt alloys order at 300C and FePt near 500C for similar dosages. Near the ordering temperature, there is a strong change in microstructure, which was altered by the irradiation treatment. The ex-situ irradiated films' order parameter, S, was not able to achieve the same high value as non-irradiated films after similar annealing treatments. The differences in ordering will be discussed in terms of the thin film morphology pre-, during-, and post- irradiation.

MP-P50

THE EFFECT OF ION IMPLANTATION UPON THE MICROSCALE DEFORMATION OF AMORPHOUS AND CRYSTALLINE MATERIALS

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Focussed Ion Beams (FIB) are being increasingly used for the fabrication of micro scale components for MEMS / NEMS applications. Extended exposure to beams of this type can however lead to the implantation of ions into, as well as phase transformations within, the fabrication material. Modifications of this type from tensile and/or compressive surfaces can have an effect upon the resulting strength of the component which cannot be currently predicted. In order to provide MEMS / NEMS devices with improved functionality, the investigation of this potential strengthening mechanism is highly desirable.

Micro sized cantilevers of dimensions » 40 x 10 x 10 µm were fabricated by Ga+ Focussed Ion Beam machining from Zirconium based amorphous materials and crystalline Gold. Many of these samples were then exposed to additional ion implantation on their tensile or compressive surfaces in order to allow comparison with control samples, having experienced no subsequent exposure. A specially developed machine for the direct evaluation of microscale mechanical properties was then used to apply bending loads to the cantilevers through the displacement of a nano-indentor. The application of these loads has allowed the deformation behaviour resulting from the varied locations and durations of ion implantation to be evaluated.

Examination of deformed samples, load-displacement data, local Gallium content and deformation modes is completed in order to evaluate the deformation mechanisms resulting from additional ion implantation, as well as their effect upon the performance of the micro scale cantilevers tested.

MP-P51

PHASE FORMATION, CORROSION BEHAVIOR AND MECHANICAL PROPERTIES OF BORON IMPLANTED NEAR-ALPHA TITANIUM ALLOY

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Ion implantation of B into Ti or Ti alloys is of interest to improve surface properties for medical applications. Here the modification of the near-alpha alloy Ti-4Al-1.5Mn by beam-line high dose ion implantation of B is studied.

B was implanted into Ti-alloy at 60 keV with doses ranging from 1x1017 cm-2 to 5x1018 cm-2. The depth profile of the implanted boron ions was measured by Auger Electron Spectroscopy (AES). The implantation results in the Gaussian boron distributions with maximum concentrations ranging from ~10 to ~85 at.%. As a function of the fluence, we follow the different phases and microstructure using Grazing Incidence X-Ray Diffraction (GIXRD). GIXRD shows that for B doses <5x1017 cm-2 (maximal B concentration ~50 at.%) only TiB phase is formed while by increasing B dose above 5x1017 cm-2 the formation of TiB2 phase is observed. Mechanical properties such as hardness and elastic modulus were studied by microindentation testing. Evolution of hardness vs. indentation depth curves have been correlated with phase formation observed by GIXRD. For the highest B dose the hardness is ~4.5 times higher than that of unimplanted Ti-4Al-1.5Mn. The hardness of the implanted layer increases with increasing B dose.

Corrosion potential at room temperature of the implanted surfaces in aerated 1 % NaCl solution is closer to the noble values in comparison to the unimplanted Ti-4Al-1.5Mn. In the passive corrosion region the B implanted surfaces are also more corrosion resistant. The improvement of the corrosion behavior is discussed on the basis of B ion implantation induced formation of titanium borides.

MP-P52

THE EFFECTS OF Si INCORPORATION ON THE THERMAL AND TRIBOLOGICAL PROPERTIES OF DLC FILMS DEPOSITED BY PBII&D WITH BIPOLAR PULSES

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The thermal degradation of diamond-like carbon (DLC) films is major problems in achieving high temperature application such as aluminium or magnesium molds. Though many studies have been carried out to reveal high temperature behaviour of DLC films, most of the studies dealt with thermal stability of DLC films in vacuum or inert gas conditions. In the present study, the thermal and mechanical properties of silicon-incorporated DLC films in ambient atmosphere were investigated. The DLC films were deposited using a bipolar plasma based ion implantation and deposition (PBII&D) technique, and the contents of Si in the films were controlled by changing the tetramethylsilane (TMS) fraction in the gaseous mixtures of toluene and TMS to 0, 20, 50, 74 and 100 vol.%, while the deposition pressure was maintained at 0.1 Pa. The deposited DLC films were annealed at 500 oC for 30 min in ambient atmosphere. From the results of Raman spectra, hardness and friction measurements, we found that the thermal and mechanical properties of the DLC films deposited with 74 and 100 vol.% of TMS were not affected almost by thermal annealing at 500 oC. The friction coefficients of the annealed DLC films decreases gradually with increasing TMS fraction in the gaseous mixtures, and exhibits a minimum value of 0.032-0.034 at 50-74 vol.% of TMS. The DLC films deposited with 100 vol.% of TMS exhibits a relatively high friction of 0.058 and fracture of the films, which is related to SiC-like characteristics of the deposited films. The friction coefficients of annealed DLC films are lower than those of as-deposited films due to graphitization of the films and transferred graphitic layers on the counter parts. The results of electron probe micro analyzer (EPMA) and x-ray photoelectron spectroscopy (XPS) measurements in the wear surfaces are also discussed.

MP-P53

PREPARATION AND PROPERTIES OF W CONTAINING DIAMOND-LIKE CARBON FILMS BY MAGNETRON PLASMA SOURCE ION IMPLANTATION

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W-containing diamond-like carbon (DLC) films were prepared on silicon wafer and glass substrates by a process combining reactive magnetron sputtering with plasma source ion implantation (PSII). W disc was used as a target for the sputter source. Ar/C2H2 mixed gas was introduced into the discharge chamber. The negative high voltage pulse (typically –10kV, s, DC -0.5kV) was applied to the substrate holder. The chemical100Hz, 100 composition of the films was determined using X-ray photoelectron spectroscopy (XPS) and Auger electron spectroscopy (AES). The surface morphology was observed by a scanning electron microscopy (SEM). The film structure was characterized by Raman spectroscopy and X-ray diffractometry. The sheet resistivity of the films was measured by a four-point probe method. Furthermore, a ball-on-disc test was employed to obtain information about the frictional properties and sliding wear resistance of the films. The structure of the films changed from metal containing DLC to composite of metal containing DLC and metal carbides with increasing in metal content in the films. Coexistence of WC and WC1-X carbides were observed for the films composed with higher amount of W than 20 at.%. The sheet resistivity of the films was decreased drastically with increasing metal content in the films. The tribological properties of the films were improved by metal elements doping. The friction coefficient of around 0.1 was derived.

MP-P54

THE INVESTIGATION CHANNEL FOR CONDENSED MATTER ION-LUMINESCENCE STUDING ON THE BASE OF URALS STATE TECHNICAL UNIVERSITY CYCLOTRON

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During 1998-2005 the optical channel on the base of classical 120-cm cyclotron in Ural States Technical University are exploited. The accelerated ions H+, He+, C3+, N3+, O4+ and Ar6+ with energies 1 MeV/nuclon allow to create in matter a “density” of cm-3 and to investigate processes ofexcitation energy from 1019 to 1021 eV energy dissipation, defect creation and accumulation, condensed matter modification by luminescent spectroscopy method.

The main interest of our experiments consists in the study of electronic excitation’s generation as well as defect creation after ion bombardment in alkali halides (CsCl, BaF2) and -Al2O3, BeAl2O4, Be2SiO4, Al2Be3Si6O18, Gd2SiO5-Ce, Y2SiO5-Ce,oxides (BeO, Lu2SiO5-Ce). The simultaneous ion’s bombardment of crystal and ion-luminescence registration give the opportunity to observe a defect’s creation process in real time. So, the ion-luminescence spectroscopy could be used as effective method of control during surface modification process using ion’s irradiation.

MP-P55

SILICON CARBIDE AND BORON CARBIDE THIN FILMS FORMED BY PLASMA IMMERSION ION IMPLANTATION OF HYDROCARBON GASES

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Mostly, in plasma immersion ion implantation plasma-forming gases of gaseous elements, such as nitrogen or oxygen, are used. They lead to formation of nitrides and oxides. Excess nitrogen or oxygen can not stay on the surface of the substrate. In case of carbon, the situation is different. The implantation process is accompanied by a deposition process.

Samples of silicon wafers, silicon films on metal, and boron films on metal were immersed in RF plasmas of hydrocarbon gases, such as methane and toluene. They were pulse-biased at different pulse durations and repetition rates at voltages up to 30 kV. After the process, the samples were analyzed by photo-electron spectrometry for their composition, and by X-ray and electron diffraction for their microstructure. The results show that under all conditions the silicon carbide and the boron carbide films were amorphous. The carbon depth profile depended on the process parameters, mainly on the number of applied pulses. The carbon implantation process was accompanied by deposition of a-C:H films. While in case of toluene, the carbon deposition process dominated, in case of methane, it was possible to implant carbon in depth. The implantation process could be enhanced by increasing the pulse repetition rate.

MP-P56

THIN FILM DEPOSITION OF MAGNESIUM BASE ALLOYS BY ION BEAM SPUTTERING

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An ion beam sputtering (IBS) system has been employed for syntheses various magnesium alloy thin films. Transition metals (TM), such as Fe, Co and Ni, were doped as the additional elements in Mg. The sector pieces of target materials were placed on the target holder. The chemical compositions of thin films were controlled by changing TM area ratio to Mg. The target was irradiated with an Argon ion beam, generated by electron cyclotron resonance (ECR). These Mg-alloy films were characterized by EDX, XRD and TEM. Various Mg-alloy films could be deposited on the Si-wafer or glass substrate by changing the target area ratios of the target plate. It was observed that the all of deposited films were constructed with nanocrystals, and they were 10~20 nm in diameter. The hydrogenation of film was examined under H2 atmosphere up to the pressure of 5 MPa. Hydride formation was recognized only in Mg-Ni alloy films after exposure to the high pressure H2.

MP-P57

STUDY OF DAMAGE DEPTH PROFILES OF ION-IRRADIATED POLYMERS

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Neutron depth profiling (NDP) was used for study of damaged areas of ion-irradiated polymers. Free radical distributions in modified layers of polymeric material were traced by Li ions. In NDP analyses Li distributions (polymer damage depth profiles) were studied using 6Li(n,alpha)T nuclear reaction. Damage depth profiles, e.g., in poly(aryl-ether-ether ketone), irradiated with 2 MeV oxygen ions in the fluence range from 3x1013 to 6x1014 ions/cm2, were found to be fractioned into two considerable parts followed basically both electronic and nuclear transfer energy distributions. The NDP method was also used for analysis of dynamic behaviour of the damaged regions in polymers. Using thermally provoked desorption, alteration of damage depth profiles were analysed up to the melting points of the polymers.

MP-P58

SURFACE CHARACTERIZATION OF β-FeSi2/ Si HETEROJUNCTIONS PREPARED BY MAGNETRON SPUTTERING

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β-FeSi2 thinfilms were grown on Si(100) and Si(111) substrate at room temperature by magnetron sputtering and β-FeSi2/Si heterojunctions were prepared. Target and substrates are cleaned by neutral molecule source (NMS). Surface properties of β-FeSi2/Si heterojunctions were characterized with Scanning Electron Microscopy (SEM) and Atomic Force Microscopy (AFM). Crystalline structures of the films were determinated by X-Ray Diffraction (XRD) analysis and Energy Dispersive Spectroscopy (EDS). β-FeSi2 found to be polycrystalline in nature and structural parameters were evaluated from the XRD pattern. Surface morphologically and crystallinity of the template layers found to be depend on the surface conditions of the substrate. AFM observations show that the surface structure of (111) oriented substrates appears to be in order than the surface structure of (100).

MP-P59

THE EFFECTS OF GRAIN BOUNDARY SCATTERING ON THE ELECTRICAL RESISTIVITY OF SINGLE-LAYERED Ag AND DOUBLE-LAYERED Ag-Cr THIN FILMS

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The electrical resistivity of polycrystalline single-layered Ag films with thicnesses of 9.0-286.0 nm, is studied as a function of the temperature in the interval between 90-300 K. Temperature-dependent resistivity measurements show that the resistivity of the Ag films increases with decreasing film thickness and is greater than that of the bulk Ag. Our analysis has shown that the grain-boundary scattering is the dominant mechanism on the excess resistivity of the Ag films and the resistivity data could be analysed in terms of the Mayadas-Shatzkes (M-S) model. Both of the theoretical and experimental values of the R reflection coefficient of the electrons are calculated to be 0.32 and 0.35 respectively, by taking average over the whole temperature and thickness range studied. R reflection parameter is also found to increase slightly with decreasing film thickness and temperature. This thickness-dependent variation of the reflection coefficient indicates that the grain boundary scattering increases with decreasing Ag film thickness.

The resistivity measurements both of the two series of Ag-Cr films prepared onto Ag substrate-films with thicknesses of 9.0 and 99.0 nm, by depositing Cr films of which have thicknesses of 11.0-27.0 nm and 26.0-56.0 nm, respectively are also performed over the 90-300 K temperature range. We have observed that the resistivities of Ag-Cr films are greater than those of the bulk Ag-Cr film and base Ag films, with equal thickness and increases with decreasing thickness of the Ag- films. According to our analysis, the observed resistivity increase in the Ag-Cr films, is caused dominantly by an increased grain boundary scattering and residual resistivity due to the deposition of the Cr impurities, with respect to those of the base Ag films. The interface scattering can not be responsible for the excess resistivity of the Ag-Cr films.Theoretical and experimental average values of the reflection coefficient is found to be 0.46 and 0.45 respectively, over the whole temperature and thickness range studied. The deposition of the Cr films onto Ag-substrate films, causes to an increase in the reflection parameter of the Ag films from 0.35 to 0.46. This result indicates that the grain boundary scattering increases due to the deposition of the Cr films, and is the dominant contribution on this observed resistivity increase. It is also found that R reflection parameter increases slightly, as the thickness of the Ag-base films decreases

MP-P60

ELECTRICAL AND MECHANICAL PROPERTIES OF SURFACE MODIFIED DLC COATINGS BY PLASMA IMMERSION ION IMPLANTATION

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Interconnect delay is a main factor of performance limiting for ULSI circuits when feature size is scaled to deep sub-micron region. A low dielectric constant material is an effective way to solve the RC time delay. The dielectric constant of SiO2 films deposited by PECVD process is about 4.1. It can't satisfy the requirement in this sub-micron age. Diamond-like carbon (DLC) films have many superior properties such as high hardness, low friction coefficient, chemical inertness, high electric resistance and high infrared transparency. However, few studies have reported the influence of surface modification on dielectric property of DLC films. This study will deposit the DLC films by the PECVD and PVD method. Using the plasma immersion ion implantation (PIII) with different voltage levels (5 kV, 25 kV and 40 kV) and ion species (Ar, N2 and C2H2) to modify the surface of the DLC films. The aim of this study is to investigate the effects of PIII on the structure and dielectric constant of the DLC films. The implanted DLC films are analyzed by SEM, AFM, ESCA, Raman spectroscopy and nano-indentation. It is found that C2H2 gas ion implantation can effectively reduce the dielectric constant of DLC films to 2.5 owing to the content of sp3 C-C bonds increase obviously.

