Diffusion-barrier properties and thermal stability of TiAlSiCN, TiAlSiCN/SiBCN, and TiAlSiCN/AlOx films

Ph.V. Kiryukhantsev-Korneev*, **K.A. Kuptsov, T.B. Sagalova, N.V. Shvindina, A.V. Bondarev**

National University of Science and Technology "MISIS", Moscow, Russia
*kiruhancev-korneev@yandex.ru

The Ti-Al-N protective coatings are widely used in practice (metal cutting and forming tools, roller bearings and other machine parts) because of their high mechanical and tribological properties, good thermal stability and excellent oxidation resistance. The Si incorporation into the Ti-Al-N coating resulted in the formation of nanocomposite structure with the (Ti,Al)N crystallites embedded in the amorphous SiN_x matrix. Nanocomposite structure of the Ti-Al-Si-N coatings promoted to the increasing of the hardness and maximal usage temperature. C-doped Ti-Al-N coatings are characterized by improved tribological properties due to the solid lubricant effect of the amorphous carbon. Recently developed Ti-Al-Si-C-N coating on Al_2O_3 model substrate show high thermal stability of structure and extremely high hardness ~40 GPa up to 1300°C. But for the practical application it's very important to have the high diffusion barrier properties of coatings. The aim of the present work is to investigate the diffusion barrier properties, thermal stability, and oxidation resistance of the Ti-Al-Si-C-N base coatings as well as multilayer (ML) TiAlSiCN/SiBCN and TiAlSiCN/AlOx coatings with additional layers which improve listed characteristics.

TiAlSiCN coatings were deposited using magnetron sputtering of composite targets produced by self-propagating high-temperature synthesis. ML coatings were manufactured by step-by-step magnetron sputtering (TiAlSiCN layer) and ion sputtering (SiBCN or AlOx layers). NiCrAlW disks and alumina plates were used as the substrates. To reveal the diffusion barrier properties and oxidation resistance the as-deposited coatings were subjected to the air annealing at temperatures from 800 to 1000°C. Additional thermo-cycling experiments for 20, 50, and 100 cycles (20-1000°C) were fulfilled. Thermal stability of coatings was estimated by vacuum annealing. The structure, chemical and phase composition of as-deposited and thermal-treated coatings were studied by means of glow discharge optical emission spectroscopy, X-ray diffraction, transmission and scanning electron microscopy. The coatings were characterised in terms of their hardness, elastic modulus, and elastic recovery.

Results obtained show that in the ML coatings the SiBCN and AlOx layers play role of the barriers against Ni diffusion from the substrate into the coating and thus significantly improve the thermal stability of whole ML coating. TiAlSiCN/SiBCN and TiAlSiCN/AlOx coatings on Al_2O_3 substrates also demonstrate better oxidation resistance (critical temperature of 1100°C) and thermal stability (1400°C) than basic TiAlSiCN coating. Combination of high diffusion barrier properties, high oxidation resistance and mechanical properties makes TiAlSiCN/SiBCN and TiAlSiCN/AlOx coatings promising candidates for protective purposes to be used in different high-temperature applications.