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Controlling the B/Ti ratio of TiBx thin films grown by high-power impulse magnetron sputtering

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TiB_x thin films grown from compound TiB_2 targets by magnetron sputter deposition are typically highly over-stoichiometric, with x ranging from 3.5 to 2.4, due to differences in Ti and B preferential-ejection angles and gas-phase scattering during transport from the target to the substrate. Here, we demonstrate that stoichiometric TiB_2 films can be obtained using high-power impulse magnetron sputtering (HiPIMS) in Ar. The B/Ti ratio x is controllably varied from 2.08 to 1.83 by adjusting the length of HiPIMS pulses t_{on} between 100 and 30 μs, while maintaining average power and pulse frequency constant. Energy- and time-dependent mass spectrometry analyses of ion fluxes incident at the substrate position show that the density of metal ions increases with decreasing t_{on} due to a dramatic increase in the peak target current density resulting in strong gas rarefaction. With t_{on} below 60 μs, film growth is increasingly controlled by ions, rather than neutrals, incident at the substrate. Thus, since sputter-ejected Ti atoms have a higher probability of being ionized than B atoms, due to their lower first-ionization potential and larger ionization cross-section, the Ti concentration in as-deposited films increases with decreasing t_{on} as ionized sputtered species are steered to the substrate by the plasma in order to maintain charge neutrality.

Keywords
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Pulse length
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