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Effect of the enlarged target power densities during shortened voltage pulses on high power impulse magnetron sputtering of zirconium

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High power impulse magnetron sputtering of zirconium was investigated at a high average target power density in a period, being approximately 100Wcm^{-2}. The depositions were performed using an unbalanced circular magnetron with a directly water-cooled planar zirconium target of 100mm diameter. The repetition frequency was 500Hz at duty cycles ranging from 4 to 10% and an argon pressure of 1Pa. Time evolutions of the discharge characteristics were measured to provide information on absorption of energy in the discharge plasma and on transfer of arising ions to a substrate (located 100mm from the target) at an average target power density in a pulse up to 2.22kWcm^{-2}. Time-averaged mass spectroscopy was performed at the substrate position. High fractions (21-32%) of doubly charged zirconium ions at rapidly decreasing fractions (from 23 to 3%) of singly charged zirconium ions, and hence the total fractions (from 44 to 29%) of the zirconium ions, were found in total ion fluxes onto the substrate, when the average target power density in a pulse increased from 0.97 to 2.22kWcm^{-2}. It was shown that ion energy distributions are extended to high energies (up to 100eV relative to ground potential) under these conditions. The rise in the values of the average target power density in a pulse resulted in a decrease of the deposition rate of films from 590 to 440nm/min at a weakly decreasing ionized fraction (from 55 to 49%) of sputtered zirconium atoms in the flux onto the substrate.

Keywords
HiPIMS
Mass spectroscopy
Ion energy distribution
Deposition characteristics