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Influence of processing parameters for adhesion strength of TiN films prepared by AIP technique

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초 록: The arc ion plating (AIP) technique has been used widely for thin coating in the area of surface engineering. The TiN coating is important in the field of dies, cutting tools and other mechanical parts. When forming the TiN films by AIP technique, the processing parameters such as arc power, bias voltage, working pressure, temperature of substrate and pre-treatment affected the adhesion respectively. The results of scratch test revealed that the adhesion strength was influenced by arc power most strongly. And a sequence of the importance of each parameters has been obtained. The crystal structure and cross-section of TiN films are also be investigated.

1. 서 론

The arc ion plating (AIP) technique has been used widely for thin coating in the area of surface engineering, especially for the deposition of wear-resistant coating onto cutting tools, dies and forming tools. This method is fast, efficient, and relatively cost effective, providing attractive mechanical properties for the depositing of functional thin films [1].

In recently decades, this arc ion coating technique has been concentrated on the synthesis of titanium nitride (TiN). This coating is of high hardness and low friction coefficient, and this coating has spread broadly for the high speed cutting tools. In this work, the TiN coatings were deposited by using an AIP technique for the purpose of searching the relationship between the adhesion strength and processing parameters.

2. 본 론

2.1 Experiment

The SKD61 steel has been selected and polished until 1 μm polishing disc to get the mirror plates of surface as the substrates for the coating. The TiN films are deposited on the substrates by using the AIP system shown in Fig.1. Six processing parameters are set, they are pre-treatment voltage (V) and time (minutes), arc power (A), bias voltage (V), working pressure (torr) and temperature of substrate (℃). Total 18 times of experiments desighed by Taguchi program have been completed.

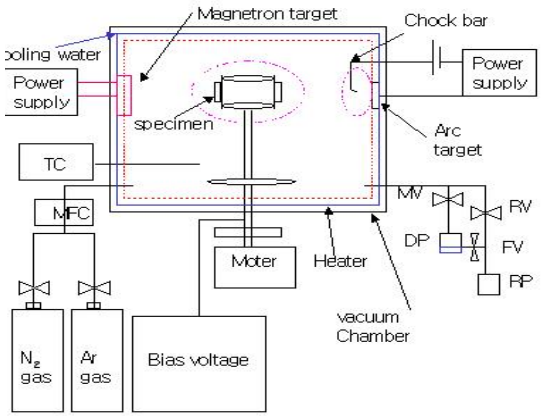

Fig.1 Schematic diagram of AIP system

The surface morphologies and cross-section images of the coatings are observed by scanning electron microscopy (SEM). The crystal structures of the coatings are characterized by X-ray diffraction (XRD) equipment. The adhesion strength between films and substrates are obtained by linear scratch tester (RST S/N: 27-0510).

2.2 Results:

2.2.1 The surface morphology and cross-section of TiN films.

Fig.2 (a) indicates the surface morphology of TiN films after coatings. It is significant that there are some macro-particles on the TiN films. Fig.2 (b) shows that the TiN films is distributed uniformly on the SKD 61 substrate by SEM micrograph. From the 18 times of experiments, the average value of thickness of TiN films is 2.07 μm.

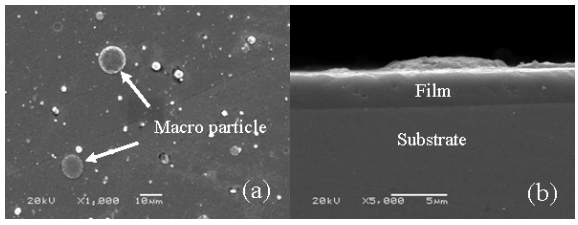

Fig.2 a) surface morphology and b) cross-section of TiN films

2.2.2 The crystal structure of TiN films

Fig.3 shows the XRD patterns of the TiN films under the typical condition shown in Tab.1.

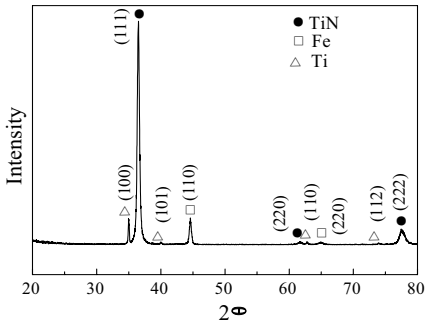

Fig.3 The XRD patterns of typical TiN films

The TiN with strongest preferred orientation of (111) has been detected. Also the weak peak of (220) and (222) could be observed. Simultaneously the peak of pure titanium exists in the films. However, the element of iron could be detected though the TiN films do not contain this element. This can be explained by the reason that TiN films is so thin (about several μm) that the substrate (tool steel) could be detected by XRD equipment.

Table.1 Parameter of typical deposition

Parameter	Value	Unit
Pre-treatment voltage	100	V
Pre-treatment time	15	minute
Arc power	60	A
Bias voltage	450	V
Temperature of substrate	320	℃
Working pressure	5×10-3	torr

2.2.3 The influence of the processing parameters

The critical load are considered as the ruler for evaluating the adhesion strength of TiN films and substrates. When the stylus of tester are translated along the sample with increasing loading, the critical load (Lc) value indicates the load where the stylus just touch the substrate. This can be found from another works [2].

The results of linear scratch test are presented in Fig.4. In the 18 times of experiments designed by Taguchi program, each parameter has 3 levels. For adhesion strength, the sequence of the importance can be obtained from the difference between

maximal and minimum value for each parameter. It is Iarc > t(pre) >VB(pre) > Pwork(N2) > Vbias> Tsub.

From Fig.4, it is obvious that the arc power influences the critical load most strongly. Compare to

it, the effect of temperature of substrate, bios voltage and working pressure is weaker. Besides, although the

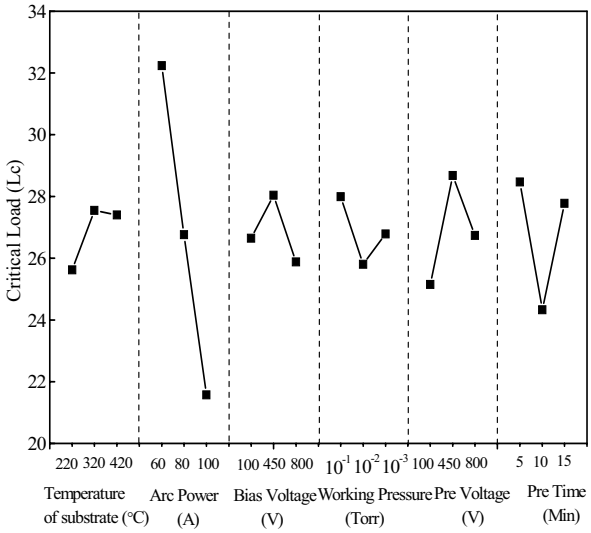

Fig.4 The influence of each parameter for critical load during scratch test

effect of pre-treatment time and pre-treatment voltage is not as strong as arc power, they are stronger than others. This result illuminates that the activity of surface according to pre-cleaning and pre-ion bombardment is valuable.

3. 결 론

The TiN films with average thickness of 2.07 μm have been coated on the substrates of SKD 61 tool steel.

From XRD analysis, the preferred orientation of films is (111), with other orientations of (220) and (222). And the elements of Ti and iron can be detected in typical condition.

The sequence of importance to influence the adhesion is Iarc > t(pre) >VB(pre) > Pwork(N2) > Vbias > Tsub. The arc power is the most important parameter for adhesion strength between TiN films and substrates. And pre-treatment is also important.

감 사 의 글

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참 고 문 헌

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