TiAlSiN 코팅의 대기중 고온산화 속도와 스케일 분석

High-temperature Oxidation Kinekics and Scales Formed on the TiAlSiN film

지권용*, 박상환, 김민정, 박순용, 정승부, 이동복
성균관대학교 신소재공학과(E-mail: kwony@skku.edu)

초 록: $Ti_{0.26}Al_{0.16}Si_{0.01}N_{0.57}$ (at%) coatings were synthesized on stainless steel 304 by using arc ion plating systems (AIPS). Targets employed for the deposition were Ti, AlSi(67:33at%) and AlSi(82:18at%). The thickness of TiAlSiN coatings is 4㎛. The oxidation characteristics of the deposited coatings were studied by thermogravimetric analysis (TGA) in air between 800 and 900 °C for 75 hr. The oxide scale formed on the TiAlSiN coatings consisted of rutile-TiO_2 layer and α-Al_2O_3. At 800 °C, the coatings oxidized relatively slowly, and the scales were thin and adherent. When oxidized above 900 °C, TiO_2 grew fast over the mixed oxide layer, and the oxide scale formed on TiAlSiN coatings was prone to spallation. Microstructural changes of the TiAlSiN coatings that occurred during high temperature oxidation were investigated by EPMA, XRD, SEM and TEM.

1. 서론

Transition metal nitride films such as TiN and CrN are widely used for cutting tools or die molds because of their high hardness and superior resistance to wear and corrosion, however they are inevitably degraded by oxidation during service at high temperatures.[1] To further increase the oxidation resistance, nano-multilayered CrAlSiN, AlTiSiN, TiAlCrSiN films were deposited on a steel substrate by the cathodic arc plasma process, and their high-temperature oxidation behavior was studied by oxidizing in air between 800 and 900°C using TGA in this study. It is important to note that nano-multilayered films are of increasing interest due to their superior mechanical and lubrication properties in advanced tribological applications where single layer films are in sufficient. The oxidized films were characterized by XRD, XPS, AES, EPMA, and TEM.

2. 본론

Figure 1 shows the SEM/TEM/XRD results of the film. Surface grinding marks that were made prior to deposition were visible owing to the film thinness, along with microdroplets (Fig. 1a). The film consisted of a few nanometer-thick, alternating Al-Si-N/Ti-Si-N nanocrystalline layers parallel to the substrate surface (Fig. 1b).

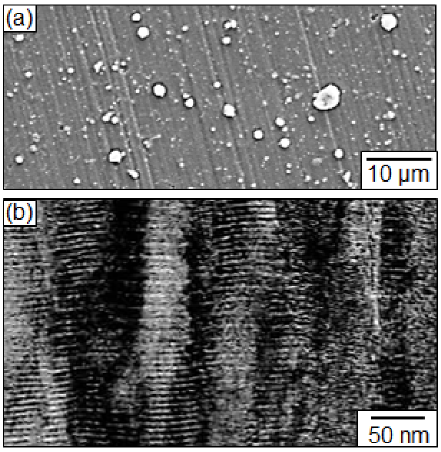

Fig. 1 TiAlSiN film deposited on the steel substrate. (a) SEM top view, (b) cross-sectional TEM image.

Figure 2 shows the AES depth profiles of the film after oxidation at 800°C for 5h. During oxidation, nitrogen diffused outward to escape from the surface, and oxygen diffused inward. Based on the maximum concentration point of noble Au, it is seen that the outwardly diffusing Al^{3+} ions formed the outer most Al_2O_3 layer, while the inwardly diffusing O^{2-} ions formed the underlying oxide layer. The high-temperature oxidation resistance of the film mainly depends on α-Al_2O_3, which grows very slowly due to its highly stoichiometric structure. SiO_2 also resists oxidation but was not identified by AES due to its small amount.

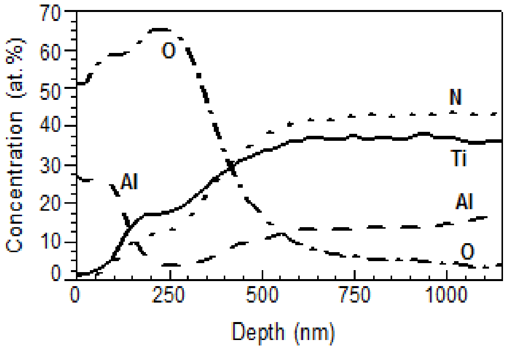

Fig. 2 AES depth profiles of the TiAlSiN film after oxidation at 800 °C for 5 h.

3. 결론

The $Ti_{.26}Al_{.163}Si_{.012}N_{.565}$ thin film initially oxidized to an α-Al_2O_3 layer containing some TiO_2 through the outwardly diffusing Al and some Ti ions, below which a rutile-TiO_2 layer containing some Al_2O_3 formed through inwardly diffusing oxygen ions at 800°C. Later, another TiO_2-rich surface layer formed over those preformed (Al_2O_3-rich)/(TiO_2-rich) bilayers, because Ti continuously diffused outward from the film. Silicon tended to accumulate underneath those oxide layers, due to its thermodynamic nobility. At 900 °C, the oxidation rate increased with partial scale spallation. The outer TiO_2 layer, the intermediate Al_2O_3 layer, and the inner TiO_2-rich layer intermixed with some Al_2O_3 and SiO_2 formed at 900 °C.

감사의 글

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참고문헌

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