Nanostructural and Optical Features of nc-Si:H Films Prepared by Aluminium-induced Crystallization

금속유도 결정화 기법에 의해 제조된 나노 결정 실리콘의 구조적 화학적 성질

*J.-H. Shim, N.-H. Cho**

Department of Materials Science & Engineering, Inha Univ., Inchon, Korea

Hydrogenated nanocrystalline silicon (nc-Si:H) has attracted much attention in electronic industry for its potential applications in photoluminescence (PL) and electroluminescence (EL) devices based on Si. Silicon is an indirect band structured material with a band gap of ~ 1.1 eV. Therefore, it cannot emit visible light at R.T. and as a result Si-based technologies can't be applied in optoelectronics. However, PL phenomena have recently been observed from nc-Si films if Si nanocrystallites with the size of less than 5 nm exist in the films. The luminescence is extremely sensitive to the size and fraction of the nanocrystallites. Since the size distribution of silicon nanocrystallites in the films is generally broad, the PL spectrum is also broad and featureless.

Recently, the aluminium-induced crystallization (AIC) technique has been reported to lead to the formation of grainsin Si films on foreign substrates. It is explained by the overall layer exchange of Si with Al films or vice versa during the transformation of amorphous (a-Si) to crystalline Si. The Al migrates from interface into Si layers, dissociating a large amount of Si material. The dissociated Si readily diffuses to the Al layer, creating Si nuclei and growing crystalline Si grains.

In this study, we investigated the effect of Al-doping on the nanostuctural features of nc-Si:H thin films by thin film XRD, HRTEM, Raman S., and PL. Nc-Si:H thin films were prepared by plasma enhanced chemical vapor deposition (PECVD) techniques.

Fig. 1(a) shows a cross-section bright-field TEM image of the films; the films were post-deposition heat-treated at 500 C for 15 min. The films are composed of an amorphous phase as well as nanocrystallites of around 2 ~ 5 nm in size. The selected area diffraction pattern at the left-upper corner in Fig. 2(a) was

obtained from the nanocrystalline region of the micrograph. The electron diffraction pattern exhibits some reflections corresponding to Si {211}. Fig. 2(b) shows a high resolution TEM image of the above mentioned films. This micrograph illustrates the presence of ~ 5 nm-sized Si nanocrystallites in the films. It was observed that a high concentration of nc-Si is present near the interface area of the Al/nc-Si:H; the size of the nc-Si in the inner area of the film is smaller than that of the nc-Si at the interface.

The PL spectra of the nc-Si thin films are shown in Fig. 2 it is seen that the peak intensity gradually increased at ~570 nm, as annealing temperature increased from 350 to 500 C. It is highly likely that the increase of the PL intensity is caused by the increase in the total volume of the nanocrystallites in the films. The intensity of the PL increased with increasing the Al density in the films. These show that the AIC processing enhances the nucleation of Si crystallites in the films in this experimental range.

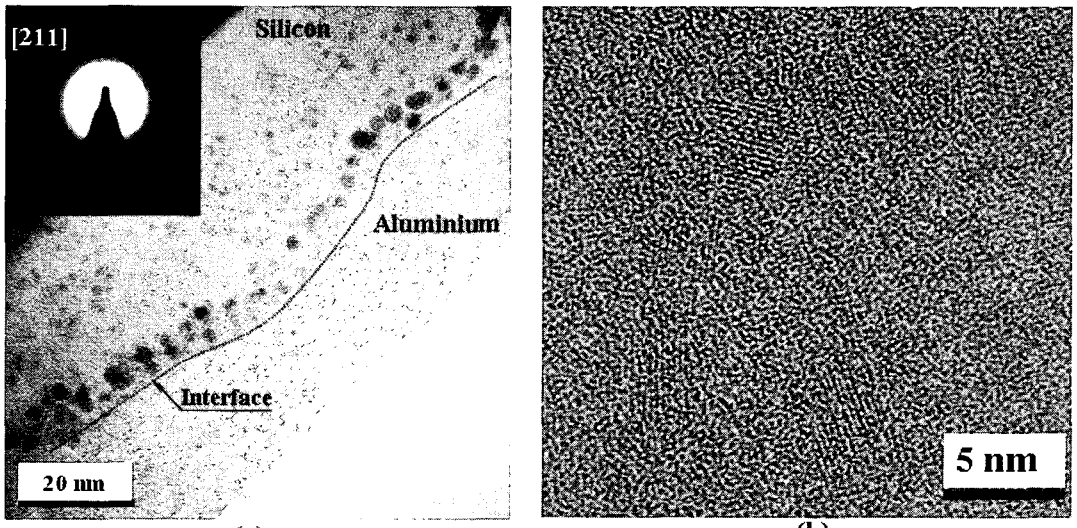

Fig. 1. (a) Cross sectional bright-field TEM image of the Al/nc-Si:H thin films. The films were post-deposition heat-treated at 500 C for 15 min. (b) HRTEM image of the thin films shown in (a).

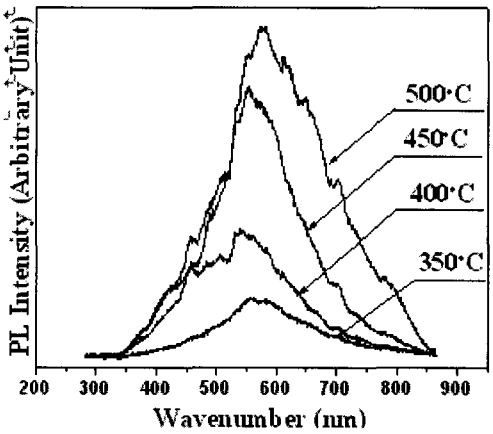

Fig. 2. PL spectra of the nc-Si:H films. The samples were annealed at 350, 400, 450, and 500 C for 15 min, respectively. The measurement was performed at R.T.