MP-P61

RADIATION ABSORBANCE PERFORMANCE OF PB IMPLANTED FABRICS

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In this study our goal is to determine radiation absorbance of implanted fabrics. Fabric samples were Pb ion implanted at a dose of $1x10^{17}$ ions/cm^2, and 30kV extraction voltage. The implanted and unimplanted samples were irradiated with ^{210}Pb source of 5 Ci for 1200 s and during this time the spectra of the source are taken by a 3”x3” NaI(Tl) scintillation spectrometer. The first peak area of the spectra are compared in view of the net counts. It is found that the radiation absorbance properties of the Pb implanted samples are increased by 6.9% and the shielding effect of the Pb implanted samples is valid for the low energy part of the spectra and decrease highly as the energy of x and x ray increase.

MP-P62

THERMAL PROPERTIES OF C AND Cu ION IMPLANTATED PES FABRICS

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In this study, thermal properties of ion implantated and non-ion implantated modify PES are investigated with Differential Scanning Calorimetry (DSC) and Thermogravimetry (TG) systems. Using MEVVA Ion implantation System, mixed metal and gas ion beams were generated and used to form buried layers of mixed metal-gas species to modify PES fabrics. In this work C and Cu metal+Gas Hybrid ion implantation on PES fabrics were performed at an extraction voltage of 30kV and with various doses. The thermal characterization of the samples by DSC and TG were performed between the room temperature and 600 °C with the heating ramp were run at 10 °C/ min. Burning temperature, mass losses and activation energy of PES during the buring were calculated and results showed that ion implantation of PES were changed burning temperature and activation energy of samples and these results are discussed in details.

MP-P63

ANNEALING EFFECTS OF TRIBOLUMINESCENCE PRODUCTION ON IRRADIATED ZnS:Mn

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The current interest in returning to the Moon and Mars by 2030 makes cost effective and low mass health monitoring sensors essential for spacecraft development. In space, there are many surface measurements that are required to monitor the condition of the spacecraft including: surface temperature, radiation fluence, and impact. Through the use of phosphors, materials doped with trace elements that give off visible light when excited, these conditions can be monitored. Practical space-based phosphor sensors will depend heavily upon research investigating the resistance of phosphors to ionizing radiation and the ability to anneal or self-heal from damage caused by ionizing radiation. Preliminary investigations into these sensors have recently been performed using a highly triboluminescent phosphor, ZnS:Mn. This phosphor has been found to be temperature sensitive from 100 to 350 °C and responsive to both impact and radiation fluence. A 3 MeV proton fluence as small as 2.3 x 1013 mm-2 was found to statistically reduce the ZnS:Mn fluorescence decay time for temperatures less than 200 °C. Reductions in decay time appear to be proportional to increasing fluence. These results have stimulated research into the effects of thermal annealing on triboluminescence. While this testing is not all inclusive; it does illuminate the process that can be used in the selection of appropriate sensor materials.

POSTER PRESENTATIONS

NANO TECHNOLOGY

N-P1

CARBONIC FILM DEPOSITION BY POWER ION BEAMS

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Carbonic thin films can be used in microelectronics, superconductors, solar batteries, logic and memory devices for increasing the processing tool wear-resistance, as magnetic nanocomposite materials for the record and storage of information etc. The contains the research results of depositing carbonic thin films on silicon substrates using ablation plasma, generated by the influence of pulsed power ion beams (H+-60%, C+-40%, E = 500 keV, T = 100 ns, density to 10 J/cm2) on graphitic targets. The content of crystalline diamond-like carbon (sp3-bond), crystalline and amorphous phases of carbon(sp2-bond) was determined by means of laser X-ray structure analysis and laser Raman spectroscopy. It turned out that the content of crystalline diamond phase in a film deposited under various conditions does not exceed several percent. A substantial amount (30-60%) of carbon crystalline phase in the form of C60 and C70 fullerenes was discovered. It is shown that the content of fullerenes and the ratio between the amount of C60 and C70 greatly depend on the conditions of carbonic film deposition and above all on the distance from graphitic target to silicon substrate. This distance determines both film deposition rate and cooling degree of plasma generated on the substrate, which causes change in the condition of film crystallization.

N-P2

CATHODOLUMINESCENCE STUDIES OF SWIFT HEAVY ION IRRADIATED Au/SiO2/p-Si STRUCTURE

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Cathodoluminescence and RBS measurements were performed on high energy irradiated and annealed Au/SiO2/p-Si structure. The nucleation of nano-clusters can take place via the inelastic “electronic” component of the ion energy loss, when it is above a threshold value. The clusters grow under subsequent thermal annealing, following Lifshitz-Slyozov-Wagner kinetics. The presence of Au is known to enhance the Si mobility in SiO2. This helps in forming Si-nc. 5 nm Au was deposited on 500 nm SiO2 thermally grown on [100] oriented p-type Si wafer. Au/SiO2/p-Si structures were then irradiated with 350-MeV Au-ions at different fluences ranging from 1x1013 cm-2 to 4x1013 cm-2. Structures were characterized before and after vacuum annealing. The RBS spectra showed the reduction in Au thickness as the fluence increases possibly due to “inelastic sputtering”. After annealing Au atoms diffused in the near surface region of SiO2. The CL spectra consists of ultraviolet peak which is attributed to Neutral Oxygen Vacancies (NOV) and blue violet peak which is interpreted to be due to paramagnetic E’ centres as well as NOVs.Both E’ and NOVs are Oxygen Deficient Centres. The CL peak at 4.3 eV is due to singlet to singlet transition (S1 to S0). Whereas the CL peak at 2.7 eV is due to triplet to singlet transition.(T1 to S0). SWIFT heavy ion irradiations leads to formation of E’ centres. Annealing transforms E` centres into NOVs. Thus the CL spectra taken at room temperature showed an increase in the 4.3 eV peak and not much increase in the 2.7 eV peak. Now there are more NOVs and no E`. The CL spectra taken at 10 K showed similar effects. NOVs are precursor to the formation of Si-nc. Thus a synthesis route to form precursor to Si nanoclusters (Si-nc) has been found out.

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N-P3

CAVITY-ENHANCED VISIBLE LIGHT EMISSION FROM HYDROGEN ION IMPLANTED SILICON-ON-INSULATOR STRUCTURES

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During last few years, many efforts have been devoted to develop new optoelectronic materials and devices compatible with current silicon processing. A number of methods to produce Si-based nanocomposite materials light-emitted in the visible spectral region at room temperature (RT) have been suggested. Silicon-on-insulator (SOI) structures because of its cavity properties allow to modified the emission spectrum of the irradiative centers produced in the top silicon layer. We report the cavity effect on the RT green photoluminescence (PL) from the hydrogen ion implanted SOI layers. SOI-structures were implanted with H+ ions at an energy of 1017 cm-2 and subsequently annealed at the temperature 24 keV to a dose of 3 104 bar. BothTa=450-1000 °C for 5 h in an Ar ambient under pressure P = 1-1.2 the SOI structures annealed under low pressure and the respective Si samples annealed under pressure up to 12 kbar emitted one broad PL band peaked near 430 nm. The formation of the multi-peak PL spectrum in the green-yellow region was observed from the H-ion implanted SOI structures annealed under pressure of 12 kbar. The obtained effect was connected with the cavity effect between the mirrors formed by the top Si/Air and SOI/silicon dioxide interfaces. The cavity enhancement of PL emission for 40 times was found at the wavelength of 560 nm. The total effective cavity length of 870 nm was calculated from the wavelength spacing between neighboring resonant peaks. It was obtained that annealing under hydrostatic pressure higher than 6 kbar prevented the out-diffusion of hydrogen in the form of gas bubbles, which took place after annealing at T=600 °C under atmospheric conditions. Absence of micro-pores and gas bubbles in the top surface region creates the conditions to retain the mirror quality of the SOI/Air interface. The origin of the observed PL is discussed.

N-P4

ION BEAM-INDUCED FORMATION OF CARBON NANOFIBERS FROM DECACYCLENE

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Vapor deposition of decacyclene, C6(C10H6)3, in vacuum on a flat plate of any material for only a few minutes gave cylindrical whiskers of decacyclene with lengths of 1 μm-20 μm and uniform diameters of 20 nm-100 nm, which were then converted to conducting amorphous carbon fibers by irradiation with 200 keV N+ ions to a fluence of more than 10^16 ions/cm2. The whiskerswere proposed to be generated by a novel upside-down vapor-liquid-solid growth mechanism in which the whiskers were grown from the surface of supercooled liquid decacyclene toward the vacuum. The fluence for the carbonization was much lower than that for sputtering hydrogen atoms from decacyclene, which suggests that the irradiation caused the molecular dehydrogenation from decacyclene accompanying the development of graphitic structure. Application of an ion beam for the preparation of carbon nanofibers is advantageous for aligning the fibers on a desired location, since the fibers are generated only on the irradiated part at ambient temperature without catalyst.

N-P5

CHARGE ACCUMULATION IN SILICON-ON-INSULATOR STRUCTURES WITH Ge+-ION IMPLANTED BURIED SILICON DIOXIDE

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The nanocrystals synthesized in SiO2 layers have been recently proposed as suitable materials for metal-oxide-semiconductor (MOS) field-effect transistor memory structures. We report the results on the electro-physical properties of MOS transistors prepared in the top silicon film of silicon-on-insulator (SOI) structures containing Ge nanocrystals in the buried SiO2 layers. Ge nanocrystals were produced in thermally grown SiO2 films by the implantation of Ge+ ions at an 1015 cm-2 and subsequent annealing at Ta=850energy of 40 keV to dose of (5-8) oC. Then, silicon films were bonded upon the structure. Finally, Al/n+-Si/Ge-SiO2/p-Si/Al and Al/p+-Si/Ge-SiO2/p-Si/Al structures and lateral p-n-p- (n-channel) and n-p-n- (p-channel) MOS transistors were formed.

It was obtained that carrier accumulation in MOS structures depend on the direction of built-in electrical field in MOS structures. From the drain-gate current-voltage (I-V) measurements, it has been observed that in the case of n-channel transistor, positive charge related to the Si/SiO2 interface or to the charged oxide is accumulated. In the case of p-channel transistor, the obtained results pointed out the presence of negative charge related to silicon dioxide matrix. These results were in good agreement with ones observed by high-frequency capacitance-voltage (C-V) curves. Accumulation of the excess negative and positive charges in the prepared structures is connected with the presence of Ge atoms in the SiO2 films in two different positions. Positive charge is due to the Ge atoms diffused to the SiO2/Si interface. The formation of negative charge is associated with electron trapping on Ge nanocrystals synthesized in the buried dielectric.

N-P6

EFFECTS OF ION IMPLANTATION ON NANO-TOPOGRAPHYC PROPERTIES

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It is well known that surface properties at nano-scale are determinant in a number of applications, such as sensors and biomedical and optical devices. Nevertheless, the relations between surface treatment parameters and their effects on the topography at the nano-scale, the surface energy or the light reflectivity are often poorly understood.

In this study, a special glass material was selected and subjected to ion implantation treatments with different parameters and species, such as Ar, Ne, C, N, CO and NH2. The resulting surface topography at the nano-scale was studied by Atomic Force Microscopy (AFM) and the surface energy was evaluated with the contact angle method. Additionally, the modifications induced on optical properties, i.e. reflection,were evaluated with two different wave length lasers.

The results showed remarkable differences in the surface nano-topographyes and the contact angle (from 15° to 70°) that were obtained. Furthermore, the effects of the ion implantation parameters had also very significant consequences on the background noise effects, of great importance for the optical properties.

To conclude, the study have shown that ion implantation represents a powerful tool on modifying key properties on surfaces that play a very relevant role in the response elicited on living tissue and bio-molecules, which is notoriously relevant for the application as bio-sensors.

N-P7

EFFECTS OF POST IMPLANTATION ON THE LUMINESCENCE PROPERTIES OF Si NANOCRYSTALS FORMED IN SiO2 BY ION IMPLANTATION

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Si nanocrystals embedded in a SiO2 matrix by ion implantation were post implanted with 11B and 28Si ions to observe the variation in the photoluminescence (PL) properties with the structural and chemical modification introduced by ion beam irradiation. We observed that nanocrystal-related PL emission at the red/infra-red region decreases and quenches after a critical dose for both implantations. PL emission resumes upon annealing and reaches its maximum value with high enough annealing duration. It is well known that bulk Si is amorphized by Si implantation when the implantation dose exceeds certain threshold value while B ions can not amorphize the Si surface at room temperature. Thus, quenching PL signal can not be attributed to the amorphization of Si nanocrystals alone. The radiative and non-radiative defects are likely to play an important role in the observed variation of PL spectrum of Si nanocrystals. A defect-related light emission is usually observed at around 650 nm which is believed to results from the SiO2 matrix defects formed by ion implantation. This peak is observed after both Si and B post implantation and disappears upon annealing. This demonstrates the defect formation and recovery process in the SiO2 matrix by post implantation and annealing processes. The same cycle is likely to happen within the Si nanocyrstals: they are defected by the ion irradiation and these defects create non-radiative channels for transitions, quenching the light emission from nanocrystals at the red/infra-red region. Annealing the defects at high enough temperatures for sufficiently high duration leads to the recovery of the light emission.

