PO1024

Investigation of HIPIMS discharge by energy resolved mass spectrometry in a reactive atmosphere with Oxygen content

Yolanda Aranda Gonzalvo[1], Arutiun P. Ehiasarian[2]

[1]Hiden Analytical Ltd., Warrington, United Kingdom [2]Nanotechnology Centre for PVD Research, Materials and Engineering Research Institute, Sheffield Hallam University, Sheffield, United Kingdom

gonzalvo@hiden.co.uk

HIPIMS (High Power Impulse Magnetron Sputtering) discharge is a PVD technique for the deposition of high-quality thin films. Recently, HIPIMS has been used for deposition of oxides in particular for TiO_2 and TiO_xN_y.
In this study, the operation of HIPIMS in an atmosphere of working gases of Ar and N_2 with 20% O_2 content and a Ti target was investigated. The plasma was operated at a pressure of 1-1.7 Pa and an Ar:Air partial pressure ratio ranging from 45:1 to 45:10 was used to operate at the metallic-to-poisoned point. The peak current was varied from 3 to 10 A with a pulse duration of 200 µs.The frequency was adjusted between 100 and 400 Hz to maintain a constant average power of 0.6 kW. Time-resolved measurements of the plasma parameters near the substrate were carried out using energy resolved mass-spectrometry.
Mass spectrometry measurements showed that the reactive HIPIMS discharge produced a deposition flux with a significantly increased content of ionised film-forming species, such as Ti^{1+}, Ti^{2+}, $N^{1+,}$ O^{1+}, TiO^{1+} and $TiO_2{}^{1+}$. Increasing the air content in the discharge resulted in an enhanced activation of the oxide species, TiO^{1+} and $TiO_2{}^{1+}$, and a reduction in the atomic ion N^{1+}, Ti^{1+} and Ti^{2+}. Ions with energies up to 80 eV were detected during the pulse with reducing energy in the pulse-off times in the metallic mode. The ion energy decreased considerably when the discharge was operated in the oxide mode.
In the mass spectrum of negative ions only the O^- and $O_2{}^-$ species were observed. The detailed study of the energy distribution of O^- and $O_2{}^-$ shows high-energy ions formed at the cathode with energies proportional to the full cathode voltage. The ion energy distribution function shows that in the transition from metallic to the oxide mode there is about 100 V drop of the voltage on the oxide surface layer on the cathode; this corresponds well with the measured cathode voltage.

Keywords
HIPIMS
reactive sputtering
mass spectrometry
time resolved
negative ions