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Properties of coatings and SPS sinters made of tungsten diboride alloyed with Ti, Cr, Mo, Re and Zr

R. Psiuk [1,*],M. Wiśniewska [2], D. Garbiec [2], T. Mościcki [1,]
[1] Institute of Fundamental Technological Research PAS, Warsaw, Poland
[2] Research Network Łukasiewicz Metal Forming Institute, Poznań, Poland

Abstract:
Tungsten borides due to theirs properties can be an alternative to superhard materials. While they possess high hardness, chemical and thermal resistance, they are easier to manufacture than diamond and cubic boron nitride. Tungsten borides in bulk form can be produced without employing high pressures (>5GPa), and in case of coatings there is no need to use processes with high plasma density. Tungnsten boride properties can be improved by alloying with various trasnsition metals, e.g. titanium (Figure 1). To enhance the properties of tungsten diboride (WB_2), we have synthesized and characterized solid solutions of this material with titanium, chromium, molybdenum, rhenium and zirconium. The obtained materials were subsequently deposited as a coatings. Various concentrations of these transition-metal (TM) elements, ranging from 0.0 to 24.0 at. %, on a metals basis, were made. Spark plasma sintering (SPS) was used to synthesize these refractory compounds from the pure elements. Elemental and phase purity of the both samples (sinters and coatings) were examined using energy-dispersive X-ray spectroscopy (EDS) and X-ray diffraction (XRD), and microindentation was utilized to measure the Vickers hardness under applied loads of 200 gf. XRD results indicate that the solubility limit is below 8 at. % for Mo, Re, Zr, and below 16 at. % for Cr. Above this limit both diborides $(W,TM)B_2$ are created. Addition of TM caused decrease of density and increase of hardness and electrical conductivity of sinters. Deposited coatings $W_{1-x}TM_xB_{2-z}$ (x=0.24, z=0.2—0.07) are homogenous, smooth, and hard. Coatings with addition of Mo, and Zr have hardness above 40 GPa. Addition of Cr increased the films hardness to 50 GPa. Coatings alloyed with Zr exhibits fracture toughness values of 2.11 $MPa*m^{1/2}$, which is value similar to TiN or CrN/TiN coatings.

Keywords: tungsten boride, superhard materials, spark plasma sintering SPS, magnetron sputtering

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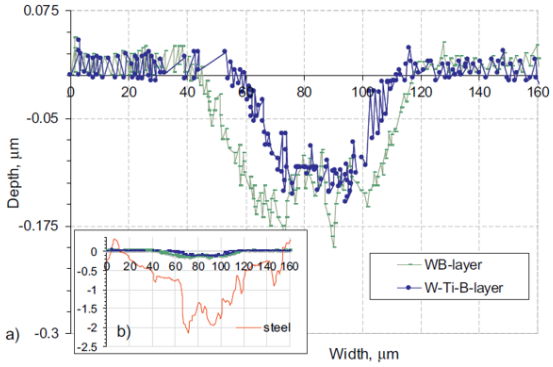

Figure 1: Figure illustrating the increase of wear resistance of tungsten diboride alloyed with titanium.

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