N-P8

GERMANIUM NANOPARTICLE FORMATION IN THIN OXIDE FILM ON Si BY NEGATIVE-ION IMPLANTATION

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Nanoparticles are required to be formed with well defined size and depth in a very thin oxide film such as gate oxide layer for developing single electron devices due to Coulomb blockade phenomenon. Negative-ion implantation has an advantage of almost “charge-up free” feature even in insulators and is suitable for doping atoms to create nanoparticles with precise controls of depth and dose amount rather than conventional one. There has been interest in extending the technique to the nanoparticle formation with semiconductor elements such as germanium, silicon besides in addition to noble metals. In this paper, we describe germanium negative-ion implantation into silica glass and thin thermally grown oxide film on silicon substrate. The nanoparticles were investigated by optical absorption and cross-sectional TEM observation. Silica glass and 25-nm-thick SiO2 on Si(100) substrate were implanted with Ge negative ions at 10 keV with 5x1015 ions/cm2. Samples were annealed at various temperatures. The calculated depth profile of implanted Ge atoms by TRIM-DYN predicted to be almost Gaussian with a peak concentration of about 7 at.% at 12 nm in depth at the condition. In optical transmittance measurement, the silica glass sample showed an optical absorption band ranging from 200 nm to 275 nm with decreasing its intensity as increase in wavelength after annealing at less than 600oC and as implanted. This absorption well agreed with a high energy tail of the calculated absorption with a peak near 185 nm by surface plasmon resonance (SPR) of Ge nanoparticles in SiO2. Ge nanoparticles were considered to form in silica glasses. For the SiO2/Si sample, cross-sectional TEM images showed Ge nanoparticles with the maximum diameter of 4 nm at around 12 nm in depth and they remained there after annealing at more than 700°C.

N-P9

NANO-PHASE TRANSFORMATION IN C-ion IMPLANTED SiO2 AFTER SWIFT HEAVY ION BOMBARDMENT

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SiO2 samples were firstly implanted at room temperature with 120 keV C-ions and then irradiated with 950 MeV Pb ions or 345 MeV Xe ions, respectively. The C-ion implantation was done at the 200KV Heavy Ion Implanter (IMP, Lanzhou) and the selected dose was from 5.0x1016 to 8.6x1017 C/cm2. The Pb ion irradiation was performed at IRASME (CIRIL-GANIL, Caen) and the irradiation fluence was in the region from 5.0x1011 to 3.8x1012 Pb/cm2. The Xe ion irradiation was carried out at HIRFL (IMP, Lanzhou) and the irradiation fluence was 5.0x1011 or 1.0x1012 Xe/cm2. The samples were investigated using HREM (CARET, Sapporo), micro-Raman and micro-FTIR spectroscopies. The obtained micro-FTIR spectra showed that significant chemical bonds such as Si-C and Si(C)-O-C bonds were formed in the C doped SiO2 samples after swift heavy ion irradiations. The obtained micro-Raman spectra suggested that sp3C- and sp2C bonds and Si-related micro-structures were formed in the samples. The amount of the sp3C bonds increasing with the increase of the heavy ion irradiation fluence. Furthermore, HREM observation suggested that new nano-phase along the incident ion trajectory was formed only in the c-doped region.

All these results implied that nano-sized Si cluster and/or SiC structures may form in the C doped SiO2 samples after swift heavy ion irradiations. The possible mechanism of the formation of new chemical bonds and new nano-phase in C-doped SiO2 under swift heavy ion irradiations was discussed.

N-P10

GROWTH OF PERIODIC NANO-LAYERS OF NANO-CRYSTALS OF Au, Ag, Cu BY ION BEAM

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Multilayered thin films of SiO2/AU+ SiO2/, SiO2/Ag+ SiO2/, and SiO2/Cu+ SiO2/, were grown by deposition. We have previously shown that MeV ion Bombardment of multi-nano-layers of SiO2/AU+ SiO2/ produces Au nanocrystals in the AU+ SiO2 layers. An increased number of nano-layers followed by MeV ion bombardment produces a wide optical absorption band, of which its FWHM depends on the number of nano-layers of SiO2/AU+ SiO2/. We have successfully repeated this process for nano-layers of SiO2/Ag+ SiO2/, and SiO2/Cu+ SiO2/. In this work we used 5 MeV Si as the post deposition bombardment ion and monitored the location as well as the optical absorption's FWHM for each layered structure using Optical Absorption Photospectrometry. The concentration and location of the metal nano-crystals were measured by Rutherford Backscattering Spectrometry. We will report on the results obtained for nano-layered structures produced by post deposition bombardment of SiO2/AU+ SiO2/, SiO2/Ag+ SiO2/, and SiO2/Cu+ SiO2/ layered systems as well as the results obtained from a system containing a periodic combination of SiO2/AU+ SiO2/, SiO2/Ag+ SiO2/, and SiO2/Cu+ SiO2/.

N-P11

NANO-FABRICATION UTILIZING POINT DEFECTS INDUCED BY ION-IMPLANTATION

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Nano-technology has been developed most drastically in semiconductor device process. Particularly, for the vertical direction of the substrate, stacking of mono-atomic layers is realized by MBE (Molecular Beam Epitaxy) deposition method. Nevertheless, for patterning in the plane of the substrate, nano-fabrication is not realized due to the limit of precision in photo-lithography. In order to realize nano-fabrication in a plane, utilization of self organization and self assembly in materials is tried. For example, self-assembled quantum-dots are fabricated utilizing misfit strain in lattice mismatched hetero-epitaxial layers.

Recently, the authors found that a cellular structure is developed on the GaSb and InSb surfaces ion-implanted at a low temperature and explained that this phenomenon is due to the behavior of point defects induced by ion implantation. The incidence of energetic heavy ions into material creates a lot of vacancies and interstitials by displacing constituent atoms from crystallographic sites. In the case of the authors' work, one Sn+ ion accelerated at 60 kV creates about 3200 vacancies and the same number of interstitials in a compound semiconductor GaSb. These free point defects migrate and interact in the material, and finally most of the induced point defects disappear by recombination and migration to sinks. However, a part of induced point defects survive due to the difference in mobility between vacancies and interstitials. These survived point defects develop the cellular structure.

On the basis of this knowledge, we propose a new nano-fabrication technique using ion beam in this article. In this technique, an initial pattern is prepared artificially by FIB (Focused Ion Beam) on or under the substrate surface and the pattern is developed self-organizationally utilizing movement of point defects which are induced by ion implantation at relatively low temperatures.

N-P12

NANOWIRES WITH FREELY CONTROLLED SIZES FORMED BY SINGLE ION TRACK REACTIONS IN POLYMERS

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The chemical effects induced by the ion bombardment in polymers and organic materials have attracted great attention because the bombardment of these materials produced several physical and chemical modifications in bombardment area. The heavy ion beams can achieve ultra-high density energy deposition and penetrate up to 100 mm into a polymer. The target area is excited into a non-homogeneous field of chemical reactions, known as the chemical core of an ion track. In recent years, the effects of deposited energy density on chemical products in solid polymer have been examined. In particular, the effects of ion beam bombardment on polystyrene (PS) have been reported as a ”prototype-polymer” because not only PS predominantly undergoes crosslinking by g-ray, electron, and ion beam irradiation but also the concurring process of main-chain scission is virtually negligible. Radiation sensitivity of polymers, especially the chain scission and crosslinking G-values (number of crosslinks/100 eV of absorbed dose), have been studied for several kinds of ion and electron beam. The ion track radius is also an important parameter because the energy of the incident ion is deposited in a defined area, and the spatial distribution of energy deposited by charged ions plays a significant role in the chemical reactions. Ion irradiation at low fluence without overlapped ion tracks produces single ion events in the target materials. Focusing on the cross-linking reactions in PS induced by the ion track, the reaction along an ion projectile gives a cylinder-like nano-structure (nanowire) in thin films on a substrate. The size (length and thickness) and number density of the nano-wires can be controllable by changing the parameters of the incident ion beam and the molecular size of the target polymer, and the selective adhesion and orientation of nano-wires on a substrate is also possible.1-3) We discuss the efficiency of cross-linking reactions induced by ion beams with a variety of Linear Energy Transfer (LET) ranging from 5400 eV/nm to 13500 eV/nm in the present study. The cross-section of nano-wires based on PS was well simulated in terms of the value of LET of incident ion beams and molecular weight of the target polymer materials, suggesting the possibility of single ion track reaction as a candidate for the novel technology to give 1-D nanostructures with fairly controlled sizes in sub-nm resolutions.

N-P13

IMPROVEMENT ON THERMOELECTRIC CHARACTERISTICS OF LAYERED NANOSTRUCTURE

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We made 10-100 periodic nanolayers of electro-cooling system consist of Si 1-x Ge x / Si super lattice with Cu layer deposited on both side as metal contact. The superlattice was then bombarded by 5 MeV Si ion to form nano- cluster structure. The electronic energy deposited due to ionization by MeV Si beam in its track produced nano-scale crystals which adversely effected the thermal conductivity as well as the Seebeck coefficient of the device, thus changing the figure of merit of the system. We measured the thermoelectric efficiency of the fabricated device before and after MeV bombardment. To accomplish this we measured the cross plane thermal conductivity by 3rd harmonic method, measured cross plane Seebeck coefficient, and measured electric conductivity using Van Der Pauw method before and after 5 MeV Si Bombardment. As predicted the electronic energy deposited due to ionization by MeV Si beam in its track produces nano-scale structures which disrupt and confine phonon transmission therefore reducing thermal conductivity, increasing electron density of state so as to increase Seebeck coefficient, and electric conductivity, thus increasing figure of merit.

N-P14

ION-BEAM INDUCED NANOLAYERED NANOCRYSTALS OF BixTe3/Sb2Te3

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Nanoscale BixTe3/Sb2Te3 multilayer thin films were deposited sequentially by co-evaporation for the application of thermoelectric (TE) materials and devices. Solid antimony (III) telluride and bismuth (III) telluride were evaporated by electron beam to grow the BixTe3 and Sb2Te3 layers of the multilayer films. The grown BixTe3/Sb2Te3 multilayer thin films have a periodic structure consisting of alternating BixTe3 and Sb2Te3 layers where each layer is 5 to 10 nm thick. Rutherford backscattering spectrometry (RBS) was used to analyze the nanolayered thin films. The BixTe3/Sb2Te3 nanolayered thin films were subjected to MeV Si ion bombardments for generation of nanocrystals in the films [D. Ila et al., Nucl. Instr. and Meth. B 191, (2002) 416]. The thermal conductivity, electrical conductivity, and Seebeck coefficient of the BixTe3/Sb2Te3 nanolayered thin films were measured before and after the MeV Si ion bombardment. We used a 3_ method system to measure the thermal conductivity and a Hall measurement system to measure the electrical conductivity. A sandwich-structure thermoelectric (TE) device with a narrow platinum (Pt) strip on the top of the nanolayered thin film and another one on the bottom as a heater or temperature sensor was fabricated to measure the cross-plane Seebeck coefficient. The MeV Si ion bombardment was found to decrease the thermal conductivity of BixTe3/Sb2Te3 nanolayered thin films. Acknowledgement: Research sponsored by the Center for Irradiation of Materials, Alabama A&M University and by the AAMURI Center for Advanced Propulsion Materials under the contract number NAG8-1933 from NASA.

N-P15

OPTICAL PROPERTIES OF CU NANOPARTICLES IN SILICA

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The literature of optical effects resulting from ion beam implantation of insulators is small although it includes examples as diverse as the formation of optical waveguides, waveguides lasers, guided four-wave mixing to production of car mirrors and sun glasses. The presence of copper nanoparticles in silica modifies their luminescence and the changes in spectra are influence by variations in nanoparticle size distributions. For this study, we have prepared Cu nanoparticle imbedded in silica and studied their optical and luminescence properties. The ion implantation was made with Cu at a beam energy of 50keV and at the dose of 1x1016 .ons/cm2. Thermal treatments have been C in airmade using standard tube furnaces with temperatures from 100 to 1200 for 1 h at each temperature. Since the problem is concerned with colloid or cluster dissociation and formation the speed of cooling may be relevant as dissociated clusters might reform during the cooling cycle. The cooling period was, therefore, relatively fast and ranged from 1 min. to 10 min. depending on the maximum temperature. The example of ion implanted silica emphasize signals are altered by thermal treatments in furnace, and it is noted that such treatments influence the sizes of the nanoparticles.

N-P16

ION-BEAM INDUCED NANOLAYERED NANOCRYSTALS OF BixTe3/Sb2Te3

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Nanoscale BixTe3/Sb2Te3 multilayer thin films were deposited sequentially by co-evaporation for the application of thermoelectric (TE) materials and devices. Solid antimony (III) telluride and bismuth (III) telluride were evaporated by electron beam to grow the BixTe3 and Sb2Te3 layers of the multilayer films. The grown BixTe3/Sb2Te3 multilayer thin films have a periodic structure consisting of alternating BixTe3 and Sb2Te3 layers where each layer is 5 to 10 nm thick. Rutherford backscattering spectrometry (RBS) was used to analyze the nanolayered thin films. The BixTe3/Sb2Te3 nanolayered thin films were subjected to MeV Si ion bombardments for generation of nanocrystals in the films [D. Ila et al., Nucl. Instr. and Meth. B 191, (2002) 416]. The thermal conductivity, electrical conductivity, and Seebeck coefficient of the BixTe3/Sb2Te3 nanolayered thin films were measured before and after the MeV Si ion bombardment. We used a 3ω method system to measure the thermal conductivity and a Hall measurement system to measure the electrical conductivity. A sandwich-structure thermoelectric (TE) device with a narrow platinum (Pt) strip on the top of the nanolayered thin film and another one on the bottom as a heater or temperature sensor was fabricated to measure the cross-plane Seebeck coefficient. The MeV Si ion bombardment was found to decrease the thermal conductivity of BixTe3/Sb2Te3 nanolayered thin films.

