Influence of processing parameters for adhesion strength of TiAlN films prepared by Arc Ion Plating

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Abstrsct : Wear resistant TiAlN thin film has been widely deposited on the surface of cutting and forming tools by using Arc Ion Plating. TiAlN films are deposited by the processes designed by the Taguchi L18 experimental design. The L18 experimental design is applied to achieve surface properties and adhesion. The deposition parameters are working pressure, substrate temperature, bias voltage, arc power and pre-sputtering bias voltage and time. The most influential parameters on surface properties and adhesion are substrate bias voltage, working nitrogen pressure and arc power. The optimal coating processes are obtained for surface properties and adhesion.

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 TiAlN 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 TiAlN 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 designed by Taguchi program(Table. 1,2) have been completed.

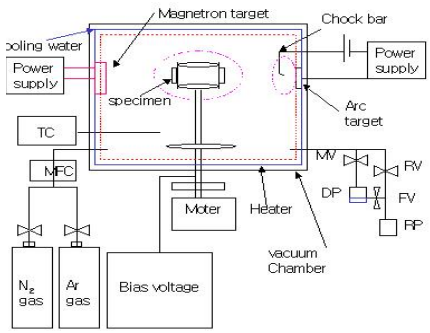

Fig.1 Schematic diagram of AIP system

The surface morphology 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).

Table. 1 Taguchi L18 experimental design: design number

Experimental no.		Variable							
std	run	H	A	B	C	D	E	F	G
1	7	1	1	1	1	1	1	1	1
2	12	1	1	2	2	2	2	2	2
3	2	1	1	3	3	3	3	3	3
4	6	1	2	1	1	2	2	3	3
5	10	1	2	2	2	3	3	1	1
6	17	1	2	3	3	1	1	2	2
7	18	1	3	1	2	1	3	2	3
8	15	1	3	2	3	2	1	3	1
9	4	1	3	3	1	3	2	1	2
10	9	2	1	1	3	3	2	2	1
11	14	2	1	2	1	1	3	3	2
12	3	2	1	3	2	2	1	1	3
13	8	2	2	1	2	3	1	3	2
14	13	2	2	2	3	1	2	1	3
15	11	2	2	3	1	2	3	2	1
16	5	2	3	1	3	2	3	1	2
17	16	2	3	2	1	3	1	2	3
18	1	2	3	3	2	1	2	3	1

Table. 2 The Taguchi L18 experimental design: variables

Variable	Design number		
	1	2	3
A: Pre-treatment voltage(V)	-100	-450	-800
B: Pre-treatment time(minute)	5	10	15
C: Arc power(A)	60	80	100
D: Bias voltage(V)	-100	-450	-800
E: Temperature of substrate (℃)	220	320	420
F: Working pressure(torr)	5×10^{-1}	5×10^{-2}	5×10^{-3}

2.2 Results:

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

Fig.2 (a) indicates the surface morphology of TiAlN films after coatings. It is significant that there are some macro-particles on the TiAlN films. Fig.2 (b) shows that the TiAlN films is distributed uniformly on the SKD 61 substrate by SEM micrograph. From the 18 times of experiments, the average value of thickness of TiAlN films is 2.03μm.

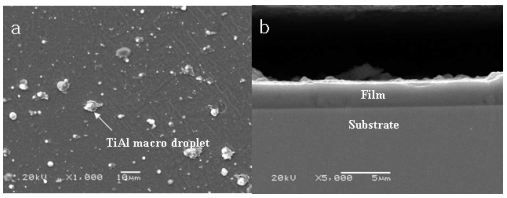

Fig.2 a) surface morphology and b) cross-section of TiAlN films

2.2.2 The influence of the processing parameters

The critical load are considered as the ruler for evaluating the adhesion strength of TiAlN 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 bias voltage and working pressure is weaker. Besides,

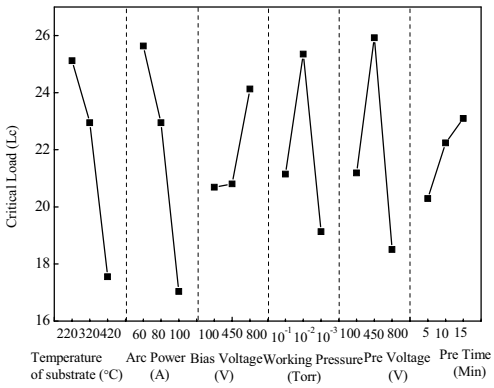

Fig. 3 The influence of each parameter for critical load during scratch test

although the 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 TiAlN films with average thickness of 2.03μm have been coated on the substrates of SKD 61 tool steel.

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

감 사 의 글

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