VIth International Workshop on Plasma-Based Ion Implantation

Abstracts

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VI.5

Growth of the Carbide, Nitride and Oxide of Silicon by Plasma Immersion Ion Implantation
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Plasma immersion ion implantation (PIII) has been applied for the formation of silicon carbide, silicon nitride and silicon oxide thin films in Si, offering the possibility of the growth on three-dimensional objects. This could be an important step to the next-century semiconductor architecture. SiC is a semiconductor which is applicable in high temperature, high frequency and high power electronics. Si₃N₄ and SiO₂ are insulators, which are also necessary for semiconductor design.

The thin films in Si were formed by pulse biasing Si wafers in methane (CH₄), ammonia (NH₃), nitrogen (N₂), water (H₂O) and oxygen (O₂) RF plasmas, respectively. The composition and structure of the resulting layers in dependence on the preparation conditions — namely the implantation temperature and the number of pulses received by the wafers — was elucidated by means of Rutherford Backscattering Spectrometry (RBS), Nuclear Resonance Analysis (NRA) for H depth profiling and Transmission Electron Microscopy (TEM).

It is shown that by using CH₄ PIII all C/Si ratios of 0 to 1/0 can be obtained, whereas for N₂, NH₃, O₂ and H₂O implantation a saturation concentration of nitrogen and oxygen in the range of the one of the stoichiometric nitride and oxide exists. By using (HR)TEM, SiC is shown to grow heteropitaxially aligned with the Si matrix, depending on the trapping behaviour for H as a function of the temperature. Si₃N₄ grows polycrystalline, whereas SiO₂ stays amorphous for all implantation temperatures considered in this study.

VII.1 - invited

Contamination Issues in Semiconductor Plasma Immersion Ion Implantation
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Plasma immersion ion implantation (PIII) has been applied to many areas with regard to semiconductor and microelectronics processing, for instance, synthesis of silicon-on-insulator (SOI), formation of shallow junctions, fabrication of low-k materials, microwavengineering, processing of light-emitting materials, and so on. While PIII offers distinct advantages such as small footprint, simple instrumentation, and high throughput, the lack of an ion filtering mechanism in PIII implies that contaminants in the plasma are easily co-implanted into the samples. This drawback can cause fatal effects in semiconductor processing. The contaminants usually come from gases in the residual vacuum or metallic species originating from either the vacuum chamber or exposed areas such as the wafer stage. A small amount of atmospheric species such as oxygen and nitrogen are inevitable in the plasma because most PIII instruments are not designed for UHV (ultra-high vacuum) operation. They can affect the surface properties of the implanted materials, e.g. excessive surface oxidation in the SPEMOX (separation by plasma implantation of oxygen) and deleterious effects such as damage and sputtering in the hydrogen PIII or ion cut process. Metallic contaminants released from the exposed surfaces of the PIII chamber and co-implanted into silicon are also known to be detrimental. We experimentally and theoretically studied the magnitude and effects of residual gas and metallic contamination in the hydrogen PIII process and will present our results in this invited talk. We will also present results of our pure silicon liner.