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The effect of substrate temperature on the properties of tungsten boride layers deposited by radio frequency magnetron sputtering and pulsed laser deposition

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Tungsten borides (W-B) with a hardness exceeding 40 GPa belong to the group of superhard materials. Moreover, it has been confirmed that (W-B) layers are about twice harder than the equivalent bulk material. Hence, W-B layers are presently under great interest. In this paper we present the effect of substrate heating on the properties of W-B layers deposited by laser pulse and magnetron.

All layers were deposited from the same target with the boron to tungsten ratio of 4.5. During the deposition the Si substrate was in room temperature or was heated up to 320°C or 540°C. In the pulsed laser deposition (PLD) process the Nd: YAG laser (λ = 355 nm, τ = 10 ns, fluence = 4.8 J·cm^{-2}, f = 10 Hz) has been used and the deposition process was occurred in vacuum. In the magnetron sputtering (MS) process the power supply to the magnetron cathode was 60 W and process occurred in argon pressure of $9.8 \cdot 10^{-3}$ mbar (gas flow of argon was 19.2 mL/min).

Layers deposited on unheated substrates were amorphous and had low adhesion. In SEM images many cracks and delamination have been observed. After heating the substrate up to 320°C both types of layers had better adhesion but their structures were different: MS layer was amorphous and PLD layer was partially crystalline (about 8%) where the crystal phase (CrPh) has been identified as WB_3 (cell parameters a = 5.204 Å, c = 6.300 Å). Further increase of the substrate temperature up to 540°C resulted in adhesion increase. The CrPh of PLD layer remained WB_3 and the CrPh content was 17%. MS layer was fully crystalline and the CrPh has been identified as WB (a = 3.128 Å, c = 16.559 Å).

Presented results indicate that to ensure good adhesion of W-B layers is required to heat the substrate at least up to 320°C. Moreover, the elemental composition of deposited layers is strongly dependent on the deposition method.

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