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Microstructure, Mechanical and Friction Behavior of Magnetron-sputtered V-C Coatings

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Abstract:

Transition metal carbides exhibit superior mechanical and tribological properties at a wide range of environmental conditions and contact pressures. More recently, vanadium carbide coatings have been considered for a number of industrial applications (e.g. automotive components, cutting tools, ball bearings) due to their high corrosion resistance and mechanical stability at elevated temperatures. While some studies have provided significant new insights on deposition methods of vanadium carbides, the friction and wear mechanisms of these coatings have received little attention. The goal of this study is to link micro- to macroscale tribology in order to provide an excessive understanding of the sliding mechanisms of various vanadium carbide-based (VC_{1+x}) coatings. More generally, we are studying the influence of V:C ratio over a wide range of normal loads and contact areas. The coatings are prepared using non-reactive d.c. magnetron sputtering with a segmented VC/graphite target (i.e. target diameter of 75 mm, 500 W target power, substrate temperature < 150°C, and Ar gas pressure of 0.6 Pa). The resulting V:C ratios vary between 1:1 and 1:3. The microstructures of the as deposited coatings are characterized using X-ray diffraction and cross-sectional focused ion beam imaging, while elemental analysis is performed by means of X-ray photoelectron spectroscopy, electron probe microanalysis, and micro-Raman spectroscopy. Mechanical properties measurements show that the hardness (H) and the reduced modulus (E_r) of the coatings decrease with increasing the carbon concentration (i.e. H ranges between 15 and 33 GPa and Er ranges between 239 and 391 GPa for the low and high vanadium concentration respectively), which correlates well with the adhesion results obtained from scratch tests. However, reciprocating micro- and macroscale tribological tests reveal higher friction values and increased wear with the high vanadium content coatings. This sliding behavior is attributed to differences in the third body formation and velocity accommodation modes, which are analyzed *ex situ* by means of XPS, micro-Raman spectroscopy and atomic force microscopy. The results obtained on the V:C coatings are compared to friction and sliding mechanisms in W:C systems.