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Reactive HiPIMS deposition of Ti-Al-N: Influence of the deposition parameters on the cubic to hexagonal phase transitionLukas Zauner¹, Tomasz Wojcik², Tomáš Kozák³, Jiří Čapek³, Hamid Bolvardi⁴, Szilárd Kolozsvári⁵, Paul Heinz Mayrhofer², Helmut Riedl¹

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The introduction of enhanced ionization rates during reactive high-power impulse magnetron sputtering (R-HiPIMS) allows for additional pathways in tuning the structural and chemical evolution by surface-diffusion driven growth. Hence, especially depending upon the charge state and mass-ratio of the metal-ions incident on the growing film, metastable thin films are decisively influenced in their overall growth characteristics. Here, we review in detail the dependence of the phase-stability (*i.e.* x_{max}) on varying deposition parameters during R-HiPIMS of Ti-Al-N thin films using $Ti_{1-x}Al_x$ composite targets. The influence of HiPIMS pulse parameters such as frequency, pulse length, or peak power density, but also of deposition parameters including N_2 partial pressure, substrate bias voltage, or target compositions were investigated methodically. The so obtained coating structures were analysed with respect to phase-stability, thermo- mechanical properties, and morphology applying nanoindentation, X-ray diffraction combined with electron imaging techniques. The systematic studies revealed an Al solubility limit of $x_{max} \sim 0.55$, obtained for a duty cycle of 3.75 % and a N_2 -to-Ar flow-rate ratio of 0.3. Moreover, sufficient intermixing of the arriving film species controlled via bias potentials was observed as decisive for the deposition of high Al containing *fcc*-structured coatings. Based on time- and energy resolved mass-spectroscopy measurements it can be concluded that the ratio and energy of Ti^{n+} - and Al^{n+} -ions, arriving simultaneously at the substrate surface, are highly influential for stabilising the preferred cubic modification with respect to the prevailing deposition conditions.

Keywords

R-HiPIMS

Mass-spectroscopy

Phase Formation