Mechanical performance of a WB_2-Al and WB_2-Ag composite coatings deposited by HiPIMS magnetron sputtering

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High-power pulsed magnetron sputtering is an effective engineering technique for improving the oxidation and wear resistance of metallic materials through the deposition of thin films [1].

In this work, WB_2-Al and WB_2-Ag composite coatings were fabricated by magnetron sputtering to mitigate the degradation of stainless steel under wear conditions while simultaneously increasing their thermal conductivity. The phase composition, microstructure, hardness, residual stress, and fracture toughness were measured. In the case of residual stress two methods were compared. The results of residual stress measurement with Laser Spallation Technique LST was compared with more common method using the modified Stoney equation. Additionally, wear resistance was systematically measured for various metal addition rates. At low metal addition amounts (1-8 at.%), the coatings deposited at 400°C were crystalline (polymorph P6mmm α-WB_2) and characterized by hardness exceeding 30 GPa. Further increasing the metal content resulted in the appearance of a second phase. The release of second phase could be detected, and the microstructure of the ceramic matrix changed to an amorphous one. The hardness and residual stress of the layer decreased, but wear resistance and measured by cantilever bending fracture toughness increased. For example, at room temperature, the wear rate of WB_2 coatings with an 8 %at. Ag coating is 6.563×10^{-6} $mm^3/(N\ m)$, approximately two orders of magnitude lower than the 8.175×10^{-4} $mm^3/(N\ m)$ of the substrate.

The metal addition and the oxide scale formed on the surface act as a lubricant. The introducing of a conductive metal to the ceramic matrix further increases the thermal conductivity of the deposited coatings. This work demonstrates that magnetron-sputtered WB_2-Al and WB_2-Ag composite coatings can improve the fracture toughness and simultaneously the wear resistance of steel materials. Hard and efficiently heat-conducting composite coatings made of W-B materials with Al or Ag filler may be good candidates for anti-radiation-related applications.

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