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N-P17

OPTICAL PROPERTIES OF TB NANOPARTICLES IN ZnO

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Ion implantation plays an important role in semiconductor physics and technology. It permits the introduction of dopants or luminescent ions into many different classes of materials. ZnO is a transparent II-VI compound semiconductor with a direct band gap of 3.37 eV at room temperature and a wurtzite crystal structure. For this study, we have prepared Tb+ nanocrystals imbedded in ZnO and studied their optical and luminescence properties. Therefore ZnO samples were implanted with Tb ions at room temperature at an energy of 400 keV. The Tb fluence was high, it varied from 1x1016 to 2x1017 ions/cm2, in order to ensure a sufficient concentration for the formation of nanoparticles in the ZnO crystal surface layer. Due to beam heating, the surface temperature was increased during the implantation. The ZnO samples were cut to 10x5x0,4 mm3 by MATECK (Germany).The implants were made with a high ion beam current density and the Tb ions were implanted into the (0001) oxygen-face of single crystals. The implant layer shows amorphised behaviour as monitored by the RBS/Channeling analysis. After implantation and after post-irradiation annealing, optical absorption was measured in a UV-VIS-NIR range and luminescence spectra were recorded at room temperature.The emission spectra of the sample are composed of several bands origanating from the transition from 5D3 to 7Fj and 5D4 to 7Fj (j=3-6). Strong green luminescence emission appears at 543 nm. For all implanted samples carrier relaxation from the excited states of ZnO single crystal to rare earth dopants is disclosed by the fact that the emission intensity of Tb3+ centers increases with increased Tb dose at the expense of the emission from surface defect states in ZnO matrix. It is concluded that ZnO is a useful and interesting host for dispersed Tb nanoparticles, also because the optical features may be compatible with the semiconducting properties of ZnO.

N-P18

PLATINUM NANO-PARTICLE CATALYST SUPPORT TECHNIQUEBY ION IMPLANTATION AND SURFACE ETCHING METHOD

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The Ion implantation and surface etching (IISE) method is a support technique of catalyst for micro total analysis systems (u-TAS) that were reported the case of the gold nano-particle is oxidized catalyst. In this report, we apply the IISE to fabricate platinum nano-particles. Pt ions have 3.1 MeV energy were implanted into (100) single crystal silicon substrate was cooled by liquid-nitrogen. The Pt ions were distributed 1.5 um depth by TRIM_f98 simulation. 7.5 N KOH solution etched the silicon surface at 335 K after Pt implanted. These conditions were same as gold case. The several ten nanometers Pt particles were observed on the etched surface by scanning electron microscope (SEM). The result compares with gold case; it is the smaller amount but uniform size particles. It seems that the agglomeration of platinum during etching process was different from gold. We examined the conditions of IISE such as ion dose, etch time and temperature, to the preparation.

N-P19

TEMPERATURE DEPENDENCE AND ANNEALING EFFECTS OF ABSORPTION EDGES FOR SELENIUM QUANTUM DOTS FORMED BY ION IMPLANTATION IN SILICA GLASS

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We have fabricated Se nanoparticles in silica substrates by ion implantation followed by thermal annealing up to 1000oC. The Se nanoparticle formation was analyzed by optical absorption spectroscopy with Tauc law. The sample with the highest dose (1 x 1017 ions/cm2) showed the nanoparticle formation during the ion implantation, while the lower dose samples (1 and 3 x 1016 ions/cm2) required thermal treatment to obtain nano-sized particles. The Se nanoparticles in silica were found to be amorphous. After thermal annealing, the particle sizes became larger than the exciton Bohr radius for bulk Se. Thus, the absorption edges for different doses approached the value of bulk after thermal annealing. The temperature dependent absorption spectra were also measured for this system in a temperature range from 15 to 300 K.

N-P20

POST IMPLANTATION METHOD TO MODIFY THE SIZE AND SHAPE OF NANOPARTICLES MADE BY ION IMPLANTATION

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Ion implantation and thermal annealing method is a simple and versatile method of synthesizing nanoparticles in various host materials. But this method has difficulties in synthesizing small nanoparticles with high density and acquiring uniform size distribution. To overcome this disadvantage, post implantation method was adopted instead of thermal annealing.

236 keV Au ions were implanted on silica glass with high doses to supersaturate the Au ions, and then 3 MeV Si ions were post-implanted to induce the nucleation of nano-clusters. The results of cross-section HRTEM and optical absorption photospectrometry of these samples showed that Au nanoparticles were synthesized and the average size and the size distribution of Au nanoparticles were reduced in comparison with the thermal annealing method.

In the case of 80 keV Ag implanted silica glass with high dose, nanoparticles of 20~50 nm size were formed without any treatment. With the post-implantation of 3 MeV Si ions on this sample, some changes of size and shape were observed by cross-section HRTEM.

We showed the possibility of the size and shape modification by post-implantation method this study.

N-P21

Si IMPLANTATION IN SiO2: STRUCTURE OF Si NANOCRYSTALS AND COMPOSITION OF SiO2 LAYER

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Silicon is known to be a poor light emitter. However, once in nanometer scale, it can emit a strong visible and infrared light after excitation. Si nanocrystals with a diameter of around 3 nm are produced by implantation of Si ions into amorphous SiO2 followed by thermal annealing. These nanocrystals could allow the use of Si for making luminescent devices compatible with optoelectronic integrated circuits. Si ions have been implanted with an energy of 100 keV to fluences ranging from 2E16 to 3E17 Si/cm3. The effect of Si implantation fluence on the microstructure of the Si-nc and the SiO2 matrix has been examined using TEM, XRD and XPS. The size, spatial distribution and concentration of the Si-nc have been investigated by TEM and compared to the depth distribution of Si implanted ions. A crystalline structure of the nanocrystals has been observed for local Si concentration in excess of about 3E21 Si/cm3. Moreover, defects (twins, SF's) and faceting have been observed by HRTEM in nanocrystals larger than 6 nm. These large Si-nc are produced with a local Si concentration in excess of about 2.4E22 Si/cm3. XPS has revealed the presence of an oxygen poor surface layer in the SiO2. This effect of oxygen depletion is also visible in TEM over a layer of about 25 nm.

N-P22

SiO2:nc-Si NANOCOMPOSITES ION-DOPED WITH P, N, B IMPURITIES: MODIFICATION OF THE PHOTOLUMINESCENCE PROPERTIES

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Improvement of the luminescence efficiency of SiO2:nc-Si system is an important task for application of this system in optoelectronics. Ion implantation can be successfully used not only for synthesis of light-emitting Si nanocrystals, but for further modification of their properties. For example, phosphorus ion doping has been previously shown to improve the intensity of the red / near-infrared emission of the SiO2:nc-Si layers. In the present report we generalize the experimental data on the photoluminescence (PL) of the ion-doped SiO2:nc-Si nanocomposites for various conditions of the system synthesis and doping. Silicon nanocrystals of 3-5 nm in size were formed by Si ion implantation into thermal SiO2 films and postannealing (1000 or 1100 °C). The P, N, B ions were implanted with a wide range of doses into either pre-synthesized SiO2:nc-Si layers or Si-implanted SiO2 films. The impurity implantation was followed by annealing at 1000°C. PL was detected in the range of 350-1000 nm at room temperature. The impurity dose evolution of the spectra and intensities of the PL has been studied. It is established that, independently of ion kind, implantation of P, N, B ions completely quenches the PL related to both Si nanocrystals (peak at 750 nm) and initial oxygen-deficient centers (peak at 420 nm) due to introduction of nonradiative defects. For the highest doses, additional defect-related PL peaks at 525 and 650 nm are observed. Subsequent annealing, for certain impurity concentrations, leads to the recovery or significant enhancement of PL. The second effect takes place in the case of phosphorus doping. Several mechanisms such as defect transformation, impurity-stimulated nucleation and growth of nanocrystals, and electronic processes in Si quantum dots are discussed.

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N-P23

THE FORMATION OF NANOSTRUCTURES IN METALS BY THE LOW-ENERGY ION IRRADIATION

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The goal of this paper is to show the results of experimental studies of formation of nanoclusters in metals by the low-energy ion irradiation and computer simulation of nonlinear effects on an atomic scale.

The subjects of the investigation were polycrystalline armco-iron and instrumental steels. All samples were irradiated by low-energy ions of residual gas in discharge plasma. The fine dislocation structure of the samples was being studied using the transmission electron microscopic method. The electrical resistance and microhardness measurements were made before and after the irradiation. We showed that the process of low-energy influence led to the formation of a complex multilayer structure in the near-surface area. There were the layers with the amorphous structure, a microcrystalline and nanocrystalline structure. The low-energy ion irradiation led to a change of physical and mechanical properties of irradiated materials. It is necessary to emphasize that samples behavior depends on the time elapsed after stopping irradiation.

These modifications in materials could be understood within the conception of active self-organizing processes in crystal lattices. We showed by a computer simulation that nonlinear oscillations were excited in the system of coupled atomic oscillators in crystal lattices, which resulted in the formation of nanoclusters.

N-P24

ZnO NANOCLUSTERS FORMATION IN SiO2 BY LOW ENERGY ION IMPLANTATION

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Zinc oxide is one of the most interesting wide band-gap semiconductors, due to its 3.3eV direct band-gap and the large exciton energy of 60 meV at 300K. It is easily n-type doped while p-type doping is much more difficult, as in equivalent large band-gap semiconductors like GaN. This is due to the low dielectric constant and contracted impurity orbitals. Because of its optical, electrical, and piezoelectric properties, ZnO is involved in many applications such as: UV light emitters, UV lasers, non linear optics, transparent electronics, solar cells, MEMS devices, gas sensors, field emission, spintronics. Due to quantum confinement effects, the ability to fabricate ZnO at controlled nanocluster sizes enhanced the potential for new applications in ultraviolet luminescent devices particularly when the nanostructures are localized in very high electric field.

Variable size ZnO nanostructures embedded in silica substrate were obtained by low energy ion implantation. The samples obtained by both Zn implantation and Zn and O coimplantation sequences were subject to post annealing in inert and oxidizing atmosphere. The size, distribution and optical properties of the nanoclusters were obtained by optical spectroscopy measurements.

POSTER PRESENTATIONS

MODELING, SIMULATIONS AND THEORY

MS-P1

THE STUDY OF THE INFLUENCE OF THE PARAMETERS OF ION IRRADIATION ON THE CHARACTERISTICS OF NITRIDE IT IS LAYER IN AUSTENITE STEELS BY THE METHODS OF THE COMPUTER SIMULATION

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The technology of ion nitriding is used for an improvement the surface properties of construction materials. With the help of nitriding it possible to increase the hardness of surface and wear resistance. In contrast to the traditional methods of nitration the use of high-dose low-energy nitriding makes it possible to obtain thick nitride layers at moderate temperatures, which makes it possible to avoid phase transitions in the workable material. Despite numerous investigations, the mechanisms of ion irradiation are not well understood. As the result - there is no adequate model, explaining the special features in the propagation of nitrogen into the depths of the material with the high-dose low-energy treatment of alloys at present.

The computer model of the formation of nitrided layers in the alloys during the high-dose ion irradiation is proposed in present work. The processes of diffusion, surface sputtering, formation and the disintegration of doped complexes are considered in current model. The calculations of nitrogen concentration in austenite steels for different current densities and ion energies were carried out. The results of computer simulation coincide well with existing experimental data. The results suggest that there are optimum values of ion current and energy, making it possible to carry out most effectively the process of alloy’s nitriding.

MS-P2

ABOUT PRECIPITATION OF CARBON IONS ON BOUNDARY BETWEEN SILICON OXIDE AND SILICON DURING IMPLANTATION

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For an explanation of effect carbon ions precipitation to boundary between silicon oxide and silicon [1] we modify model [2,3].

na(x1+- na nv kcap + nc nd kact-x2 ∂2na /∂ t = Da ∂na /∂–1capτx0)/
RpΔ∏ 2√Rp2) / Δx + x0)2 / 2(Rp - 2cap + j0 exp(τna(x2 + x0)/-(1)
ncndkact (2)t=nanvkcap∂nc(x,t)/∂
x+x0) (3)(Rp⊗dσnvndkann+j0N-ncndkact-x2∂2nd/∂t=Ddv∂nd/∂
x+x0) (4)(Rp⊗dσnvndkann+j0N-ncndkact-x2∂2nv/∂t=Ddv∂nv/∂
t =∂n1(t)/∂ 1cap (5)τna(x1 + x0)/
2cap (6)τt = na(x2 + x0)/∂n2(t)/∂

vbt,x0= Rp=658 A,Δ16 Òm2, Rp=2711 A, d=3.52*10σ3, N=5.04*1022 cm x1=1460 A, x2=3060 A/cm2. The values of free parameters of model (Da, Ddv,μA, j0=1.5 2cap=192.94 s) wereτ1cap=356.63 s, τ23 cm3/s, kact, kann, kcap=34.848*10 selected by a method of the least squares so that in the best way to correspond to experimental structures. We suppose two stage precipitation of carbon to the oxygen centres. At the first stage the active carbon ion is trapped by vacancy near boundary. At the second stage there is a precipitate formation with cap. Assumingprobability Ppre. Then we have equation kcap*Npre*Ppre=1/ 1/Ppre=3641 and 3 we receive the consent inoxi/2.33) *1022 cmρNpre=4.677*(parameters at density internal SIMOX oxide equal to 2.6977 g/cm3 and density of external thermal oxide equal to 1.4595 g/cm3.

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MS-P3

EFFECT OF TARGET BIAS ON MAGNETIC FIELD ENHANCED PLASMA IMMERSION ION IMPLANTATION

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Recent studies have demonstrated that sheath dynamics in plasma immersion ion implantation PIII can be significantly affected by an external magnetic field, especially in the case when the magnetic field is parallel to the workpiece surface or intersects it at small angles. So, one way to enhance implantation current may be the use of magnetic field. In this work we describe two-dimensional numerical simulations of magnetic field enhanced plasma immersion implantation system for different bias voltages. We simulate a system with crossed ExB fields similar to that used in cylindrical magnetrons. Negative bias voltage is applied to a cylindrical target located on the axis of a grounded cylindrical vacuum chamber. An axial magnetic field is created by a solenoid installed inside the cylindrical target. This way the main component of the magnetic field is parallel to the target surface above the solenoid and intersects the cylindrical workpiece at edges. The computer code employs a particle-in-cell algorithm for simulating the movement of charged particles in the electromagnetic field and a Monte Carlo method for collision of ions, electrons and neutrals in the plasma. Secondary electron emission from the target subjected to ion bombardment is also included. It is found that a high density plasma region is formed around the cylindrical target due to the intense background gas ionization by the magnetized electrons drifting in the crossed ExB fields. An increase of implantation current density in front of high density plasma region is observed. Effect of the target bias on the sheath dynamics and implantation current of magnetic field enhanced PIII is discussed.

