Abstract

(Cr$_{0.5}$Al$_{0.5}$)$_{1-x}$Si$_x$N coatings with Si contents from 0-11.5 at. % were deposited on Inconel 718 by RF magnetron co-sputtering. In ball-on-disc wear tests, increased friction coefficient of (Cr$_{0.5}$Al$_{0.5}$)$_{1-x}$Si$_x$N coatings with increasing Si content at high temperature was revealed, owing to the occurrence of tribochemical reaction which is verified through XPS analysis. The calculated yield pressure of CrAlSiN coatings was proportional to the wear resistance at ultra-high temperature(500 °C, 850 °C and 950 °C). CrAlSiN coatings with maximum yield pressure by adding 9.0 at. % Si exhibited superior resistance to plastic deformation and wear. Moreover, the formation of protective third-layer on the surface resulted in the extremely low wear rate at 850 °C and 950 °C. On the basis of these improved tribological behaviors, the superior durability of (Cr$_{0.5}$Al$_{0.5}$)$_{1-x}$Si$_x$N coating is thus demonstrated.

Results & Discussion

Tribological Characterizations

- The wear rate of CrAlSiN with 9 at.% Si content was minimum.
- The wear rate testing at 850 °C and 950 °C was smaller than 500 °C.
- The wear resistance of CrAlSiN coatings was dependent on the resistance to plastic deformation.
- Controlling Si content to 9 at. % to obtain best high temperature tribological properties.

Experimental Procedure

- The CrAlSiN coating was protected by tribo-oxide layer, resulting in low wear rate of coating at high temperature.
- The third-body layer of Si(OH)$_4$ was known to be a self-lubricating layer when tested at room temperature.
- The Si(OH)$_4$, which was known to be a self-lubricating layer at room temperature, was not observed.

Experimental Procedure

Characterizations of CrAlSi$_x$N coatings

- The maximum yield pressure of CrAlSiN2 with 9 at.% Si addition reached 8336 nm$^2$-GPa and it was 40% higher as compared with the CrAlN coating.
- The friction coefficient increased with the Si content at 500 °C, 850 °C and 950 °C owing to the absence of lubricating Si(OH)$_4$.
- The wear rate decreased at temperature above 850 °C because of the formation of oxidation layer, which provided better resistance to deformation.
- The wear resistance of CrAlSiN coatings was related to the resistance to plastic deformation, in which the CrAlSiN coating with 9 at.% Si content exhibited the lowest wear resistance and appropriate COF.

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