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Formation of Ar2+, ArTi+, and Ti2+ dimer ions in a dc magnetron discharge

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Formation of Ar^+ and Ti^+ monomer and of Ar_2^+, $ArTi^+$, and Ti_2^+ dimer ions in a magnetron discharge with a Ti target at argon gas pressures of 0.3–2.1 Pa was investigated by energy-resolved mass spectrometry. An unbalanced magnetron with diameter 50 mm was operated in direct current mode with a power of 150 W. Energy spectra of Ar^+ and Ti^+ ions show distinct features which are related to the specific formation processes taking place in the plasma region and during ion bombardment of the Ti cathode. Our observations proved that low-energy Ar^+ ions are produced inside the plasma region. The high-energy component of argon ions is attributed to sputtered or back-sputtered Ar atoms which subsequently become ionized in the plasma region. Ti^+ ions originate from sputtering events and the subsequent ionization far away from the cathode. The measured energy distribution of titanium ions does not follow Thompson's formula but at the lowest gas pressure the measured energy distribution can be modelled by a shifted Maxwellian distribution. Formation of Ar_2^+, $ArTi^+$, and Ti_2^+ dimer ions show pronounced pressure dependence which is attributed to various formation and loss processes inside the plasma region. Estimates show that associative ionization with excited argon atoms is the dominant formation mechanism. Ti_+^2 ions are formed by sputtering of Ti_2 dimers and the subsequent ionization in the plasma region. Ti_2^+ ions quickly thermalize with increasing gas pressure leading to an enhanced loss presumably due to reactions leading to particle growth.
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