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Design of carbide-based amorphous and nanostructured coatings

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Carbide-based coatings with transition metals often form a nanocomposite structure with nanocrystalline carbide grains in an amorphous matrix. Such coatings may exhibit excellent mechanical and tribological properties and have a use in a wide range of applications. Magnetron sputtering offers enormous possibilities to control the properties of the coating by a careful tuning of the size and distribution of the nanocrystalline grains and the matrix. We have earlier demonstrated how this can be achieved in TiC-based coatings by sputtering of supersaturated metastable solutions of metals with a weak carbide-forming ability (e.g. Al, Ni, Fe, Pt). Theoretical calculations as well as experiments show that it energetically favourable to remove carbon from the carbide leading to smaller grains and a more carbon-rich matrix. A potential use of such a concept is self-adaptive films which form a low-friction graphitic surface in a tribological contact. In the present paper we will summarize some recent theoretical and experimental results from our group on metastable carbide coatings prepared by magnetron sputtering in the Ti-Me-C system (Me = 3d transition metals). DFT calculations show that the general trends in stability including filling of antibonding states can explain the properties of the coatings. The calculations have been confirmed by e.g. tribological studies clearly demonstrating, for example, reduced friction and improved wear properties in e.g. the Ti-Ni-C system. Furthermore, some elements may induce a complete amorphization of the coating leading to a glassy carbide film. Although such films have been described earlier no systematic study of glass-forming ability (GFA) has been carried out. We will show trends in the GFA in several sputtered Me-X-C systems (Me = Zr, Nb, Cr, X= Si, B, Ti). The results show that a wide range of carbide glass coatings can be deposited with interesting physical and chemical properties including improved corrosion resistance.

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