The microstructure of polycrystalline silicon thin film that fabricated by DC magnetron sputtering

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Abstract : DC magnetron sputtering was used to deposit p-type polycrystalline silicon on n-type Si(100) wafer. The influence of film microstructure properties on deposition parameters (DC power, substrate temperature, pressure) was investigated. The substrate temperature and pressure have the important influence on depositing the poly-Si thin films. Smooth ploy-Si films were obtained in (331) orientation and the average grain sizes are ranged in 25-30nm. The grain sizes of films deposited at low pressure of 10mTorr are a little larger than those deposited at high pressure of 15mTorr.

Key words : DC magnetron sputtering, polycrystalline silicon thin films.

1. Introduction

Polycrystalline silicon thin films are being actively studied for use as the absorber layer in solar cell, thin film transistor, sensor, and other device applications. Compared to hydrogenated amorphous silicon (a-Si:H) material, poly-Si has many advantages such as stability against light soaking, better electrical conductivity, higher carrier mobility and higher light absorption in long-wavelength region[1].There have been a variety of techniques on the thin film growth of poly-Si. Among them, low pressure chemical vapor deposition (LPCVD) as well as solid phase crystalline (SPC), excimer laser annealing (ELA), and metal-induced crystalline(MIC) have been considered as the conventional methods. However, these methods have some disadvantages such as high deposition temperature, long annealing time, non-uniformity of grain growth, expensive processing costs, and the migration of metal elements.

DC magnetron sputtering is a simple vapor deposition process. It has many advantages of high growth rate low temperature deposition and good reproducibility[2].In this study, to investigate the film microstructure and growth mechanism of poly-Si thin film, p type poly-Si was deposited on the n type Si(100) wafer by DC magnetron sputtering. In addition, the epitaxial orientation, microstructual characteristics and surface properties of the films were analyzed by X-ray diffraction (XRD) and scanning electron microscope (SEM).

2. Experiment

P type poly-Si thin films were deposited on n type Si(100) wafer by DC magnetron sputtering using p type Si target. Prior to deposition, substrates were cleaned by immersing into aceton with the aid of ultrasonic cleaning. A pre-sputtering process was employed for 10min to clean target surface. The deposition parameters are summarized in table1.

Table1. Deposition conditions of poly-Si by DC magnetron sputtering

Parameter	Condition
Base pressure	10^{-6}Torr
Working gas pressure	10mTorr, 15mTorr
Sputtering power	20W, 40W
Sputtering gas	Ar
Deposition temperature	200℃,500℃
Deposition time	1hr, 2hr

3. Results and discussion

Fig. 1. shows that the X-ray diffraction patterns of ply-Si thin films exhibit (331) peak of 2θ angle at 57.1° corresponding peak of Si. The (331) peak of the thin films which were deposited in lower temperature and lower pressure is stronger. The corresponding parameters of the (331) peak are listed in Table 2. Based on the XRD results the average size (D) of crystalline grain can be evaluated by Scherrer formula as :

$$D = \frac{0.9\lambda}{\beta\cos\theta} \quad [3]$$

Where D is the grain size, λ is the X-ray wavelength (0.154056nm), θ is the Bragg angles, and β is direction.

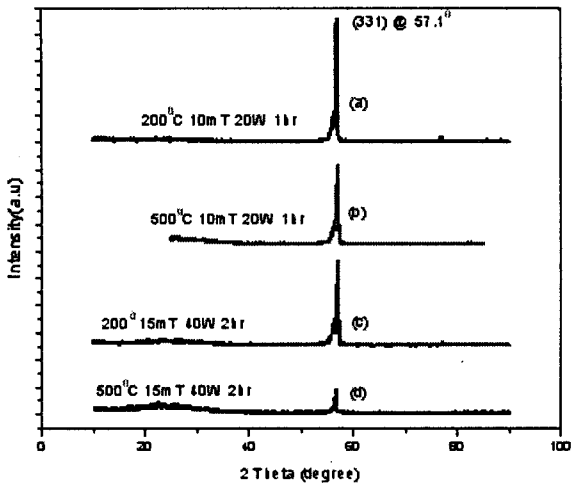
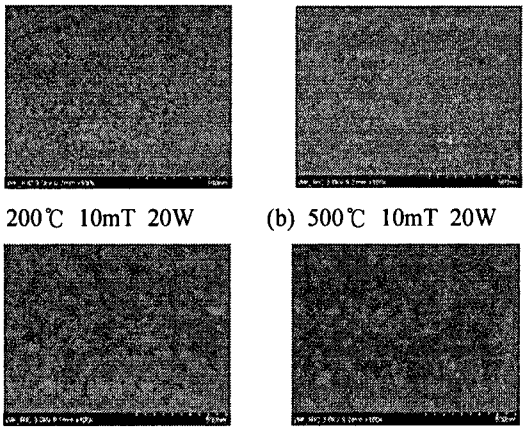


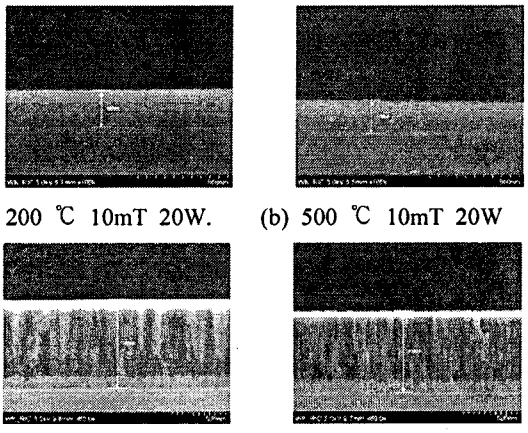
Fig. 1. XRD patterns of poly-Si thin films deposited at different conditions



(a) 200℃ 10mT 20W (b) 500℃ 10mT 20W

(c) 200 ℃ 15mT 40W (d) 500 ℃ 15mT 40W

Fig. 2. SEM micrographs of poly-Si thin film deposited at different conditions



(a) 200 ℃ 10mT 20W. (b) 500 ℃ 10mT 20W

(c) 200 ℃ 15mT 40W (d) 500 ℃ 15mT 40W

Fig. 3. The cross-section micrographs of poly-Si thin film deposited at different conditions

Table 2. Parameters of the X-ray diffraction patterns of poly-Si films

	2θ(°)	FWHM/(°)	D/nm
(a)	57.05	0.30	30.19
(b)	57.11	0.30	30.19
(c)	57.11	0.36	25.14
(d)	56.81	0.32	28.26

The grain size of the thin films which deposited in lower temperature and lower pressure is bigger.

The SEM surface micrographs of poly-Si thin film deposited at different conditions are presented in Fig.2. Irrespective of the small variation in the surface roughness, the morphology if films exhibits a smooth film structure.

Fig. 3. Shows the cross sectional SEM for poly-Si thin film deposited at different conditions. The microstructure of crystals deposited in lower temperature and lower pressure is more compactor, as seen in Fig. 3(a) and (b). As seen in Fig. 3(c) and (d), the grain size of the films deposited in higher temperature(Fig.3d) is larger. The same result obtained in table 2.

4. Conclusion

The properties of (331) orientation polycrystalline silicon thin films were obtained by DC magnetron sputtering. The poly-Si thin films, and the average grain sizes are ranged in 25-30nm. The substrate temperature and temperature have the important influence on depositing the poly-Si thin films.

Acknowledgement

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