Depth Resolved Element Concentrations of Carbides and Oxides Obtained by ERDA

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Silicon carbide is a semiconductor material especially suited for the use in high temperature environments due to its wide band gap and high thermal stability. Here a relatively new method is used to synthesize thin SiC films and it is shown how ERDA measurements helped to optimize process parameters and to improve the crystalline quality of the films. Titanium oxide is an interesting material due to its insulating and optical properties, as well as its blood compatibility. One way to prepare titanium oxide thin films is to implant oxygen ions into titanium with high fluences. The resulting implantation depth distributions were evaluated with ERDA and this was the first step to examine the phase formation. The measurements were performed with 210 MeV I ions using the position sensitive ionization detector of the ERDA setup [1].

Silicon carbide thin films

Thin epitaxial silicon carbide films were grown either by fullerene carbonization of silicon substrates or by fullerene carbonization with simultaneous coevaporation of silicon [2]. In the first process the evaporated fullerenes crack on the hot substrate surface and SiC is formed. Further carbonization leads to diffusion of silicon from the substrate through the formed SiC layer and to reaction with the carbon on the surface. This mechanism results in SiC covered silicon with many deep pits in the substrate. To avoid the pitting, silicon has to be delivered to the growing SiC film by an additional silicon vapor flux which should equal the carbon flux. In this way the substrate is no longer needed as silicon source. ERDA measurements were performed to investigate the stoichiometry of SiC films for various values of the Si/C-flux. The results show that in every case the 1:1-stoichiometry is obtained. Superstoichiometric SiC films with surplus silicon could not be formed indicating that the silicon vapor flux still has to be increased. Electron microscopy reveals that the pit size in the silicon substrate is reduced by the coevaporation of silicon, but pits are still present. This is in agreement with the ERDA results. To obtain the cubic SiC-phase the process parameters must be optimized with respect to the residual gas pressure in the deposition chamber. If the residual gas pressure (mainly originating from water vapor) is too high, growth of twinned cubic SiC occurs or in the worst case the resulting SiC film consists of a mixture of hexagonal and rhombohedral SiC polytypes. The good separation for light elements available with ERDA made it possible to examine also the oxygen contamination in the SiC films. From the depth resolved oxygen concentrations obtained it could be deduced that the oxygen content in the films correlates with the residual gas pressure. This is shown in fig. 1 for two SiC films prepared at two different pressures.

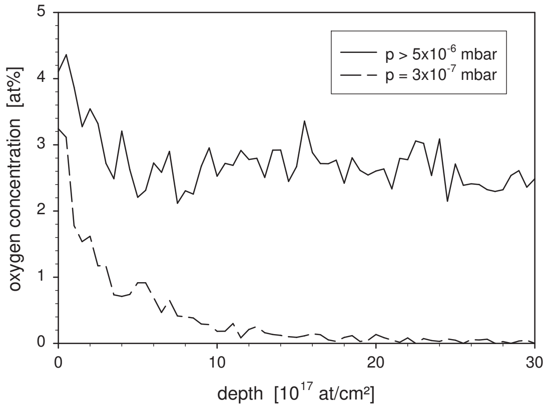

Fig. 1: Oxygen concentration depth profiles of SiC films grown at two different residual gas pressures.

Oxygen ion implanted titanium

Oxygen ions were implanted into titanium at temperatures below -20°C to investigate the oxide phase formation under non-diffusional conditions [3]. The implantation energy was 180 keV and the doses were in the range from 1 to $15*10^{17} O^+/cm^2$. To clear the mechanisms of phase formation a distinct knowledge of the concentration depth distribution of implanted oxygen is necessary. For this task RBS can be applied, but due to the small backscattering cross-section of oxygen in comparison with that of titanium, the oxygen profile has to be indirectly calculated from the missing titanium signal. On the other hand ERDA cross sections for oxygen and titanium differ only by a factor of 0.8 and energy spectra are separated for each element. This allows a more accurate determination of the chemical composition. Additionally an eventual contamination with carbon can hardly be detected with RBS, but so with ERDA. The calculated oxygen depth profiles of the implanted titanium samples exhibit a Gaussian shape for all doses proving that no diffusion took place during implantation. In combination with X-ray and electron diffraction the present phases could be determined and also the change in oxide phases with increasing implantation dose.

References

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