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Material flux optimization in HiPIMS through the control of the magnetic field

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Various phenomena affecting deposition rate (r_d) in high power impulse magnetron sputtering (HiPIMS) were investigated as a function of the magnetic field (B) above a metal target. In this work, the value of B of a 50 mm magnetron was controlled by applying paramagnetic spacers with different thicknesses in between the magnetron surface and the Nb target, while using a constant discharge power of 500 W. A weaker B (a thicker spacer) led to an increase in r_d by a factor of ~4.5 (from 10.6 to 45.2 nm min^{-1}) compared to the configuration without any spacer. However, this maximum r_d value was still about 30% lower in comparison to the DC magnetron sputtering mode at an identical average power. We demonstrate that the r_d is governed by two processes depending on B: (i) attraction of target ions back to the target is the dominant effect leading to reduced r_d for strong fields B (i.e., high discharge current and low cathode voltage), while (ii) nonlinear dependence of the sputtering yield on the ion energy is the principal cause of the r_d loss for weak B values (i.e., low discharge current and high cathode voltage). In addition, we observed that a variation in the spatial distribution of the sputtered material needs to be considered for a correct interpretation of the experimental data. Maps of the material flux distribution for different B will be presented and discussed.

Keywords
high power impulse magnetron sputtering (HiPIMS)
deposition rate
niobium coating
return effect
yield effect