MS-P4

INFLUENCES OF LOW ENERGY ATOMS IMPACTS ON THE SURFACE AND FILM GROWTH BY COMPUTER SIMULATION

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It is very important to increase the deposition energy of atoms and/or ions in the thin film synthesis because the increase of deposition energy can considerably improve the properties of thin films synthesized. In the past years, some effective techniques based on energetic deposition, such as ion beam assisted deposition (IBAD), ion beam mixing, etc. have been invented and the mechanism of energetic deposition bas been widely investigated theoretically and experimentally. The atomistic process of energetic deposition, however, is still not clear. In the present paper, the influences of low energy atoms impacts on the surfaces have been studied by molecular dynamics simulation with interaction potential with Embedded Atom Method (EAM). A kinetic Monte Carlo simulation method has been developed to simulate the energetic deposition process and film growth in more realistic space scale and time scale. Adatom yields, sputtering yields, vacancy yields and the influences of incident energy on the nucleation and the evolution of surface morphology are studied. The role of energetic atom in the film growth and atomistic mechanisms of film growth in energetic deposition are discussed.

MS-P5

ION BEAM ASSISTED COATING OF 3D-OBJECTS: CYLINDERS, SPHERES, WEDGES

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Re–sputtering of simultaneously deposited material is a side–effect of ion bombardment during film growth of ion beam assisted deposition. This mostly undesirable effect leads to a reduction in the film growth rate. Because of this dynamic ion etching the actually deposited mass does not correspond to the evaporated one as determined for example with a quartz crystal. The loss has to be accounted for by an increase in process time when a particular film thickness is required. The situation may become critical when the ion impact angle deviates from the surface normal, i.e. when either a plane substrate has to be tilted or when 3D–objects like cylinders, spheres or wedges have to be coated. In the present study the deviations of film thickness are discussed for off–normal ion incidence IBAD. Mathematical expressions are given which describe the dependence of the sputtering yield on the impact angle by fitting to experimentally obtained data. They are applied to calculate film thickness deviations in dependence on the particle impact angles. As an example for coating components with curved surfaces, coating of cylinders, spheres and wedges are discussed.

MS-P6

FORMATION OF SHALLOW JUNCTION IN SUBMICRON TECHNOLOGY OF MOS DEVICES

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Sheet resistant of the shallow junctions formed by spin on glass diffusion into monosilicon of ultra large scale integration (ULSI) technology were studied using ATHENA and ATLAS's simulator. The junction formation of Metal-Oxide-Semiconductor Field-Emission-Transistor (MOSFET) elevated source/drain structures by difussion from polycrystalline and amorphous silicon layers doped by diffusion from spin on dopants. The diffusion technique, influence of the microstructure of a deposited layers, polysilicon, or amorphous silicon to the uniformity of the junction underneath mono-silicon substrate were also studied. Crititical thermal budgets required for good shallow P+N, and N+P junction were traced using furnace annealing and rapid thermal annealing of spin on dopant at different temperatures and times. Junction with depth of less than 50nm were successfully achieved by diffusion spin on dopant technique hence the sheet resistant values were 200 ohm/sq, 44 ohm/sq, 31 ohm/sq and 18 ohm/sq for temperatures of 850°C, 900°C, 950vC and 1000°C respectively.

MS-P7

PHYSICAL MECHANISMS OF FORMING THE MICROSTRUCTURE OF NIOBIUM FILMS UNDER LOW TEMPERATURE ION-ATOMIC DEPOSITION

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The paper is aimed at the experimental study and computer simulation of the radiation effect on the microstructure of niobium films being irradiated with their own ions during low temperature deposition.

Films were formed by the thermo-ionic deposition. Metal vapors were obtained by electron-beam heating of the material. The ion current density was controlled by the degree of vapor ionization in the low-voltage discharge of direct current. The ion energy was varied by applying the potential onto the substrate and was from 5 to 500 eV. The structure of niobium films was studied as a function of the degree of ionization of the flow deposited and of the ion energy. The X-ray diffaction methods were used to determine the changes in the mean-size block structure and microstrains of the crystalline lattice depending on the ion flow parameters. The measurements of the film density change with ion energy changing were carried out. The microstructure of films was examinated using the electron microscopy.

The computer simulation of the ion-atomic deposition of niobium films was performed under conditions corresponding to the experimentally observed ones. It is shown that the ion action exerts an influence on the growing film relief. An effect of ion densification is studied. The mechanisms of atomic ordering under ion irradiation are studied. It is shown that the radiation-induced defects have an influence on the process of film growth. The relation between the change in density and the size of the block film structure under ion densification has been revealed.

The physical mechanisms of ion-assisted irradiation effect on the film properties are discussed.

MS-P8

PIC SIMULATION OF PLASMA BEHAVIOR AROUND PLURAL TARGETS TO WHICH POSITIVE, NEGATIVE, OR NEGATIVE AFTER POSITIVE PULSE VOLTAGE IS APPLIED

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The plasma behavior around plural numbers of targets has been simulated under the condition of plasma immersed ion implantation (PIII) using the particle-in-cell simulation software

MS-P9

POINT DEFECTS DYNAMICS IN KRYPTON IMPLANTED TITANIUM: A COMPUTER INVESTIGATION

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The interaction of rare gas atoms with solid is an important process in nuclear reactor technololgy and material modification process such as ion-beam mixing.Krypron and Xenon are produced in uranium by fission reactions and are implanted in the metallic fuel elements.The properties of their host are affected by the presence of these atoms in their matrix,since they are the primary source of point defects (vacancies, interstitials and their clusters).Using pair potentials,a molecular dynamics simulation of the dynamics of the point defects associated with krypton implantated in titanium is presented.

MS-P10

SCATTERING OF LOW ENERGY IONS FROM A SOLID SURFACE: TRANSPORT THEORY CALCULATION OF THE REFLECTION COEFICIENT

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Scattering of low energy ions (a few keV) from a solid surface is studied. Numerical simulation contributes significantly in the understanding of physical processes encountered in ion-surface interaction. In this paper, a model based on the transport theory is used to calculate reflection coefficient of the scattered particles in the incidence plane. This method is valuable for low incidence and scattering angles. Multiple scattering of incident ions is included and the binary-collision approximation is assumed. Angular distributions of the reflection coefficient are then obtained for different cases. Comparison of these results with Monte Carlo simulation (TRIM) and other results is done and a discussion is given.

MS-P11

SIMULATION STUDIES OF RADIATION INDUCED SEGREGATION IN 316SS

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316SS is a candidate material for beam window and spallation neutron source of the Accelerator Driven Subcritical System (ADSS), which is proposed for radioactive waste transmutation and as a possible future energy source. One of the problems in 316SS is radiation-induced segregation (RIS). RIS near grain boundaries affects significantly the physical, chemical, and mechanical properties of austenitic stainless steels. Pervious studies show that RIS leads directly to changes in swelling and mechanical properties in structural materials. Radiation-induced redistribution of solute atoms under irradiation has been observed in the past. As a result of this, a large change in composition of alloy has been observed at the defect sinks. In the present work, theoretical model of Wiedersich is used to understand the mechanism of radiation induced atomic transport. Coupled continuity equation for solute atom, vacancy and interstitial in 316SS are numerically solved to obtain best fits to the experimental depth profile by varying the diffusivity coefficients. Numerical values of coefficients, obtained by simulation, are used to understand the microscopic mechanism of atomic transport. This model simulation explains the experimentally observed phenomenon of Cr-depletion and Ni-enrichment in irradiated 316SS. The values of the diffusivity coefficients thus obtained suggest that Cr atoms move away from the grain boundary by diffusing via vacancies, whereas Ni atoms enrich at the grain boundary by diffusing via interstitials.

MS-P12

STUDY OF SPUTTERING PROCESS WITH LARGE GAS CLUSTER ION IMPACT

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Gas cluster ion beam (GCIB) is one of the promising techniques for nano-scale surface modification processes. The unique point of GCIB process is that very large cluster with the size of several thousands is irradiated on target materials. Then, large number of cluster atoms are radiated on very narrow and shallow surface region. This high-density particle and energy irradiation are expected to cause large motion and enhancement of chemical reactivity of atoms. High yield sputtering is one of characteristic effects of GCIB process and is considered due to above unique collisional process. However, the mechanism of sputtering by large cluster impact is still unknown. In this paper, the mechanism of sputtering process by energetic large cluster ion impact was studied using molecular dynamics (MD) simulations. The MD simulations of Ar1000 accelerated with totally 50keV impacting of Si(100) target was performed with 50 trials at different impact points in order to improve statistical reliance. From MD simulations, about 20 Si atoms/impact of sputtering yield was obtained. Not only Si monomer but also Si clusters such like Si2, Si3, etc. were found in sputtered particles, and yields of molecules were Si1 : Si2 : Si3 = 12 : 2.5 : 0.5 (unit in molecule count). Kinetic energy distribution analysis showed E-2 dependency. This result suggests that sputtered particles with high-energy cluster impact could be generated by cascade collision mechanism rather than thermal evaporation process, which was observed with the MD simulations of sputtering by low-energy fluorine reactive cluster ions.

In addition to these MD results, experiments of sputtering with GCIB were also performed and sputtering mechanism by large gas cluster ion will be discussed.

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MS-P13

FRACTAL ANALYSIS OF SELF-ORGANIZED STRUCTURES IN IMPLANTED SEMICONDUCTORS

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The processes of self-organization in single crystal semiconductors under ion bombardment is the item of increasing interest at the last time. These processes can lead or for recentralization after amorphization in continues process of ion bombardment or to creation of ordered three dimensional (3D) systems of clusters which can present association of structural defects and impurity atoms. In some cases such clusters can demonstrate quantum dimensional properties by electrophysical, optical,luminestcent and other parameters.

The problem of analysis order degree of elements in such a system is the self consistent task. We solve this problem by means of fractal analysis in combination with other analytical methods (Fourier transform) and with using of experimental methods of investigation (AFM-microscopy, Auger-spectrometry with high space resolution, Raman scattering of light, low temperature photoluminescence) for comparison. It was shown that fractal dimension serve as quantitative parameter characterizing the degree of order for nanodimensional elements. In some cases this parameter will discover the ordering even if when other methods can not give the possibility disclose the ordering and make a quantitative estimation of its degree.

The computer simulation of systems consisting of different structure elements with different level of ordering was carried out. This procedure gave the possibility to estimate of ordering level quantitatively. In some cases the dependence of this ordering on fractal dimension demonstrate non monotonic (in separate cases - oscillating) character. For system with the dense space structure of clusters the dependence of fractal dimension on degree of organization exist as quasilinear and it’s angle coefficient increase with growing of cluster density.

MS-P14

SCIENTIFIC VISUALIZATION: ANALYSIS, EXPLORATION AND PRESENTATION OF TRI-AXIAL TECHNIQUE ψ STRESS STATES OF KR-IMPLANTED TITANIUM DETERMINED BY X-RAY SiN2

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This is an auxiliary research carried out in parallel to NEAR SURFACE STRESS DETERMINATION IN Kr-IMPLANTED POLYCRYSTALLINE TITANIUM BY X-RAY METHOD [1]. The stress states encountered in similar research is oftenSIN2 complicated and analysis and hence presentation thereof is partial due to the unavailability of computational and visual tools. Stress states determined using X-ray/neutron diffraction involves the gradient determination of SIN2 curves. This process, inter alia, contracts the stress to a scalar loosing the directionality and multivariate nature of the observed stress state. Also, SIN2 curves are often imperfectly assumed to be linear curves by ignoring curvatures encountered. However, textured samples are known to result in curvature and split in the curve. In this paper we present a novel approach to the stress state analyses obtained from such curves. Stress in the material under investigation is considered as tensorial quantities from initial measurement phase to the final presentation. Furthermore other features such as curvature, splitting and oscillatory behaviours of the curves are discussed and addressed by means of visual techniques. This discussion inherently brings in the depth resolution of such stresses calculated in implanted samples, which are in turn explained by means of clear visual explanations. Various visual tools, which are not in common use in the field, are critically compared and the exponential benefits are discussed. Scientific Visualization, if properly applied, is essential to the stress measurements and analysis due to the complexity of underlying physical phenomena. Best practices and guidelines are provided in the case of Kr-implanted Titanium sample.

[1] S. Nsengiyumva, A.T. Raji, S.R. Naidoo, T.E. Derry, R. Bucher, C. M. Comrie, D. T. Britton and M. Hãärting, this Conference.

MS-P15

SPUTTERING OF Au AND Bi THIN FILMS UNDER (20 - 160) keV Ar+ IONS BOMBARDMENT

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The sputtering yields produced by bombarding Au and Bi metal foils with swift Ar+ ions at normal incidence have been measured over the bombarding energy range (20 - 160) keV. Upon implantation at a fixed ion fluences of 1.5 1016 ions/cm2 and 1.5 1015 ions/cm2, respectively, the Au and Bi samples were analyzed by using the Rutherford backscattering (RBS) technique in view to determine the amount of atoms sputtered from the samples surface. The extracted sputtering yield data have been compared to values derived from Sigmund's linear cascades theory, by Yamamura's semi-empirical formula and by Monte Carlo computer simulation using the TRIM code. A fairly good agreement was observed between the measured sputtering yields and those calculated following the first two models. While the values generated from TRIM code simulation for the Au target were found also consistent with measured yields data, those for Bi lied a factor of ~ 2 below the same predictions. The influence of the ion fluence on the measured sputtering yield values have been also investigated in this study.

POSTER PRESENTATIONS

BIOLOGICAL EFFECTS

BE-P1

THE INFLUENCE OF LOW-ENERGY ION IRRADIATION IN GLOW DISCHARGE PLASMA ON BIOLOGICAL OBJECTS

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The main purpose of the experiment is to investigate the reactions of the influence of low-energy irradiation in glow-discharge plasma (GDP) on biological objects. S. cerevisiae yeast, cereals seeds and human blood leukocytes were chosen as the objects under investigation. Special attention was given to a comparative analysis of the GDP influence on leukocytes of healthy people and people with different acute and chronic inflammatory diseases as well as people suffering from cancer. All the objects were placed into a specially constructed plasmagenerator and were exposed to the irradiation by ions of residual gases of vacuum in glow-discharge plasma. the ion energy depended on the voltage in the plasmatron and did not exceed 0.8-2.5 keV. Irradiated dose was 2•1017 ion•cm-2.•The irradiation time lasted for 1-15 min. Seeds and yeast were irradiated in GDP both open and in glass, plastic and quartz test tubes, in the dry and aqueous medium. Leukocytes were irradiated in blood composition in the same kinds of test tubes. Comparative investigation of experimental objects was made visually by means of digital microscopy analysis and fluorescence microspectral analysis of cells using fluorescence probes.

