Applied and Atomic Physics

Structural coatings, Surfaces studies and ionic implantation

The properties of the surface are modified by means of two techniques: the first one is ion implantation with energies ranging between 100 and 400 keV and the second one is to coat the surface with a hard amorphous carbon film or a related material. The aim of ion implantation technique is to modify the alotropic properties or the crystalline structure of the surface of the different materials. The aim of the second one is to grow a hard film using a CH3+ ion beam to protect the surface of the wear produced by abrasion or chemical attack. The characteristics of the substrate modified using these procedures are evaluated by various methods. They are Raman Spectroscopy, XPS and EELS for the structural studies, and the utilization of heavy ion beams for the measurement of the composition and concentration of different elements in the treated surface, by means of HIRBS and ERDA techniques.

The principal protecting coatings produced and studied are hard amorphous carbon films (a:C) of about 1 μm thickness, N containing a:C films and amorphous carbon rich SiC films.

During the last years, several developments have been performed with the purpose of using the heavy ion beam in the analysis of materials. In particular for the determination of the concentration profile of elements, as a function of depth, near the surface of materials (around one micron). Several diffusion coefficients were obtained using the HIRBS technique with fluor beam of 38 MeV energy.

A new gaseous detector E-Delta E was developed and tested to be used with the ERDA technique to identify light elements.

Application of Heavy Ions Backscattering Spectrometry to diffusion studies

R. A. Pérez, G.García-Bermúdez, D. Abriola, F. Dyment and H. Somacal.

The feasibility of using HIRBS (Heavy-Ion Rutherford Backscattering Spectrometry) to measure the concentration profile induced by the diffusion of one element in other is analyzed. The principal advantage of HIRBS over conventional RBS (Rutherford Backscattering Spectrometry) is the improved mass resolution for the analysis of high atomic number samples. This property allows us to measure the diffusion profile deep into the sample avoiding surface effects that could perturb the diffusion process. The application of HIRBS to diffusion measurement makes it possible to bridge the gap between different techniques, such as RBS and the serial sectioning technique.

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Surface analysis using heavy ion beams

G. García-Bermúdez, M. Alurralde.

It is a review of the heavy ions techniques applied to the analysis of materials. Describe the physical principle and their main characteristic. The techniques are: NRA (Nuclear Reaction Analysis), HIRBS (Heavy Ion RBS), CEBS (Coulomb Excited Backscattering Spectrometry), and ERDA (Elastic Reaction Detection Analysis).

Structure and thermal behavior of N containing a-C thin films obtained by high energy ion beam deposition

E.B. Halac, H. Huck, G. Zampieri, R.G. Pregliasco and M.A.R. de Benyacar

a-C:N films have been obtained by high energy ion beam deposition at ambient temperature, using CH_4-N_2 and CH_4-NH_3 as starting gas mixtures. The as-deposited and thermally annealed samples were studied using APS, Raman, KVV Auger and EELS spectroscopies. The experimental results indicate that the sp^2 bonded C content is about 60% and that there is a reduced short range order in the a-C:N films as compared with a-C ones. Thermal graphitization is dependent on the thickness and chemical composition of the films; it is suggested that the size of the graphitic cluster is higher in annealed a-C:N samples than in annealed N free films.

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Microstructural analysis of hard amorphous carbon films deposited with high-energy ion beams

R.S. Brusa, A. Somoza, H. Huck, N. Tiengo, G.P. Karwasz, A. Zecca, M. Reinoso and E.B. Halac

Hard amorphous carbon films produced using high-energy (ca. 30 keV) ion beam deposition of CH_3^+ and CH_4^+ on silicon wafers, have been investigated by Positron Annihilation Spectroscopy, the results are correlated with Raman Spectroscopy and Electrical Resistivity measurements. The microstructural modifications of the films as a function of the annealing temperature in the 300-600 °C range have been studied. The evolution of the fractions of sp^2 and sp^3 bonds is described and related to the changes of the open volume defect distribution and the graphitization process.

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Growth of amorphous Si_xC_{1-x} thin films using a methane-silane high energy ion beam

E.B. Halac, H. Huck, C. Oviedo, M. E. Reinoso, M. A. R. de Benyacar

Amorphous Si_xC_{1-x} films, with *x* ranging from 0.25 to 0.50, were grown by high-energy ion beam deposition starting from a methane-silane gas mixture. XPS analysis of the samples shows that it is possible to incorporate silicon to the amorphous carbon matrix giving a Si/C ratio depending on the methane-silane gas mixture. Raman spectra of the thermally annealed films indicate that the silicon incorporation in a-C films increases their thermal stability. There is no evidence of a complete graphitization up to 900 ^oC, while in a-C samples graphitization occurs at about 500 ^oC. This result shows that thermal stability is a function of the film composition.

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Characterization of amorphous carbon rich SiC thin films obtained using high energy hidrocarbon ion beam on Si

H. Huck, E.B. Halac, C. Oviedo, G. Zampieri and M. Benyacar

Amorphous $Si_{1-x}C_x$ films, with *x* ranging from 0.54 to 0.71 and low hydrogen content (less than 5 %) were grown by high-energy hydrocarbon ion beam deposition on silicon wafers. The resulting films were studied using XPS, AES, EELS and Raman spectroscopies. As *x* increases, there is a higher number of C atoms in sp^2 sites, showing that for high carbon concentrations the bonding character of the C atoms is a function of the Si/C relative content in the films. Films annealed at different temperatures were studied by Raman and XPS spectroscopies; there is no evidence of a complete graphitization up to 900 ^0C. It is concluded that the presence of Si in the films increases their thermal stability.

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Cratering in PMMA induced by gold ions: dependence on the proyectile velocity.

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Surface tracks induced by individual ion impacts on the surface of poly(methyl methacrylate) thin films are investigated for Au ions of different velocities v (from 0.02 to 1 MeV/u). The incident ions hit the surface at 79° to the surface normal, inducing particle ejection (a crater) and surface plastic deformation (a hillock) close to the zone of impact. Crater and hillock dimensions were measured using scanning probe microscopy in the tapping mode. Typical craters for 197 MeV impacts are 22 nm wide, 60 nm long, and 10 nm deep. For 20 MeV ions average dimensions are: 20 nm (width), 35 nm (length), and 2.5 nm (depth). Crater length and depth, as well as hillock length and height increase with projectile velocity up to v around 0.7 cm/ns and tend to saturate for higher velocities. Crater width, however, varies very weakly with projectile velocity. The total mass of ejected particles per MeV ion impact, Y, is estimated to be around 3´10 6 u for 197 MeV Au ions and of the order of 3´10 5 u for 20 MeV Au ions. A power fit to the data gives $Y \propto v^2$, but for v > 1 cm/ns the trend is a saturation of the total sputtering yield.

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