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High temperature oxidation-resistance and tribology of the Zr-Cr-Al-N coatings

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Zr-Cr-N coatings have been considered promising to be used on cutting tools if combined properties of CrN and ZrN coatings could be achieved. Now, low onset oxidation temperature is the main restriction. An improvement in oxidation-resistance can be acquired in most coatings by the introduction of Al being expected the formation of protective Al_2O_3 scales which can separate the coatings from the oxidant atmosphere. Thus, in the present paper different Al contents were added into Zr-Cr-N coatings deposited by reactive magnetron sputtering method, and oxidation-resistance of the coatings was evaluated by high temperature oxidation tests at 700, 800 and 900 °C. The tribological tests were conducted at room temperature, 500 and 700 °C, respectively. The results showed that the introduction of Al element did not improve short-term oxidation-resistance of the coatings due to a premature formation of ZrO_2 on the coating surface. However, long-term oxidation tests demonstrated that a better oxidation protection of the coatings could be achieved with the highest Al content. During 20 h thermal exposure at 800°C in air, the mass gain kept a low value and a dense Al_2O_3 scale was found on the surface of the highest Al content coating. On the Al-free or low Al coating, mixed oxides including Zr, Cr and metal elements from substrate were detected. After 5000 lap pin-on-disc sliding test, the highest Al content coating was almost worn out. As compared, the low Al coating exhibited better performance during tribological test. The friction coefficient and wear rate were 0.66 and 11.1 x 10^{-6} mm^3/Nm, and 0.86 and 12.9 x 10^{-6} mm^3/Nm for room temperature and 500°C tests, respectively. The high temperature tribology behavior was correlated with either the E/H ratio or the early-stage oxidation products.

Keywords
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