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Non-gaseous Plasma Immersion Ion Implantation and Its Applications

Seung Hee Han, Enkyeom Kim, Won Woong Park, Sun-Woo Moon, Kyunghun Kim, Sung Min Kim

Photo-electronic Hybrids Research Center, National Agenda Research Division Korea Institute of Science and Technology, Seoul 136-791, Korea

A new plasma process, i.e., the combination of PIII&D and HIPIMS, was developed to implant non-gaseous ions into materials surface. HIPIMS is a special mode of operation of pulsed-DC magnetron sputtering, in which high pulsed DC power exceeding ~1 kW/cm^2 of its peak power density is applied to the magnetron sputtering target while the average power density remains manageable to the cooling capacity of the equipment by using a very small duty ratio of operation. Due to the high peak power density applied to the sputtering target, a large fraction of sputtered atoms is ionized. If the negative high voltage pulse applied to the sample stage in PIII&D system is synchronized with the pulsed plasma of sputtered target material by HIPIMS operation, the implantation of non-gaseous ions can be successfully accomplished.

The new process has great advantage that thin film deposition and non-gaseous ion implantation along with in-situ film modification can be achieved in a single plasma chamber. Even broader application areas of PIII&D technology are believed to be envisaged by this newly developed process.

In one application of non-gaseous plasma immersion ion implantation, Ge ions were implanted into SiO2 thin film at 60 keV to form Ge quantum dots embedded in SiO2 dielectric material. The crystalline Ge quantum dots were shown to be 5~10 nm in size and well dispersed in SiO2 matrix. In another application, Ag ions were implanted into SS-304 substrate to endow the anti-microbial property of the surface. Yet another bio-application was Mg ion implantation into Ti to improve its osteointegration property for bone implants. Catalyst is another promising application field of non-gaseous plasma immersion ion implantation because ion implantation results in atomically dispersed catalytic agents with high surface to volume ratio. Pt ions were implanted into the surface of Al2O3 catalytic supporter and its H2 generation property was measured for DME reforming catalyst.

In this talk, a newly developed, non-gaseous plasma immersion ion implantation technique and its applications would be shown and discussed.

Keywords: PIIID (plasma immersion ion implantation and deposition), HIPIMS ion implantation