PO4012

Effect of ion-to-neutral ratio on thickness distribution of Ti and Al films on inner wall of small hole deposited by HiPIMS

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In the previous report, the authors have demonstrated the availability and advantages of high-power impulse magnetron sputtering (HiPIMS) in the control of the direction and energy of the ion flux incident to the inner walls of sub-millimeter scale tubular components. For the deposition of Titanium Aluminum nitride ((Ti, Al)N) films, the chemical composition was varied in the deeper position of the inner wall. In order to clarify the transportation behavior of the sputtered species into the small hole structure and to deposit the film with uniform chemical composition in any depth of inner wall of small hole, the present study focused on the effect of ion-to-neutral ratio in the HiPIMS plasma on the thickness distribution at the inner wall surface. Control of ion-to-neutral ratio of Ti and Al was achieved by changing pulse peak current density under constant input power of 220W and pulse width of 100 μs. The pulse repetition frequencies were varied from 80 to 500 Hz to achieve the different peak current density of 0.5, 1 and 2 A/cm^2. After the confirmation of the different ion-to-neutral ratio by the optical emission spectroscopy for different peak current density, depositions of Ti and Al into the small hole structure with a width of 2mm were performed. Surface morphology and cross-sectional microstructure of the films on the inner wall were observed using scanning electron microscopy (SEM). Fabrication of the film cross-sectioning was performed by focused ion beam (FIB). As results, Ti film was deposited at maximum 5 mm of depth on inner wall under the condition with the highest ion-to-neutral ratio. On the contrary, Al was deposited at maximum up to 10mm of depth in the lowest ion-to-neutral ratio. The role of ionization of sputtered species and its effect on the particle trajectory into the small-hole structure are discussed by comparing the thickness distribution of Ti and Al film.

Keywords
HiPIMS
small hole
inner wall
peak current density
ion-to-neutral ratio