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Vacuum arc plasma generation and thin film synthesis from a TiB2 cathode

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Titanium diboride exhibit a hardness of up to ~50 GPa, and is promising for the next generation of hard and wear resistant coatings. However, the field is comparatively unexplored, primarily due to challenges associated with materials synthesis. Previously, deposition of TiB_2 coatings by physical vapor deposition (PVD) has been demonstrated by sputtering techniques. However, there is no reproducible synthesis of TiB_2 from arc evaporation, and from the reported few attempts on use of TiB_2 cathodes for thin film synthesis, extensive instability, cracking, and cathode failure can be concluded. In this work, we show analysis of the cathode, the plasma, and then film, for utilization of TiB_2 cathodes for thin film deposition in a DC vacuum arc system. Two routes for preventing a non-stable plasma generation are presented. First, in the absence of an external magnetic field, the observed rough cathode surface with sharp grains of TiB_2 crystals leads to dissipation of the arc, and consequently to reduction of heat and stress which prevents cracking. The study of cathode surface erosion is correlated to charge-state-resolved analysis of plasma ion composition and ion energy, macroparticle generation, as well as resulting film composition. Plasma analysis shows average ion energies of 115 and 26 eV for Ti and B, respectively, and a plasma composition of approximately 50 % Ti and 50 % B. This is consistent with the measured film composition, as obtained by X-ray photoelectron spectroscopy. A second route for stabilizing the plasma generation is by adding carbon to the TiB_2 cathode (1wt%). The stabilized synthesis process can be explained by the hindering of crack propagation and the increase of thermal shock resistivity. Altogether, the results are of importance for the use of cathodic arc as an efficient and useful method for synthesis of metal borides.

Keywords
vacuum arc
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