The experimental data obtained indicate the availability of the reaction of biological objects to the GDP irradiation or to water irradiated by the GDP at the same conditions.Irradiated seeds had 3-4 fold speed excess of germination. Irradiated yeast had more viability and metabolic activity. Leukocytes of chronic patients were also stimulated by the GDP and leukocytes of patients with acute diseases were inversely depressed. After the GDP irradiation all immunocytes populations of cancer patients had an increase in total reactivity on different influences including cancer-embryonal antigen. The mechanism of this effect has been studied little so far but the results obtained show the possibility of practical application of biotropic GDP influence for more successful realization of genetic resource of any organism.

BE-P2

CELL ADHESION TO NITROGEN-DOPED DLC FABRICATED BY PLASMA-BASED ION IMPLANTATION AND DEPOSITION METHOD USING TOLUENE GAS

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Diamond-like carbon (DLC) has excellent chemical stability, mechanical, tribological and biological properties. Several techniques have been proposed for DLC fabrication. Plasma-based ion implantation and deposition (PBIID) method has several advantages such as little limitation in sample shape in comparision with conventional PVD or CVD methods. In this study, we investigated cell adhesion to nitrogen-doped DLCs fabricated on silicon wafer and silica-glass substrates by PBIID method using toluene gas.

In the experiment, a pulsed RF and a negative DC high voltage were alternately applied to an electrically floated sample holder in vacuum. The sample itself worked as an antenna of RF power with 500W and the frequency of 13.56MHz. The width of pulsed RF was 30msec. The negative high voltage and the HV pulse width were –5kV and 5msec respectively, and the pulse repetition rate was 2kHz. Nitrogen gas was introduced between 0 and 20 sccm through a mass flow controller and toluene gas was supplied directly from liquid without flow control at 1x10-2 Torr. Raman spectroscopy and FT-IR-ATR measurements were performed to investigate the structure of the films. The hydrophilicity of the surface was measured by the water contact angle. Cell adhesion tests were performed using Fibroblast (L929).

The deposition rate calculated from the film thickness was 613nm/h with nitrogen flow ratio at 1sccm and decreased to 286nm/h with increasing nitrogen flow ratio at 20 sccm. The Raman spectra did not change with nitrogen flow ratio, and the ratio of the intensity of D peak to G peak (ID/IG) was about 1.0. On the other hand, FT-IR-ATR spectra showed that CN single and triple bonds increase with increasing nitrogen flow ratio. The water contact angle decreased slightly with increasing nitrogen flow ratio. This means that the surface becomes hydrophilic. The cell adhesion percentages were increased with the nitrogen concentration.

BE-P3

DAMAGE EFFECTS OF MEV PROTON BOMBARDMENT IN PVDC POLYMERIC FILM

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The polymer PVDC (Polyvinyllidenechloride) is normally used as food packaging and can be combined with other plastics to improve barrier performance to oxygen, water vapour and other gases, preserving the food quality. Food irradiation is one of food safety technology that can decay caused by microorganisms. However, when a polymer is exposed to the ionizing radiation, and normally food is irradiated in its packag, the material can suffer damage according to the type, energy and intensity of the radiation what could compromise the expected safety. In this work, we are investigating the chemical species, produced by the irradiation process that could modify the food characteristics. For that we bombarded the PVDC films with 1 MeV protons at constant current and fluences from 1x1015 to 7x1015 protons/cm2. The emission of chemical species was monitored with a Residual Gas Analyzer (RGA) device, during the bombardment. Results from PVDC show the 35Cl radical is the preferentially emitted specie.

BE-P4

INVESTIGATION OF MUTATION IN PURPLE GLUTINOUS RICE BY LOW ENERGY ION BEAM

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Application of low ion beam bombardment for induction mutation in purple glutinous rice were investigated. About 4800 seeds were bombarded by low energy nitrogen ion beam at energies and fluences in ranges 60 - 125 keV and 1 - 8 x 1016 ions / cm2 respectively. With increasing of the fluences reduced survival ability in the rice seedling. Two mutants with green leaf and stem sheath were detected at 80 keV and 4 x 1016 ions / cm2. Twenty seeds of M2 plant were cultivated and HAT-RAPD was chosen to determine genetic modification at DNA level. Three primers, named OPH15, OPX13 and OPW09, revealed genetic variation between M2 mutants and wild type. All 20 M2 plants exhibited different characteristic as following: stable green leaf blade and stem sheath, green leaf and purple stem sheaths, purple leaf and stem sheaths, white seed coats, and amylose content in starch granules of some mutant seeds.

BE-P5

ION BOMBARDMENT INDUCED FORMATION OF MICRO-CRATERS IN BIOLOGICAL CELL ENVELOPES

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Low-energy ion beam bombardment of biological organisms has been recently applied for gene transfer in both plant and bacterial cells. A consistent physical mechanism for this significant result has not yet been developed. A fundamental question about the mechanism is the possible formation of pathways due to ion bombardment that are responsible for the gene transfer. We have carried out comprehensive investigations of the effects of low-energy ion bombardment of plant and bacterial cells by both gaseous and metallic ion species on their surface microstructure. Our experimental results reveal evidence demonstrating that the formation of micro-crater-like structures on the cell envelope surface is a general phenomenon consequent to ion bombardment, no matter what ion species and what biological cells, under certain ion beam conditions. The micro-craters are about 0.1 ~ 1 μm in size (diameter) and a few tens of nanometers in depth. The micro-crater formation process seems to be unrelated to the chemical composition of and rapid water evaporation from the cell envelope, but is associated with the special microstructure of the cell envelope. The formation is believed to be a consequence of a secondary effect of ion beam bombardment instead of the direct effect. However, whether the micro-craters really act as the pathways for exogenous macromolecule transfer is still under further investigations.

BE-P6

BIOFILM FORMATION BY STAPHYLOCOCCUS EPIDERMIDIS ON NITROGEN ION IMPLANTED CoCrMo ALLOY MATERIAL

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Staphylococcus epidermidis is the primary cause of medical device-related infections due to its adhesion and biofilm forming abilities on biomaterial surfaces. S. epidermidis biofilms are highly resistant to antibiotics and eradicating this layer from the surfaces is nearly impossible with host defense system. For this reason development of new materials and surfaces to prevent bacterial adhesion is inevitable. In this study, the adhesion of biofilm forming S. epidermidis YT-169a strain on nitrogen (N) ion implanted as well as on as-polished CoCrMo alloy materials were investigated. A medical grade CoCrMo alloy was ion implanted with 60 keV nitrogen ions to a high C. Thedose of 1.9x1018 ions/cm2 at substrate temperatures of 200 and 400 implanted layer crystal structures, implanted layer thicknesses, and roughnesses were characterized by grazing incidence x-ray diffraction (GIXRD), scanning electron microscopy (SEM) and atomic force microscopy (AFM). Bacterial adhesion tests were carried out in Tryptic Soy Broth supplemented with 1% sucrose. The specimens were incubated with overnight grown bacteria for 15 h with shaking at C. The adherent bacteria removed from the specimen surfaces were100 rpm at 37 diluted with phosphate-buffered saline, spreaded to Tryptic Soy Agar plates, and C. The number ofthe number of colonies was counted after 24 h incubation at 37 adherent bacteria on the surfaces of N implanted specimens was found to be CC and 191x106 bacteria/cm2 for the 200 70x106 bacteria/cm2 for the 400 specimens compared to the as-polished specimen (3x106 bacteria/cm2). The adhesion test results showed that S. epidermidis YT-169a strain adhere much more efficiently to the N implanted surfaces than to the as-polished CoCrMo alloy surface. This is attributed to the rougher surfaces associated with the N implanted specimens in comparison with the relatively smooth surface of the as-polished specimen as well as to the nature of the near-surface crystal structures.

BE-P7

BIOMEDICAL RESPONSE OF TANTALUM OXIDE FILMS DEPOSITED BY DC REACTIVE UNBALANCED MAGNETRON SPUTTERING

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Tantalum oxide films have received mostly attention as dielectric, optoelectronics and high temperature resistance materials. But the biological response of the tantalum oxide films was rarely studied. In this paper, the biomedical properties of tantalum oxide films were studied.

Tantalum oxide films were deposited on Si(100) and glass substrate at different oxygen-to-argon ratios by DC reactive unbalanced magnetron sputtering. The blood compatibility, surface energy and semiconductor properties were studied. The results showed that all the films were amorphous. The optical band-gap of the films increases from 3.65eV to 3.95eV with increasing oxygen-to-argon ratios. The surface energy of tantalum oxide films were about 40~46dyn/cm and were lower than the low temperature isotropic pyrolytic carbon (LTIC). The lower surface energy of tantalum oxide films was one of reason to its better blood compatibility.

BE-P8

IMPROVING THROMBORESISTANCE OF TI-O FILM BY PHOSPHORUS-DOPING: FABRICATING CONDITION, CHARACTERISTICS AND ANTITHROMBOTIC BEHAVIOR

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The key problem for blood contacting biomaterials is blood compatibility. Thrombi forming on material surfaces due to unexpected response of blood to biomaterial surfaces usually cause failure of artificial device and put patients in danger. One of the important considerations of antithrombotic biomaterial improvement is to control the response of blood component to materials.

Material surface characteristics have been regarded as the important factors to influence the response of blood to materials, such as surface roughness, chemical inertia, surface hydrophilic/hydrophobic property and electron conductivity. According to this consideration, modifying the surface characteristics of a material becomes an important way to develop new antithrombotic biomaterials. Ti-O films have been engaging many researchers' attentions in this ten years because of its excellent antithrombotic property. In order to reveal its thromboresistance mechanism, we focus our attention in this work on the influence of phosphorus dopping on its structure, properties and thromboresistance behavior. Ti–O thin film was doped with phosphorus by ion implantation, then annealed at different temperatures to adjust its structure and surface characteristics. The results of RBS show that phosphorus was re-distributed in the film after anneal. The resistance of the film decreased with the annealing temperature increase. The film exhibited different wettability after annealing at different temperature. The P-doped Ti–O thin film annealed at higher temperature shows significant improvement of thromboresistance. It is revealed that after doping of phosphorus into Ti–O thin film, fibrinogen absorption/denaturation and platelet adhesion / activation became much slight. It is suggested that the thromboresistance of the Ti–O thin film is related to its wide band gap n-type semiconductor nature. Key words: ion implantation, biomaterials, Ti-O Film.

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BE-P9

ANTI BACTERIAL EFFECT OF METAL AND METAL – GAS HYBRID ION IMPLANTATION ON PES FABRICS

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This study was conducted for evaluation of the affinities of two different bacteria (S.aureus ATCC:29213 and P.aeruginosa ATCC:27853) to textile products. Using MEVVA Ion implantation System, mixed metal and gas ion beams were generated and used to form buried layers of mixed metal-gas species to modify PES fabrics. In this work C and metals such as Cu, Ag, Cr, Pb, Al, and TiO metal+Gas Hybrid ion implantation on PES fabrics were performed at an extraction voltage of 30kV and with various doses. Ion impantated PES fabrics were incubated physiologic saline buffered, 0.5 McFarland (Turbidometric) microorganisms for 24 hours and washed with saline and vortexed for two minutes in 2 ml of physiologic saline three times. 100 micro litres of samples of vortexed material were incubated in blood agar and EMB agar. 24 hours later colony numbers were assessed and these products were examined by scanning electron microscopy after critical point drying. Results showed that the ion implantation decreased colony numbers of bacteriaon PES facric and these results are discussed in details.

POSTER PRESENTATIONS

INDUSTRIAL APPLICATIONS

IA-P1

DLC COATINGS ON INNER WALLS OF PET BOTTLES BY A SIMPLIFIED PBII TECHNIQUE

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Many researchers have been studied DLC coatings on inner walls of PET bottles because the DLC coating can be reduced oxygen transmission rates of the bottles drastically. There have been some ways for DLC formation on inner wall of PET bottles; however, they require rather complicated coating systems. In this study, we propose a simple way to coat on the inner walls using a modified PBII technique. The configuration is that, the outer wall is covered by an outer electrode connected to a grounded vacuum chamber, and an inner electrode, which is connected a positive high voltage pulse power supply, is inserted in the bottle. In coating process, the bottle is fulfilled with C2H2 gas of a suitable pressure, which might be changed with the size of bottles and pulse height of positive voltage. Using this way we have succeeded to coat on inner walls of the bottles. Oxygen and Nitrogen gas transmission rates were also examined for 20-s, 1-min and 5-min coated thin PET films (the thickness is 50 mm) and found that the DLC coatings reduce these rates drastically. Young's modulus and Meyer hardness of the DLC coated PET films were also estimated from penetration depth–load relationship obtained by a unique indentation testing system with a ruby ball indenter (1.5 mm in radius) at constant-penetration-depth mode. It is revealed that the apparent Meyer hardness for 1 mN load of the 5-min coated film is about 2.5 times larger than that of the non-coated film.

IA-P2

HYDROGEN GAS SENSOR USING A NOVEL GAS DIFFUSION MEMBRANE REFORMED BY ION IMPLANTATION

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It must be important to realize a reliable gas sensor for the detection of H2 which is greatly expected as clean energy in the future. There are some detection methods, for example, the catalytic reaction sensor and semiconductor sensor, a few weak points are noted such as low sensitivity or low selectivity. We tried to develop an electrochemical gas sensor that had an excellent sensitivity and selectivity for hydrogen detection, using a gas diffusion electrode reformed by ion implantation. The electrochemical gas sensor is very simple structure and works similar to a fuel cell. The sensor is constructed by electrolyte solution and gas diffusion electrode consisting of a metal electrode formed on the gas diffusion polymer membrane (ePTFE). To improve the sensitivity and selectivity of the sensor, the gas diffusion electrodes reformed by ion implantation at an energy of 150 keV with several kinds of ions (O+, O2+, N+, and N2+) at fluences of 1X1013, 1X1014, 1X1015, and 5X1015 ions/cm2, were evaluated for the hydrogen gas detection. The characteristics of the sensor were clearly dependent on each reform conditions. By using the optimum condition of the gas diffusion electrode, it showed 20 times larger sensitivity than that of a control gas diffusion electrode (non-implanted ePTFE). The sensor can be useful for hydrogen detection in practical.

