

TiC, TiN, CrN, TiCrN, TiAlN 코팅의 산화특성

Oxidation Characteristics of TiC, TiN, CrN, TiCrN and TiAlN Coatings

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초 록: 공구, 다이몰드 등에 널리 쓰이는 TiC, TiN, CrN, TiCrN, TiAlN 코팅의 산화특성을 비교하기 위하여 600°C-900°C에서 대기중 산화시험을 실시하였다. 내산화성은 (TiC, TiN), TiAlN, TiCrN, CrN 코팅의 순서로 증가하였다. 코팅원소중 Ti는 TiO_2 로, Cr은 Cr_2O_3 로, Al은 Al_2O_3 로 산화되었다.

1. 서론

To improve the performance and service life of cutting tools or die molds, coating materials which have good mechanical, thermal and chemical properties are being used. Presently, coatings widely used or studied are TiC [1], TiN [2], CrN [3], TiCrN [4] and TiAlN [5]. These coatings are normally exposed to air at elevated temperatures during service, so that the oxidation resistance is of increasing importance in practical applications. The aim of this study is to understand and compare the oxidation resistance and kinetics of TiC, TiN, CrN, TiCrN and TiAlN coatings.

2. 본론

A thin Ti plate was used as a target and a substrate to deposit TiN and TiC coatings via D.C. magnetron sputtering method. Coatings of CrN, TiCrN and TiAlN were deposited on a STD61 steel substrate by arc ion plating. A CrN coating using a Cr target, a TiCrN coating using Ti and Cr targets, and a TiAlN coating using Ti and Al targets were prepared by discharging plasma under an identical gas pressure of 5×10^{-4} torr of 100%N₂. The prepared five kinds of coated specimens were oxidized isothermally between 600 and 900°C in 1 atm of air. The oxidation characteristics were inspected by TGA, SEM, EDS and XRD.

Fig. 1 shows that the CrN coating has a relatively thin Cr_2O_3 scale, even after oxidation at 900°C for 200 hr. Some microscopic voids are seen to be scattered around the oxide scale-unreacted coating interface.

As shown in Fig. 2, a relatively thick oxide scale formed on the TiCrN coated specimen when compared with the CrN coating. The outer scale is essentially pure TiO_2 , whereas the inner scale is Cr_2O_3 -rich, TiO_2 -deficient. During oxidation, the more active element of Ti oxidized selectively to TiO_2 and covered the entire outer surface. Beneath the TiO_2 layer, the less active element of Cr progressively enriched and oxidized to Cr_2O_3 .

Since the TiAlN coating had relatively poor oxidation resistance, serious oxidation occurred noticeably at 900°C, as shown in Fig. 3. It is noted that the oxidation time of Fig. 3 is the shortest among Figs. 1-3. The thick oxide scale formed consisted of Fe_2O_3 , TiO , TiO_2 and $\alpha-Al_2O_3$. The original coating layer was completely oxidized, and embedded in the oxide scale. The position of the original coating was traced by placing fine platinum markers on the coating prior to oxidation.

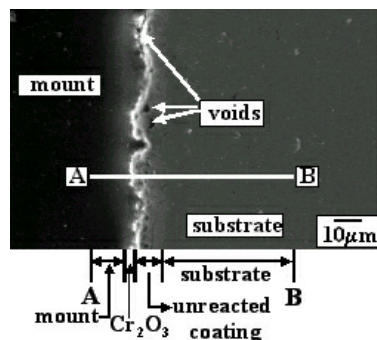


Fig. 1. SEM cross-sectional image of the CrN coated specimen after oxidation at 900°C for 200 hr.

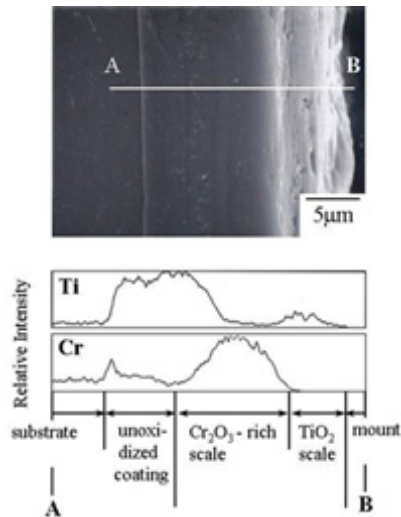


Fig. 2. SEM cross-sectional image and EDS line profiles of the oxide scale formed on the TiCrN coated specimen after oxidation at 900°C for 100 hr.

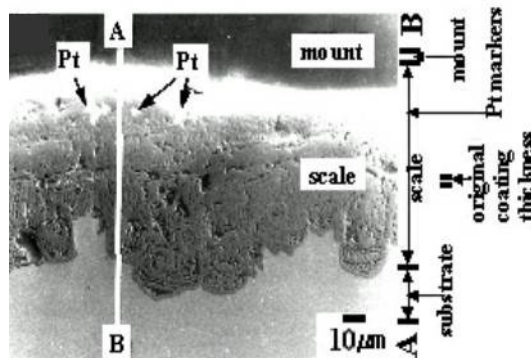


Fig. 3. SEM cross-sectional image of the TiAlN coated specimen after oxidation at 900°C for 40 hr.

3. 결론

The oxidation behavior of TiC and TiN coatings deposited on a titanium substrate was investigated between 600 and 800°C in air. Both TiC and TiN coated specimens oxidized quite similarly. These coatings were completely oxidized to TiO₂, and serious oxidation deep into the substrate was noticed. The oxidation behavior of CrN, TiCrN and TiAlN coatings deposited on a STD61 steel substrate was investigated at 800 and 900°C in air. The oxidation resistance increased in the order of TiAlN, TiCrN and CrN. The TiAlN, TiCrN and CrN coatings oxidized to TiO₂ and α-Al₂O₃, TiO₂ and Cr₂O₃, and Cr₂O₃, respectively. Since TiO₂ is a semiprotective oxide, it can not play a major role in protecting the substrate. The α-Al₂O₃ layer formed on the TiAlN coating was too thin to protect the coating from oxidation, so that the oxidation resistance of TiAlN decreased rapidly at 900°C. The Cr₂O₃ layer formed on the TiCrN or CrN coating effectively improved the oxidation resistance. Particularly, the CrN coating displayed excellent oxidation resistance.

감사의 글

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