cathode 아크 방법에 의해 증착된 TiN 박막에 대한 기판 바이어스 효과
The effect of substrate bias for titanium nitride thin films deposited by cathode Arc method

한경훈*, 박민석, 여기호, 전영하
(주) 제이앤엘테크 플라즈마 연구소

1. Introduction

The mechanical properties of Titanium nitride (TiN) thin films, known as a wear resistant hard coating, strongly depend on the deposition conditions [1 - 3]. The major process parameters include substrate temperature, process pressure, and substrate bias, etc. Especially, bias voltage has been usually applied to the substrate in order to increase the energy of the incident ions at the substrate. Thus coatings with a dense structure and high hardness could be obtained [3]. The purpose of the present study is to understand experimentally the changes in the mechanical properties of TiN film deposited with various types bias by a DC, pulsed-DC, and AC power, respectively.

2. Experiment

The TiN films were deposited on Si(100) wafer by cathode arc from a Ti target of purity 99.95%. The deposited TiN films on a WC-Co alloy of square-type of 20×20 mm was used by adhesion measurement. The base pressure of the deposition chamber was as low as 5×10^{-6} Torr. Prior to deposition, the substrate was cleaned by the Ar-ion beam with a bias of -100V for 5 min. The pressure of the nitrogen gas and substrate temperature was maintained at about 0.3 mTorr and 380℃. The deposition of TiN films were deposited with bias voltages −50V and −100V applied to the substrate at the arc currents of 60 A, respectively. The frequencies applied to the substrate are 250kHz for the AC power and 250kHz and 350 kHz for the pulsed-DC power, respectively. The types of power supply for the substrate bias are a DC, pulsed-DC, and AC power.

3. Result and discussion

The results of XRD show that the samples have a crystal structure of face-centered cubic (fcc) without any other crystal phase. The pattern shows a preferred (111) orientation for incident angles of Θ = 5. The hardness of samples tend to increase with increasing the residual stress and substrate bias voltage. The hardness for AC power is larger than that for DC power. For the pulsed-DC power, the hardness of the samples depend on the substrate bias-voltage independent of substrate frequency. We also are found that the adhesion was be subjected to the influence of the substrate bias-voltage and frequency. The results obtained from the nanoindentation experiments on TiN films with substrate bias voltage of -50V and -100V are shown in Fig. 1. The mechanical properties (adhesion, stress, and hardness) of the sample obtained from the various substrate bias are summarized in Table 1. The presented hardness values of TiN film are similar to values reported for TiN coatings [4]. In conclusion, it was found that the mechanical properties of the films depend strongly on the substrate bias voltage, frequency, and type of power supply.

Acknowledgments

This work was supported by 2010 Manufacturing Technology Innovation (10010918).

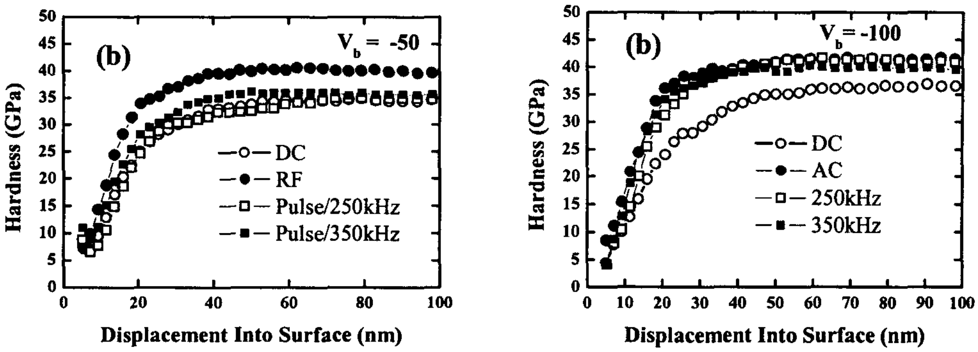

Fig .1 Hardness-displacement curves of TiN films with substrate bias voltage (V_b) of (a) -50V and (b) -100V for the several types of power.

Table.1 The valuses of adhesion, residual stress, hardness for the TiN films

Bias power	Substrate bias Bias frequency [kHz]	Substrate bias Bias Voltage [$-V_b$]	Adhesion [N]	Stress [GPa]	Hardness [GPa]
DC power	-	50	48.3	3.18	34.5
	-	100	72.8	5.24	36.7
pulsed-DC power	250	50	83.9	3.51	34.8
		100	47.6	-	41.5
	350	50	71.9	2.99	35.9
		100	51.8	4.9	40.2
AC power	250	50	48.3	3.55	40.5
		100	65.4	5.8	41.3

References

[1] S. Hogmark, S. Jacobson, M. Larsson, Wear 246 20(2000).

[2] L. Hultman, W. D. Munz, J. Musil, S. Kadlec, I. Petrov, and J. E. Greene, J. Vac. Sci. Technol. A 9, 434 (1992).

[3] I. Petrov, L. Hultman, J.-E. Sundgren, and J. E. Greene, J. Vac. Sci. Technol. A 10, 265 (1992).

[4] M. E. OHern, R. H. Parrish, and W. C. Oliver, Thin Solid Films 153, 185(1987).