The optimum condition of the reform by ion implantation, electrode material, electrode potential and the results of surface analysis will be discussed at the presentation.

IA-P3

MULTILAYERED CrN/ZrN COATINGS WITH NANOSCALE BILAYER FOR CUTTING APPLICATIONS

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Multilayer structures have been used in the coating technology for improving the performance of hard coatings for industrial applications for many years. Multilayer coating has been one of optimum solutions for high-speed machining applications due to various practice requirements for the materials used as protective coatings such as high hardness, were resistance, corrision resistance, good adhesion to the substrate.

Multilayered coatings are of great interest because they demonstrate substantial mechanical and tribological property enhancement when individual layer thicknesses approach nanometer dimensions. Several models such as TiN/CrN, TiN/AlN, TiN/NbN, TiN/VN, have exhibited very high hardness and offer potential advantages for dry machine. However, little reports on multilayered CrN/ZrN coatings can be found in recent literatures. This work reports the results of the investigation of this model prepared under different deposition conditions by a dual cathode dc magnetron sputtering. The main reasons of the CrN/ZrN system chosen in this study are that both CrN and ZrN have high hardness and tribological properties, their periodic deposition is proposed to restrict the columnar grain growth in individual layers and release internal stress of system, and provides a substantial barrier to dislocation motion. The coatings were analyzed in terms of crystalline phase composition, chemical bonding states, element concentrations, nanoindentation hardness, fracture resistance, and adhesion. A comparison with the properties of monolithic CrN and ZrN coatings was made. Our strategy is to find how processing, structure, and mechanical properties are correlated.

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IA-P4

SURFACE RESISTIVITY TAILORING OF CERAMIC INSULATORS FOR AN ION MICROPROBE APPLICATION

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An important technique used for the grading of voltage drops along high voltage ceramic insulators is to provide some surface conduction to bleed off accumulated surface charge. We have used metal ion implantation to modify the surface of high voltage ceramic vacuum insulators to provide a uniform surface resistivity on the order of 10^10 Ω/square. A vacuum arc ion source based implanter was used to implant Pt at an energy of about 120 keV to doses of about 2 x 10^16 ions/cm^2 into the surface of ceramic rods that comprise the electrostatic quadrupoles in the focusing system of the Columbia University MeV ion microprobe. Here we describe the experimental set-up used to do the ion implantation and summarize the results of implantations into test coupons and the ceramic rods.

IA-P5

SURFACE TREATMENT TO MICRO SCALE TOOLS OF SUPER-ALLOY MATERIAL BY ION BEAM

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Micro electro-mechanical system (MEMS) devices such as digital mirror device and micro gravity sensors were rolled out from silicon lithography. However that process is very expensive and there is a problem that possible utilizing material has been limited in it. The die forming process is also applied to MEMS process; however, it can use metals and polymers with low costs. For macro scaled die tools, the super-alloy material basically sintered tungsten carbide is mainly used by reason of its hardness and good frictional property, and surface treatment by ion beams has been applied. On the other hands, for the micro scale tools which were smaller than 200 um, the super alloy was an expected material caused by its hardness, but the grain size was relatively large. Furthermore, there is no micro forming tool for super alloy. We apply an ion beam process to super alloy forming and surface treatment. The surface roughness was conditioned by Ar ions bombardment. The round of tool tip was shaped also by Ar ions. Al, Au, and other ions were implanted into the surface of micro tool in order to increase the tools if life time. For micro die tool, ion beam did not only show good effect. The damages caused by ion beam such as the different abrasion rate between the cobalt binder and tungsten carbide, were disappointed. We examined the application of micro die tools ingredient of the ion beam to the preparation.

IA-P6

THICK SOI WAFERS FORMATION BY ION-CUT PROCESS

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Thick silicon-on-insulator (SOI) wafers fabrication technique has been developed by using ion-cut process, based on hydrogen ion implantation and wafer direct bonding techniques. Hydrogen ion implantation has been done on thermally oxidized Si wafers (with 400 nm BOX) at energies ranging from 70 keV to 466 keV for thick SOI wafers (200~5000 nm SOI) fabrication in the 6~9x1016 H+/cm2 dose range. Direct wafer bonding was performed by joining two wafers together after creating hydrophilic surfaces by a modified RCA cleaning, and an IR inspection was followed to ensure a void free bonding. The wafer splitting was accomplished by annealing at at 450~550 for 30 minutes, and high temperature annealing was then performed at 1100 for 60 minutes in high purity nitrogen environment to stabilize the bonding interface permanently. HR-TEM and FE-SEM observations revealed no detectable defect at the SOI structure, and the secco etch pit densities were mesured to be less than 200 cm-2 for reamining thicknesses in the 30-50 nm range. An electrical characterization of the SOI structure has been done by using MOS CV and pseudo-MOSFET analyses, and the interface trap charge density at the upper interface of the BOX was found to be low enough to keep the original thermal quality.

IA-P7

NERVE-CELL ATTACHMENT PROPERTIES OF POLYSTYRENE AND SILICONE RUBBER MODIFIED BY CARBON NEGATIVE-ION IMPLANTATION

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Ion implantation is a very useful technique of surface modification of polymeric materials to change surface biological properties such as cell attachment and protein adsorption. We have investigated surface modification by negative-ion implantation into spin-coated polystyrene (PS) on glass, and silicone rubber (SR) sheets for controlling nerve-cell attachment property. Carbon negative ions were implanted into these polymeric materials of PS and SR at various energy in 5 - 30 keV with a dose in 1.0 x 1014 - 1.0 x 1016 m in width andions/cm2 through a pattering mask which had many slits (50 m) in a region of 4 mm x 10 mm for the study on cell attachment,spacing of 70 and without the mask for evaluation of surface physical properties of contact angle and protein adsorption. After in-vitro cell culture on the implanted samples with nerve cells of PC-12h, cells were attached only on the C-implanted region of polymers at certain implantation conditions. Neurite outgrowth was also observed only on the same area at the same condition of implantation. The mean implantation conditions of energy and dose for cell attachment were 10 keV and 3 x 1015 ions/cm2 for PS and SR. In the SR sample at 30 keV implantation, cells were in abnormal in shape with a very large size, although cells attached on the implanted region. The reason of improved cell-attachment properties are considered to be lowering contact angle, i.e., hydrophilic modification by ion implantation and preferential adsorption of proteins on implanted region. The change of contact angles and protein adsorption properties for various implantation conditions will be presented at the conference.

IA-P8

PLASMA SURFACE INTERACTION OF POLYMERS

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Plasma modifications of polymer based materials such as Silicon catheter and Polysulfane membranes are examined in home-made Electron Cyclotron Resonance (ECR) plasma. Plasma treatment has been successfully utilized for improving the surface properties of Polysulfane membranes and for sterilization of Silicon catheter. In plasma polymer surface interactions the dominant mechanism is sputtering by ions. In membranes plasma ions increased the number of pores and pore sizes those improved diffusive characteristics of membranes without changing the chemical integrity of the polymers. In sterilization, UV lights, ion bombardment and radicals are dominant mechanisms for killing the bacteria. In silicon catheter sterilization nitrogen plasma killed the bacteria faster than the argon plasma due to the additional nitrogen radical effect. Plasma characteristics such as density, electron temperature pressure and power effects are analyzed. SEM and FTIR spectrum of polymers will be given.

IA-P9

A COMPARATIVE STUDY OF SINGLE AND DUBLEX TREATMENT OF MARTENSITIC AISI 420 STAINLESS STEEL BY USING PLASMA NITRIDING AND PLASMA NITRIDING-PLUS-NITROGEN ION IMPLANTATION TECHNIQUES

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Martensitic AISI 420 is a high chromium mould steel which is suitable for tools for moulding corrosive plastics. In this study, micro-pulsed plasma nitriding and plasma nitriding + nitrogen ion implantation techniques have been used, in order to improve the surface hardness and tribological properties of the AISI 420 substrates. Firstly polished-AISI 420 samples are nitrided at 530 oC for 15h at a pressure of 10mbar. Then nitrided-samples are implanted with nitrogen ions to a dose of 2x1017 ions/cm2. The mechanical characterization both of the modified and unmodified samples has been carried out by means of the nano-hardness, wear resistance, friction coefficient and surface roughness measurements. It is found that nano-hardness, wear resistance, friction coefficient and surface roughness values improve 1.6, 3.5, 1.4 and 10 times for plasma nitrided samples, and 2.0, 4.6, 1.1 and 9 times for plasma nitrided-plus-N+ ion implanted samples, respectively in comparison with those of the unmodified AISI 420 samples. Both plasma nitriding process and plasma nitriding-plus-N+ ion implantation treatment results of the samples are also compared. The improvement of the samples modified using nitriding-plus-N+ion implantation process is found to be better than that of the samples modified bynitriding process

IA-P10

EFFECT OF PLASMA IMMERSION ION IMPLANTATION OF NITROGEN ON THE WEAR AND CORROSION BEHAVIOR OF 316LVM AUSTENITIC STAINLESS STEEL

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A great deal of research has been carried out on austenitic stainless steels in order to improve their corrosion and wear resistance. It is well known that nitrogen dissolved in austenitic steels increases the strength and resistance to pitting and crevice corrosion of the latter [1]. On the other hand doping of nitrogen in austenitic stainless steels is limited by its solubility [2]. Since corrosion and wear depends only on the surface of the alloys, surface modification will be a viable route to improve them. Out of all surface modification techniques available, plasma immersion ion implantation (PIII) is an advanced surface engineering technique due to the non-line-of-sight operation and diffusion of ions in the substrate [3]. Both implantation and diffusion of nitrogen enhance corrosion and wear resistance in austenitic stainless steels. The present study concerns with PIII of nitrogen ions on vacuum arc melted 316L (316LVM) austenitic stainless steel to improve these properties. Implantation was carried at 1keV and the substrate temperature was independently varied from 250 to 500 degree celsius with a heater to facilitate diffusion of the implanted ions. Microhardness measurements revealed a significant increase in hardness of 316LVM. X-ray diffraction analysis indicated that PIII results in the formation of iron-nitrides at all temperatures and CrN formation only at 500 degree celsius after 6h of treatment. Wear measurements on Pin-on-disc machine showed an increase in wear resistance with rise in treatment temperature.

Corrosion resistance in 3.5% NaCl increases when implanted for 3h. The passive current density seems to increase with increase in implantation time at all the temperature of treatment. Epit seems to decrease with implantation time, if the samples were treated at 500 degree celsius.

IA-P11

ENERGETIC ION DEPOSITION OF BORON ON STEELS AND TITANIUM ALLOYS: POTENTIAL AND LIMITATIONS

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Cathodic arc plasma generation technology for the deposition of boron coatings from pure boron cathodes has been developed over a period of several years . This development has included patented processes for synthesis of pure boron cathodes that remain intact under the extreme thermal stress demands of cathode operation. It also included techniques for effectively heating the cathode and promoting uniform erosion (while maintaining it in a cathode-spot operational regime), as well techniques for ducting and debris-filtering of the fully ionized boron plasma. The development program is being pursued because of the unique properties of boron and the absence of any other commercially feasible deposition technique. As a light and elemental coating material, boron has intrinsic advantages over compound coatings and carbon. The hardness of elemental boron is 33 GPa, a value greater than that of most other hardcoats. Excellent corrosion resistance and refractory properties result from the highly passive nature of the native oxide. Unlike carbon, boron will not burn and the strong resistance to acid and halide ion corrosion means that boron is putatively biocompatible. As an element, boron is highly reactive with many other elements. It forms hard and highly refractory compounds with many transition metals. Because of this high reactivity (high negative heats of mixing) boron is expected to be highly adherent to many engineering alloys. Recently a number of government-funded projects have allowed for the testing of these coatings for several proposed high value applications1. These include Ti-6Al-4V for biomedical and aerospace applications, 52100 bearing steel for tribological applications, H13 steel for molten aluminum-alloy die-casting applications , and others. In this paper we will discuss results and interpretation of Rutherford Backscattering Spectroscopy studies on coated steels and Ti alloys, with special emphasis on the types of interlayer that form between the coating and the substrate as a result of energetic ion deposition, as well as the reactivity of B with Fe and Ti. The latest conclusions about the feasibility of the application of interest, based on this materials characterization work will be discussed.

C.C. Klepper, R.C. Hazelton, J.M. Williams, et al., Amorphous boron coatings produced with vacuum arc deposition technology, J. Vac. Sci. Technol. A20 (3), 725, 2002 Aluminum Soldering Performance Testing of H13 Steel as Boron Coated by the Cathodic Arc Technique. G.M. Ludtka, V.K. Sikka, J.M. Williams, C.C. Klepper, et al. , 47th Annual Technical Conference Proceedings (April 24-29, 2004, Dallas, TX, USA) pp. 42-47

Presenting Author: Claudiu Muntele

IA-P12

CAVITATION EROSION PROPERTIES OF TiALN WITH PIID ON Al6061 ALUMINUM ALLOY

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High speed rotating machine elements in fluid machinery, such as propeller of a high speed boat requires a light weight metallic material for their improved high performance of boat. But the currently used materials are bronze, stainless steel etc. due to the cavitation erosion problem during operations even though these are heavy materials. This example tells us the needs of solutions, the way of improvement of cavitation erosion properties of light weight metallic material, aluminum alloy to enhance the resistance on cavitation erosion. One possible way could be the thin film coating process of a highly hard and ductile coating material on the surface of light weight materials. We have chosen Al 6061 as a light weight material, and TiAlN as a hard coating material due to their affinity to aluminum alloy..

Cavitation erosion tests were carried out using a magnetostrictive vibratory test device (ASTM G 32-98) on the TiAlN coated Al 6061 aluminum alloy specimen. TiAlN thin films were coated from a Ti6Al4V target material by using the PIID (Plasma Immersed Ion Deposition) process with relatively low ion energy compare to the PIII. Prior to and after the cavitation erosion test, the specimen's surfaces are carefully analyzed by using the surface analysis equipments such as Scratch tester, Nano indenter, AFM, GDOES, SEM, XRD and XPS, etc. to measure the bonding properties of the applied TiAlN coating and the substrate material. These equipments are also used for the analysis of the surface damages and the depth profiling of the important elements in new or worn surfaces. We found that our process improved the capability of cavitation erosion problem of Al 6061 alloy drastically. In this report the obtained results will be presented in detail, especially the hard coating process related physical and chemical properties of hard coating will be focused by the surface analysis of low aluminum content TiAlN thin film.

