High-Power Pulsed Magnetron Sputtering Using Cooled and Hot Targets

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High-power pulsed magnetron sputtering of metallic films was systematically investigated. The depositions were performed using two unbalanced circular magnetrons of different types with a directly water-cooled planar copper or titanium target and a hot planar titanium target of 100 mm diameter. The repetition frequencies of the pulsed dc power supply were 1 and 10 kHz at a fixed 20% duty cycle and an argon pressure of 0.5 Pa. Large differences in measured values of the deposition rate per average target power density in a period (decreased 1.5 times for copper and 4.4 times for titanium) and the ionized fraction of target material atoms in the flux onto the substrate (up to 56% for copper and 81% for titanium), obtained for these two technologically interesting materials with the cooled targets under similar conditions, were explained on the basis of model predictions. The effect of the enhanced plasma confinement was elucidated. Moreover, it has been shown that an increase in the surface temperature (up to 1700 °C) of the hot titanium target, being heated by ion bombardment itself, resulted in a rise in the deposition rate (up to 1.9 times) at a decreasing average pulse voltage (up to 1.5 times) compared to the cooled target with the same average pulse target current density (up to 0.33 Acm^{-2}). The effects of enhanced sputtering, sublimation and evaporation of the target material on the deposition rate will be discussed.