MeSiBCN (Me: Ti, Cr, Al, Mo, Zr, Ta) NANOFILMS WITH HIGH WEAR-, OXIDATION- AND CORROSION RESISTANCE PRODUCED IN VACUUM USING SHS-CATHODES*

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The metal carbide, nitride, and boride coatings are the materials of choice for a wide variety of protective applications, especially for cutting/forming tools, automobile and aircraft mechanical components. These coatings demonstrate relatively low friction coefficient, high hardness (H), wear-, oxidation-, and corrosion- resistance. The oxidation resistance (OR) and thermal stability (TS) of coatings can be farther improved by Si or Al alloying. In this work we present a thorough study of nanocomposite and amorphous MeSiBCN (Me: Ti, Cr, Al, Mo, Zr, Ta) coatings deposited by direct current or pulsed magnetron sputtering, pulsed cathodic arc evaporation (P-CAE), IIAMS and HIPIMS of multiphase electrodes obtained using self-propagating high-temperature synthesis (SHS).

The simple boride, carbide, and silicide targets as well as multicomponent TiSiB, TiAlSiB, TiCrB, TiSiC, TiCrSiC, TiAlSiCN, MoSiB, MoAlSiB, MoHfZrSiB, ZrSiB, ZrAlSiB, ZrMoSiB, TaZrSiB, TaSiCN, TaSiBN, and CrAlSiB SHS-electrodes were sputtered in Ar, Ar-N_2, and Ar-C_2H_4 gas mixtures. The metal and non-metal model materials (alumina, silicon) were used as the substrates. To evaluate the OR and anti-diffusion properties the coatings were annealed in air or in vacuum at T=500-1700°C. The structure of as-deposited and annealed coatings was studied by XRD, SEM, HR-TEM, XPS, GDOES, FTIR, and Raman. The samples were characterized using nanoindentation, impact-, RT/HT tribo- and scratch-testing.

The results obtained show that TiSiBN coatings demonstrated H~30 GPa, good long-time OR at 900^0C, but exhibited a poor resistance to the metal atoms diffusion from the metal substrates. TiAlSiBN had extremely low crystallite size <3 nm and good OR at 1100^0C. CrAlSiBN, MoSiBN, and ZrSiBN showed hardness 30-40 GPa, and good OR in range 1200-1400^0C. CrAlSiBN revealed the best wear resistance in terms of cyclic impact loadings and in sliding conditions at room temperature. On the other hand MoSiBN showed the low wear rate and low friction coefficient at $T \geq 500^0$C due to formation of MoO_3 which play role of solid lubricant. Moreover MoSiBN successfully resisted to the diffusion of metal atoms from the substrate up to 1000^0C. Nitrogen-free ZrSiB, MoAlSiB, and MoSiB with high Si content exhibited record OR up to 1500, 1600, and 1700^0C, respectively. $TaSi_2$-based coatings demonstrated medium OR with maximal T=1100-1500°C and posses self-lubricant properties in temperature range of 100-500^0C. TiCrBN have H=35 GPa stable in range 20-1000^0C, good OR at 1000^0C, relative low friction coefficient ~0.4, and minimal wear rate $\sim 1.8 \times 10^{-7}$ mm^3/(Nm). TiAlCN coatings have the best combination of H~35 GPa and friction coefficient <0.25. TiAlCN remains stable up to 1200^0C. TiAlSiCN coatings exhibit H=37-42 GPa up to 1300^0C. Even after annealing at 1500^0C TiAlSiCN demonstrates acceptable H=20 GPa, and crystallite size <50 nm. For CrAlCN the H=25 GPa, high OR and diffusion-barrier properties up to 1000^0C were achieved. Best corrosion resistance in acid and alkaline environments were obtained for nitrogen-contained TiCrBN, TiAlCN, TiAlSiCN, and TiCrSiCN coatings.

The developed coatings are found to prolong the lifetime of WC-Co instruments by 2-7 times compared with the Ti(C)N coatings and to increase the work temperature of base materials onto 200-500^0C. Combination of relatively high H, remarkable TS, and OR resistance makes new materials promising candidates for protective coatings to be used in high-temperature tribological applications.

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