A New Method for Preparation of TiAlN/Ti Films

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TiAlN/Ti 薄膜の作製方法

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1. Introduction

Ceramic hard coating by PVD or CVD has been widely used in the field of the mechanical operations, die-casting and other process which experience wear, cracking and oxidation in various applications. TiN film is the most common film used for ceramic hard coating, but recently some films which overcome the deficiencies of TiN films, have been investigated. A TiAlN film is one of the investigated films and because of its improved properties, this film has already become widely used in many mechanical processes¹⁾. TiAlN is superior to TiN in enduring high temperature, oxidation levels (about 1100K) and high productivity, leading to increased production stability. In this paper, Ti-interlayer, which is commonly used in the deposition of TiN film²⁾, is applied to TiAlN film deposition by the new sputtering method and the improvement of the adhesive properties are investigated.

2. Experimental

2. 1 Dynamic plasma cathode

A dynamic plasma cathode which is shown in Fig. 1 has been developed. By using this cathode, TiAlN/Ti film can be obtained by only one sputtering cathode apparatus. Two solenoid coils are equiped in the cathod, and plasma on the target can be confined easily in the outside or the inside of the target by changing the currents to the coils. A unique target shown in Fig. 1, was used for this experiment. Ti films are obtained when the plasma is confined in the

Fig. 1 Schematic diagram of the dynamic plasma cathode.

outside of the target and TiAlN films are obtained when the plasma is confined in the inside of the target.

The ion current density at the substrate is controlled by the current of the solenoid coils, namely the position of the plasma on the target. The ion current density increases as the plasma is confined in the inner side of the target, and the maximum ion current density is about 1mA/cm^2 at the bias voltage of -100V to the substrate. The ion bombardment during film deposition enhances the surface diffusion of sputtered atoms on the film surface. This effect is equivalent to raising the substrate temperature which leads to improvement of the crystallographic quality of films. Accordingly, the TiAl target is set in the inside of the target to improve the properties of TiAlN films.

2. 2 Film deposition

The dynamic plasma cathode of 5-inch diameter was used. The sputtering chamber was evacuated to 5×10^{-4} Pa before film deposition by the 8-inch diffusion pump. A high speed steel SKH 51 of $9 \times 21 \times 5\text{mm}$ in size was used as the substrate and was polished by the 400~1000 emery paper and 9 and $3\text{ }\mu\text{m}$ diamond paste. To achieve proper adhesion, the sputter cleaning of the substrate surface was performed by applying the bias voltage to the substrate in a pure Ar atmosphere. The TiAlN/Ti films were deposited at the substrate temperature ranging from

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Fig. 2 Depth profile of the TiAlN film.

R. T. to 400°C in a $N_2 + Ar$ mixed gas atmosphere. The vacuum pressure during sputtering was 2.6×10^{-1} Pa, and the sputtering power was 875W. The substrate bias voltage was -100V, at which the ion assist to film growth was effective but the resputtering of films is negligible. The coil current of the cathode was adjusted to obtain $\sim 2000 \text{ \AA}$ thick Ti interlayers, and the thickness of TiAlN films was $\sim 2 \mu\text{m}$.

2. 3 Measurement

The depth profile of the composition of films were measured by Auger electron spectroscopy (AES). For evaluation of the adhesion, the scratch test was chosen. A commercial LSRH Revetest scratch tester is used with Rockwell C diamond (tip radius of 0.2mm and cone angle of 120°).

3. Results and Discussion

The depth profile of compositions for the TiAlN/Ti film measured by AES is shown in Fig. 2. From this figure, it is found that the Ti-interlayer between the TiAlN film and the substrate was successfully formed by this method.

Fig. 3 shows the results of the scratch test. The samples of Fig. 3 (a) and (b) are the TiAlN film without a Ti-interlayer and the TiAlN/Ti film respectively. The load applied to the tip of

Fig. 3 Photographs of the (a) TiAlN and (b) TiAlN/Ti film after the scratch test.

the scratch tester detachment was changed in a range of 20~60N. The TiAlN film without the Ti-interlayer peeled off from the substrate SKH51 and the critical load was as low as 30N. On the other hand, the TiAlN film with the Ti-interlayer has very superior adhesion and no detachment was observed until 60N, although the trace of scratch like a shell was left in some samples. This result indicates that the Ti-interlayer obviously improves the adhesion of TiAlN films.

4. Conclusion

A new sputtering method for TiAlN coating is proposed in this paper. For this method, TiAlN/Ti films can be easily deposited without the complicated sputter apparatus by using only one target. The Ti-interlayer between the TiAlN film and the substrate was found to improve the adhesion of TiAlN films on the high speed steel.

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