Diagnostics of High-Power Impulse Magnetron Sputtering (HiPIMS) Plasma by Modified Ion-Sensitive Probes

Abstract

The dissertation deals with the experimental investigation of the discharge plasma in a pulsed magnetron discharge (HiPIMS) using two new methods developed for plasma diagnostics. First, the M-QCM system with a magnetic filter was used. The M-QCM system is equipped with a stationary magnetic field to reduce the flux of electrons from the plasma to the surface of the collecting electrode deposited on the measurement crystal surface. This collecting electrode was connected to a controllable positive voltage to control the ion flux to its surface. The M-QCM system was used to measure the deposition rate and ionization of sputtered particles in a pulsed HiPIMS magnetron with a titanium target. These parameters were studied for different magnetic field configurations of the planar magnetron itself. These measurements were used to understand the physical processes in the pulsed magnetron HiPIMS discharge in terms of charged and neutral particle fluxes as a function of the different physical conditions in the plasma. Pulsed reactive magnetron HiPIMS discharges have also been studied with a planar RF probe (modified Sobolewski RF probe) used for time-resolved in-situ plasma diagnostics. With this probe, it was possible to determine the ion flux to the substrate, the ion concentration and the electron temperature in the plasma. These parameters could be determined with time resolution and even when the surface of the probe was covered with an electrically non-conducting or semiconducting thin film. The RF probe was used to study physical processes in a reactive pulsed HiPIMS magnetron operating in combination with an additional high-frequency ECWR discharge. This hybrid plasma system was used in this configuration to deposit tin-doped hematite Fe_2O_3: Sn semiconductor thin films.

Key words: HiPIMS, magnetron sputtering, pulsed discharge, plasma diagnostics, QCM, RF probe