RECENT PROGRESS IN HARD NANOCOMPOSITE COATINGS

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The paper reports on new advanced hard nanocomposite coatings. The paper is divided into two parts. The first part of the paper is devoted to the thermal stability of hard nanocomposite coatings and protection of the substrate against oxidation at temperatures above 1000°C. It is well known that the coating nanostructure is a metastable phase. It means that in the case when the temperature T under which the coating is operated achieves or exceeds the crystallization temperature, T_{cr}, the coating material starts to crystallize. This process results in destruction of the coating nanostructure due to the formation of large grains and/or to the change of the crystalline structure of coating. It is a reason why the nanocomposite coatings lose their unique properties and easily start to oxidize. The protection of the substrate against oxidation is perfect only in the case when the coating is amorphous. It is shown that (1) there are at least two groups of hard X-ray amorphous coatings (XRAC) based on nitrides with thermal stability T > 1000°C: (a) a-(Si_3N_4/MeN_x) coatings with high (≥50 vol,%) content of Si_3N_4 phase and (b) a-(Si-B-C-N) coatings with strong covalent bonds; here Me=Zr, Ta, Ti, Mo, W, Al, etc. and x=N/Me is the stoichiometry of MeN_x metal nitride phase, (2) XRAC exhibit considerably higher resistance against oxidation compared to that of crystalline coatings, (3) both a-(Si_3N_4/MeN_x) and a-(Si-B-C-N) coatings exhibit excellent oxidation resistance in flowing air; up to ~1500°C and ~1700°C, respectively, and (4) the coating material is thermally stable and exhibits no change in its properties as long as the coating structure does not change .

The second part of paper is devoted to the nanocomposites composed of small amount of nanograins dispersed in an amorphous matrix (AM) denoted as DNG/AM composites; DMG denotes the dispersed nanograins. These nanocomposites, due to low values of the effective Young s modulus E^* satisfying condition $H/E^*\geq 0.1$, are very elastic (the elastic recovery $W_e \geq 70\%$); here H is the coating hardness, $E^*=E/(1-\nu^2)$ is the Young s modulus and ν is the Poisson s ratio. The DNG/AM nanocomposites with $H/E^*\geq 0.1$ and low E^* containing a well lubricating phase exhibit the lowest values of (i) friction ($\mu \leq 0.1$), (ii) wear ($k \leq 2x10^{-7}$ mm^3/Nm) and (iii) erosion. The correlation between H, E^*, H^3/E^{*2} H/E^* and CoF, wear and erosion are discussed in detail.