Depth Resolved Chemical Composition Determination of Hard Coatings, Semiconductors and Ion Treated Titanium Alloys with ERDA

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At the University of Augsburg different nitrides (BN, TiN), carbides (TiC, SiC) and oxides (TiO_x) have been prepared by techniques like ion beam assisted deposition (IBAD), DC-magnetron sputtering, silicon carbonization and plasma immersion ion implantation (PIII). All examined material systems bear the problem that they cannot be adequately analyzed with Rutherford backscattering spectrometry (RBS) due to vast differences in scattering cross sections and due to overlapping energy spectra. In order to get element separated concentration depth profiles with good resolution of the light elements the elastic recoil detection analysis (ERDA) was chosen as the most suitable technique. The measurements were performed with the position sensitive ionization chamber in the ERDA beam line using 210 MeV I ions [1].

1. Hard coatings

Boron nitride films were produced on silicon substrates by IBAD. To obtain stoichiometric films it is necessary to correctly adjust the atomic boron flux and the nitrogen ion flux to the substrate. Due to the excellent element resolution of the ERDA method it was possible to obtain concentration depth profiles of nitrogen, oxygen, carbon and the two boron isotopes. Purpose of the ERDA measurements was the adjustment of the process parameters in order to obtain stoichiometric films of homogeneous element concentration with depth and to reduce the impurity content (oxygen and carbon). After the resolution of the fundamental problem of stoichiometry control by the help of ERDA measurements it was possible to produce the hard cubic boron nitride phase.

Titanium nitride films were prepared on silicon by DC-magnetron sputtering. Oxygen contamination of the films due to the gettering effect of titanium was investigated. Further, inhomogeneities in element depth distribution due to presputtering of the oxygen contaminated sputter target surface could be examined.

2. Semiconductors

Epitaxial silicon carbide was prepared by two completely different processes. One process is to carbonize a silicon substrate with evaporated fullerenes [2], the other process is to implant carbon ions into silicon by methane plasma immersion ion implantation. Both processes are executed at elevated substrate temperatures and may be followed by thermal treatments to enhance carbon diffusion and SiC formation. In dependence of the process parameters the surface carbon concentration can vary from 0 to 100 at%. Therefore an accurate process control is required to obtain stoichiometric SiC of good crystalline quality. The two preparation techniques are very sensitive to contamination by residual oxygen, the second process also to contamination of hydrogen from the methane plasma. Especially the knowledge of the states of contamination before and after thermal treatment is of great relevance. With ERDA it was possible to investigate the carbon distribution in the SiC layers and also the impurity distributions in order to improve the SiC growth and annealing processes.

3. Titanium alloys

Applications of titanium alloys range from aircraft components, chemical processing facilities to medical implants, because of their remarkable mechanical and chemical properties such as high strength–to–weight ratio and corrosion resistance. The often observed poor tribological performance can be overcome by means of a suitable surface engineering method. By implanting metalloid species as N or O delivered by suitable plasmas (PIII) ceramic surface layers can be formed to improve hardness and wear resistance of titanium alloys. With ERDA the depth distribution of the light implanted elements as well as of the heavier alloying elements has been determined [3]. An increase of the implanted dose with process time has been established for all four process plasmas (N_2, NH_3, O_2, H_2O). Fig. 1 shows an example for the nitrogen plasma immersion implantation in Ti6Al4V alloy.

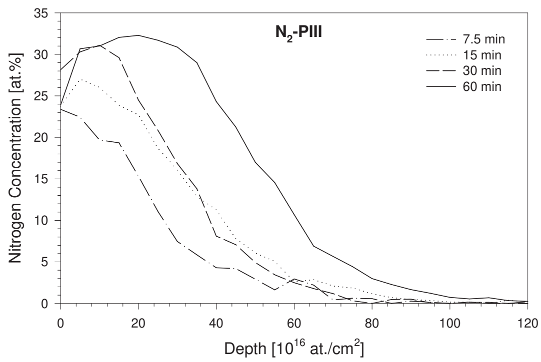

Fig. 1: Nitrogen concentration depth profiles of Ti6Al4V after nitrogen PIII for different process durations

An aluminum segregation in the samples treated with oxygen and H_2O-plasma has been found. The hydrogen amount of the samples treated in NH_3, H_2O plasma could also be measured.

References

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