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Influence of Substrate Temperature on Properties of W-Ti-B and W-Ta-B Coatings on Cemented Carbide Tools Deposited by HiPIMS

Abstract

Tungsten diborides are very promising candidates as protective coatings for tools in machining and forming. Alloying such material may not only affect its properties but also interface characteristics between coating and substrate. Here, we present deposition of $W_{0.76}Ta_{0.24}B_{2.5}$ and $W_{0.76}Ti_{0.24}B_{2.5}$ layers on cemented carbide cutting tools by high power impulse magnetron sputtering (HiPIMS). Targets used for deposition were manufactured via SPS. Coatings were deposited at substrate temperatures ranging from 200 to 500°C with step of 100°. During deposition the optical emission spectroscopy (OES) was performed to obtain characteristic signal of highly energetic plasma in HiPIMS process. Coatings properties were evaluated via nanoindentation and micropillar compression. Hardness of obtained films were heavily influence by substrate temperatures. Ta-alloyed coatings reached its maximum hardness of 41.3 GPa at 500°C while Ti-alloyed reached its maximum hardness of 42.7 GPa at 400°C. It was also revealed, by X-ray diffraction, that 300°C is the minimum temperature for obtaining crystalline layers. At 200°C hardness decreases below 30 GPa due to amorphous structure. Micropillar compression tests revealed that yield strength can reach 10.3 GPa. Additionally, coatings with addition of titanium have shown small range of plastic deformation during the tests. Such behavior is probably demonstrating relatively high fracture toughness of such material. It was further revealed via cube corner indentation that fracture toughness can reach 3.7 $MPa \cdot m^{1/2}$ for coatings alloyed with titanium. Adhesion of coatings was evaluated via scratch-test. While adhesion of coatings with addition of tantalum was better already at 300°C, titanium addition has caused the coatings to adhere significantly better at higher substrate temperatures.

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