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Low temperature growth of tungsten thin films in HiPIMS with synchronized pulsed substrate bias

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In the present study, efficient metal-ion-irradiation during film growth, and at the same time, reduction of gas ions irradiation, is demonstrated for high-power impulse magnetron sputtering (HiPIMS) by the use of synchronized, but delayed, pulsed substrate bias. In this way, the growth of high-quality polycrystalline W thin films at low substrate temperature (unheated) is demonstrated for both Ar and Kr atmospheres. The time evolution of ion and excited neutral densities in the pulsed sputtering process was characterized by the use of optical emission spectroscopy (OES) measurements. Here, the HiPIMS conditions used were a peak current density of 0.8 A/cm^2 a pulse width of 100 μs, and a frequency of 100 Hz. Based on the OES investigations, time delays of the negative substrate bias pulse of 50 V were selected to 30, 60, 90 and 120 μs. X-ray diffraction and scanning electron microscopy analyses revealed that the as-deposited W films consist of the alpha-phase with a preferred orientation of (110) and with a grain size ranging from 100-120 nm for the Ar process. In particular, with the delay time of 60 and 90 μs, higher crystallinity was confirmed in comparison with the other delay time conditions. Room-temperature electrical resistivity measured by four-point probe method could be correlated to the microstructural properties, which shows the lowest resistivity of 33.1 μΩ cm for a delay time of 60 μs. For the Kr process an even better results were obtained with larger grains (250 nm) and lower resistivity (14.2 μΩ cm).

Keywords
HiPIMS
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