IA-P13

CONTROL OF CONTACT ANGLE AGAINST PURE WATER AND CELL ADHESION PROPERTY OF HYDROXYAPATITE SURFACE BY ION IMPLANTATIONS AND PLASMA TREATMENTS

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Hydroxyapatite (HAp) is the attractive materials for engineering and bio-engineering field. Surface properties of hydroxyapatite have been improved by ion implantation and RF plasma treatment. At the standpoint of control of wettability and cell adhesion properties, N+, O+ and Ar+ ions were implanted into HAp at the 20keV with doses from 1x1013 to 1x1017 ions/cm2. For the plasma treatment process, HAp were immersed in the tetrafluoroethan (CF4), Ar, O2, C2H5OH and CH3OH plasma induced by 13.56MHz power supply with the power of 50-150W, under the gas pressure of 12Pa, with the gas flow rate of 20ml/min and at the treatment time of 0.5-30min.

Contact angle (θ) of HAP original surface was about 75 degree, however, $\theta$for ion implanted HAp specimen surfaces decreased with the increment of ion doses. At the O+ dose of 1x1017 ions/cm2 θ showed about 25 degree, which is hydrophilic surface. XPS analyses indicate that the formation of carboxyl functional group might be effective factor for the decrease. On the other hand, HAp surfaces were irradiated by several particles from plasma such as many kinds of ions and radicals due to the self -vias. Minimum θs were about 20, 18, 13, 15 and 5 degree for Ar, O2, C2H5OH, CH3OH and CF4 plasma, respectively. The surfaces with θ under 10 degree induced by CF4 plasma is generally called as super hydrophilic surface. Carboxyl functional group was observed on the Ar plasma treated HAp surface, which affect the contact angle of HAp. XPS analyses show that the CF4 plasma treated HAp surface was covered with a thin film. The film was composed of C 16%, Al 14%, F 65% and sum of Ca, P and O 5%. O1s XPS spectrum include OH binding state, which is hydrophilic functional group.

After the culture of neuronal cell (N1E-115) for 2 days, the evaluation of the growth of the cell can be estimated according to the cell form. Good adhesion property of the cell is observed for CF4 and Ar plasma treated HAp. These surfaces have hydrophilic functional groups.

The effect of ion implantation and plasma treatment on the contact angle and cell adhesion property will be discussed.

IA-P14

CORROSION BEHAVIOR OF TI-6AL-4V ALLOY TREATED BY PLASMA IMMERSION ION IMPLATATION PROCESS

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Ti-6Al-4V alloy is one of the most frequently used Ti alloys with diverse applications in aerospace and biomedical areas due to its favorable mechanical properties, corrosion resistance and biocompatibility. Meanwhile, its surface can suffer intensive corrosion caused by the wear process due to its poor tribological properties. Thus, in the present study, PIII processing of Ti-6Al-4V alloy was carried out to evaluate its corrosion resistance in 3.5% NaCl solution. Two different sets of Ti-6Al-4V samples were PIII treated, varying the plasma gases and the treatment time. The corrosion behavior is correlated with the surface morphology, and the nitrogen content. SEM micrographs of the untreated sample reveal a typical two-phase structure. PIII processing promotes surface sputtering and the surface morphology is completely different for the samples treated with N2/H2 mixture and N2 only. The highest penetration of nitrogen (~88 nm), corresponding 33% of N, was obtained for the sample treated with the N2/H2 mixture during 1:30h. The corrosion behavior of the samples was investigated by the potentiodynamic polarization method. A large passive region of the polarization curves (~1.5V), associated with the formation of a protective film, was observed for all samples. The passive current density (~3x10-6 A.cm-2) of the PIII treated Ti-6Al-4V samples is about 10 times higher than the one of the untreated sample. This current value is still rather low and maintains a good corrosion resistance. The anodic branches of the polarization curves for all treated Ti-6Al-4V samples demonstrate also that the oxide films break down at approximately 1.6 V, forming an active region. Although, the sample treated by N2/H2 mixture for 1.30h has thicker nitrogen enriched layer, the better corrosion resistance is obtained for the PIII process performed with N2 gas only.

IA-P15

FORMATION OF TRANSPARENT CONDUCTIVE TITANIUM NITRIDE THIN FILMS ON POLYETHYLENE TEREPHTHALATE AT ROOM TEMPERATURE BY LOW-ENERGY ION BEAM ASSISTED DEPOSITION

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The transparent conductors are important materials for industrial applications. The room temperature growth technique is necessary to produce organic luminescent devices. We demonstrated the film formation of transparent conductive titanium nitride (TiN) on polyethylene terephthalate (PET) at room temperature using low-energy ion beam assisted deposition and analyzed their properties. Titanium was supplied by an electron beam evaporator and low-energy nitrogen ion beam was extracted from an electron cyclotron resonance (ECR) ion source. The energy of nitrogen ion beam was set to 100 eV. The PET substrate temperature was kept at RT during film formation. The pressure in the deposition chamber was 4x10-4 Pa (background) and 2x10-2 Pa (operating). The thickness of the TiN thin films was 10 nm. The resistivity of the TiN thin films was below 4x10-5 Ω•cm and the optical transmittance of them was 80% at wavelength 550 nm. The TiN thin films formed on PET at RT by low-energy ion beam assisted deposition showed very low electric resistivity and high optical transparency.

IA-P16

EFFECT OF HYDROGEN ON THE BEHAVIOR OF CULTURED HUMAN UMBILICAL VEIN ENDOTHELIAL CELLS (HUVEC) ONTO TITANIUM OXIDE FILM FABRICATED BY PLASMA IMMERSION ION IMPLANTATION AND DEPOSITION

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The thin solid film technique is an extensively employed method for surface modification of biomedical inorganic materials and prostheses to improve biocompatibility. In this paper, titanium oxide (Ti-O) thin film was fabricated by plasma immersion ion implantation and deposition (PIII-D), and subsequently hydrogen ions were implanted into the film surface by PIII. The films containing hydrogen were then characterized using X-ray diffraction (XRD), X-ray photoelectron spectroscopy (XPS), Secondary ion mass spectroscopy (SIMS), and Atomic force microscopy (AFM). The contact angle of Ti-O film with simulate body fluid was measured. The biological behavior of cultured human umbilical vein endothelial cells (HUVECs) on Ti-O film surfaces was evaluated by the in vitro HUVECs cultured experiment. Characterization of the hydrogen doped film indicated that the structure of Ti-O film was uninfluenced after H implantation, but the H distribution of films were controlled by implantation and annealing process, and the surface roughness of Ti-O films was decreased after implantation and annealing treatments. The in vitro investigation of cultured ECs on Ti-O films revealed that the H implanted Ti-O film was accepted by ECs. The biological behavior of HUVECs, such as adherence, growth and proliferation etc, were in better biological state for hydrogen containing Ti-O films than untreated Ti-O film . The results implied that the hydrogen ion implantation technique of Ti-O film is helpful for seeding endothelial cells and can be used for preparing biomimetic functional surface for the adherence and growth of EC.

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IA-P17

IMPROVEMENT OF SURFACE MECHANICAL PROPERTIES OF POLYMERS BY HELIUM IMPLANTATION

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The employ of ion implantation as a surface treatment technology has been dominated by its applications to prevent wear and oxidation in metal alloys, although some early works already pointed that ion implantation could also be efficient as surface treatment for other materials, including polymers. Further research has shown that low dose implantation of energetic light ions could be very efficient to increase properties such as hardness and wear resistance in many different polymers. Cross linking of polymeric chains due to ionisation energy provided by the stopping process is the main mechanism to explain the increases in mechanical properties. According to this model the lighter is the ion the stronger is the effect. Hydrogen and Helium ions would be the ideal options to be employed in the treatment of polymers. As a continuation of earlier works on Hydrogen implantation, this paper collects the results obtained by Helium implantation on UHMWPE. A TECVAC 223 ion implanter, has been employed to produce He+ beams of 90 keV. Turbomolecular pumps were employed to obtain the required high vacuum. The current density was kept low to prevent heating of the substrates. Doses between 5’1015 to 2’1016 ions/cm2 were implanted on polished UHMWPE samples. Nitrogen was also implanted in separate samples,at the same conditions as a reference.

Changes in Universal Hardness were measured by using a Ficheroscope micro indenter at a maximum load of 2 mN. The results shown a clearly higher increase on hardness and surface elastic modulus for samples implanted with Helium, in comparison to those implanted with Nitrogen or unimplanted. The effect also increases with the dose, although saturates at 1’1016 ions/cm2.

IA-P18

ION BEAM IRRADIATED EPTFE AS AN ANEURYSM WRAPPING MATERIAL

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Intracranial aneurysms are frequently treated with either microsurgical clipping or endovascular coiling. However, so called broad-neck aneurysms are not suitable for these treatment options. A wrapping technique using muslin gauze, muscle piece, and ePTFE are applied for such cases in order to reinforce the aneurysm wall. However, a few weak points are noted such as low tissue affinity or low fibrin glue affinity. The material for aneurysmal wrapping demands both stable adherence to the aneurysm wall and no reactive inflammatory response. We have developed a new improved ePTFE by ion-beam irradiation technique that is biologically inert and able to adhere firmly to cell and tissue. Based on the last studies, Ar^+ ion at an energy of 150 keV with a fluence of 5 x 10^14 ions/cm^2 was chosen to irradiate ePTFE. An in vitro cell adhesion test and in vivo direct implantation of ion-beam irradiated ePTFE as wrapping material around rabbit`s common carotid arteries were examined. It was demonstrated that the surface of ion-beam irradiated ePTFE exhibits remarkably greater adhesion and promotes cell proliferation more effectively than that of non-irradiated ePTFE. The carotid artery well-wrapped by ion-beam irradiated ePTFE strongly adhered to the mural wall and induced little inflammatory reaction. The results of this investigation indicate that application of this technology would offer the best means for aneurysm wrapping. Surface characteristics and morphology of ion beam irradiated ePTFE were also investigated in relation to cell and tissue response.

IA-P19

STRESS BEHAVIOUR OF A BULK SOLID IN A SILO USING 3DIMENSIONAL (TRIAXIAL) INDICATOR

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The paper will deal with a bulk solid pressure observation inside a silo using new developed 3Dimensional (Triaxial) Indicator. New design and conception of the 3D indicator have been developed exclusively for detecting of real stresses/pressures inside vessels, bunkers and silos. Real results and outputs of the investigation will be presented and discovered in the paper. Yet, there are not investigated means able to register real stresses/pressures inside storage systems properly. Current indicators work in 2D generally and moreover, usually are situated to inner circumference of a silo body. That is the reason, why often a wall stress/pressure has been measured instead of a real stress/pressure inside bulk solids pored in a silo. The problem is more acute in regard to transport of tough flow powder, which often changes flow properties depending upon storage and environmental conditions, such as storage time, temperature, moisture, etc. Detection of the real pressure inside the storage mass using the stress/pressure indicator may be a possible solution of the problem, which is encouraged by modeling of the particulate solid flow.

IA-P20

THE INFLUENCE OF POLYETHYLENE TEREPHTHALATE SURFACE MODIFIED BY SILVER ION IMPLANTATION ON BACTERIAL ADHESION BEHAVIOR

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The prevention of medical device related infection remains a main objective because of the high risk of the complications. Efforts to prevent bacterial colonization of the biomaterials have focused on the surface modification. This paper investigates the antibacterial behavior on polyethylene terephthalate (PET) surface modified by ion implantation of silver ion (Ag+). PET films have been modified by silver ion implantation with a dose 1x1016 ions /cm2 using an ion implanter. Three methods including X-Ray diffraction (XRD), X-ray photoelectron spectroscopy (XPS) and attenuated total refection Fourier transform infrared spectroscopy (ATR-FTIR) have been used to characterize the surface structure and composition. The results indicate that silver has been successfully implanted into the surface of PET. Atomic force microscopy (AFM) show that this implantation significantly changes the surface morphology of PET. The static contact angle of water decreases from an original value of 83.5° to 67.6° by Ag+ implantation, which suggests that the hydrophilic property of the modified PET is improved. The capacity of staphylococcus epidermidis (SE) adhered onto the different PET films is quantitatively determined by the plate counting in vitro. The results indicate that the capacity of the SE adhered onto the PET film implanted by Ag+ is 5.3x106CFU/ml, but the capacity of the SE adhered onto the virgin PET film is 2.23x107CFU/ml. The releasing speed of silver ions from the implanted PET is 0.22μg/mL during 2 hours. The release of antibacterial silver ion may be the important reason of less SE adhered to the PET surface modified by Ag+ implantation. The free energy of adhesion ( ) of SE on the PET surfaces modified by Ag+ implantation is positive, which means that this adhesion is energetically unfavorable.

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IA-P21

SURFACE ROUGHNESS OF MULTILAYER HARD COATINGS CUTTING TOOLS BY HTCVD METHOD APPLIED TO TURNING OF DUCTILE CAST IRON

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In this work a nocoated and two different multilayer hard coatings cutting tools by HTCVD method, such as Ti(C,N), TiC, Ti(C,N), Al2O3 and TiN on WC substrate were used in longitudinal turning of ductile cast iron under cutting condition encountered in the shop floor. The first cutting tool, called 'HB10S', has 24 WC inserts all with square edges. The second cutting tool, called 'BK247', is a multilayer hard coatings cutting tools by HTCVD method, such as Ti(C,N), TiC, Ti(C,N), Al2O3 and TiN on WC substrate, having 24 inserts and the third cutting tool, called 'Ti410', is a multilayer hard coatings cutting tools by HTCVD method, such as Ti(C,N), TiC, Ti(C,N), Al2O3 and TiN on WC substrate, having 24 inserts. Cutting speed (vc), depth of cut (a) and feed rate (f) were kept constant. Surface roughness (based average surface roughness, Ra) was the parameters considered to compare the three cutting tools. 'Ti410' cutting tools presented better performance according to all parameters, although only end of life criterion based on Ra parameter has been reached.

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