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Mechanical properties and oxidation resistance of CrAlN/BN nanocomposite coatings prepared by reactive d.c. and r.f. co-sputtering

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Nanocomposite coatings of transition metal boron nitride (TM-B-N) such as TiBN, TiAlBN and CrBN, which exhibit excellent combination of superior mechanical, chemical and tribological properties, have drawn considerable amount of attention in the last decade. Their properties are dependent on the chemical composition and microstructure, in other words, on deposition apparatus and preparation conditions. Most of these coatings were prepared by d.c. reactive sputtering using metal/boride target in the former study. However, it seems to be difficult for the conventional reactive sputtering to control the ratio of TM-N and B-N phases, because the tendency of phase formation depends on the formation free energy even in the sputtering process as a highly non-equilibrium phenomenon. CrBN coatings, which were prepared by the reactive sputtering using chromium boride target, were reported to exhibit a moderate hardness in the range of 10 to 25 GPa resulting from the preferential formation of amorphous BN phase, while CrAlN/BN nanocomposite coatings by a reactive co-sputtering using $Cr_{50}Al_{50}$ alloy and h-BN targets attained super high hardness. CrAlN and BN phase was deposited by pulsed d.c. and r.f. sputtering, respectively. XRD and SAED analysis indicated that the coating consists of very fine grains of B1 structured Cr(Al)N phase having a strong preferred orientation. Cross sectional view TEM observation clarified that the coating showing the highest hardness has a fibre-like structure consisting of grains of ~20nm in width and about 50nm in length. XPS analysis revealed that the coating consists mainly of CrAlN and h-BN phase. Plastic hardness, H_{pl}, and effective Young's modulus, E*, of the coatings increased with BN phase ratio, reaching a maximum value of 48 GPa and 390 GPa at 8 vol. % of BN phase; and then decreased moderately to about 40GPa and 350GPa at 18vol% of BN, respectively. Furthermore, CrAlN/BN coatings showed superior oxidation resistance compared to CrAlN coatings: After an annealing at 800 ºC in the air for 1 hour, the plastic hardness of CrAlN coatings decreased to 50% of as-deposited hardness; on the other hand, the hardness of CrAlN/BN nanocomposite coatings maintained or increased attaining super high value over 50 GPa. After an annealing at 900 C for 1hour, the hardness of all coatings decreased to about 40%.

Keywords
CrAlBN
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