Effect of Reflected Ar Neutrals on Tantalum Diboride Coatings Prepared by DC Magnetron Sputtering

Katarína Viskupová[1, a)], Branislav Grančič[1], Tomáš Roch[1], Leonid Satrapinskyy[1], Martin Truchlý[1], Marián Mikula[1, 2], Viktor Šroba[1], Pavol Ďurina[1] and Peter Kúš[1]

[1] *Faculty of Mathematics, Physics and Informatics, Comenius University in Bratislava, 842 48 Bratislava, Slovakia*
[2] *Institute of Materials and Machine Mechanics, Slovak Academy of Sciences, Dúbravská cesta 9, 845 11 Bratislava, Slovakia*

[a)] *Corresponding author: katarina.viskupova@fmph.uniba.sk*

Abstract. Transition metal diboride (TMB_2) coatings are well known for their excellent physical properties such as high mechanical hardness, wear resistance and chemical stability at high temperatures, which makes them applicable as hard protective coatings for cutting tools used in machining of aluminum-, magnesium- or titanium- based alloys. These coatings are frequently prepared by magnetron sputtering from stoichiometric TMB_2 targets. However, it has been widely observed that the chemical composition of the resulting films differs from the target composition. The non-preservation of stoichiometry is caused by several mechanisms, such as different angular distribution of the sputtered B and TM atoms and different scattering probability during their transport to the substrate. In case of sputtering from targets containing heavy elements, the composition is also affected by energetic argon neutrals reflected from the target. When impinging on the growing film they cause re-sputtering of light boron atoms and reduction of the B/TM ratio. The resulting boron to metal ratio in the deposited coatings is an important factor influencing their structure and mechanical properties, therefore it is important to be able to control the composition during the film growth. In this work, we examine the effect of Ar neutrals reflected from TaB_2 target on the B/Ta ratio in magnetron-sputtered TaB_x coatings. Two targets with different thicknesses are used to influence the current-voltage characteristic of the discharge and the energy of the reflected Ar neutrals. It is demonstrated that the neutrals have a significant effect on the B/Ta ratio reduction from 1.9 to 1.4. In addition, external magnetic field from Helmholtz coils is applied, which promotes ionization of Ta atoms. The tantalum ions are then steered to the substrate, which also leads to reduction of the B/Ta ratio, but this effect is less significant in comparison to that of the Ar neutrals. While decreasing the B/Ta ratio, preferred TaB_x crystal orientation changes from (0001) to $(10\bar{1}1)$. Combination of significant substoichiometry and intense bombardment by Ar neutrals results in loss of crystallinity exemplified by diffraction maxima broadening. The variation of B/Ta ratio is accompanied by change of hardness and Young's modulus in range from 48 GPa to 32 GPa and from 532 GPa to 390 GPa, respectively. The coatings with B/Ta ratio < 1.6 show material pile-up around cube-corner indents, an indication for improved ductility.