VHF PECVD Micro-crystalline Silicon Bottom Gate TFT With Thin Incubation Layer

Juan Li, Chunya Wu[*]*, Zhiguo Meng, Jianping Liu, Shuyun Zhao, Shaozhen Xiong*
Institute of Photo-electronic Thin Film Devices and Technology, School of Information
The Tianjin Key Laboratory for Photoelectronic Thin Film Devices and Technology
Nankai University, Tianjin 300071, PR China

Lizhu Zhang
Tianjin Institute of Mechanic and Electric Professional Technology, Tianjin 300131, PR China

*email: wuchy@nankai.edu.cn, Tel/Fax: 86-22-23501620

Microcrystalline Si thin film transistor (μc-Si TFT) generally requires that the active layer should have not only high crystallization volume fraction but also thin incubation layer, especially for bottom gate TFT. It was found that decreasing the ratio of $SiH_4/[H_2+SiH_4]$ (Sc) is an effective way to decrease the incubation layer thickness of μc-Si directly deposited by VHF PECVD without any further thermal and laser treatment. Based on the μc-Si with thin incubation layer, the bottom gate thin film transistor (BG-TFT) with Al/SiNx/μc-Si/n^+-μc-Si/Al structure was fabricated..

1. Incubation layer

VHF-PECVD with the active frequency of 60M Hz was utilized to deposit μc-Si thin films. The effect of the hydrogen dilution ratio was investigated with Raman spectrum and pseudo-dielectric function. The Raman spectra of the μc-Si thin films indicate that the crystallization volume fraction (Xc) increased with decreasing the ratio of $SiH_4/(SiH_4+H_2)$, as shown in Figure 1. The silicon film structure turns from microcrystalline phase to transition phase or amorphous phase around the Sc of 5%. The variation of Raman spectra also implies that the incubation layer could be varied with the hydrogen dilution ratio.

Shown in figure 2 are Raman spectra of μc-Si thin film with the different thickness deposited at $SiH_4/(SiH_4+H_2)$ ratio of 2%. It can be seen that the incubation layer thickness of μc-Si is near 60nm. The incubation layer was thinned dramatically by further decreasing the ratio of $SiH_4/(SiH_4+H_2)$. It is thinner than 20nm for μc-Si deposited at $SiH_4/(SiH_4+H_2)$ ratio of 0.67%, as showing in figure 3.

2. Thin film transistor

Bottom gate TFTs were fabricated with μc-Si deposited at $SiH_4/(SiH_4+H_2)$ ratio of 2%. a-SiN_x:H deposited by RF-PECVD was used as the gate insulator to improve the interface between the insulator and μc-Si thin film, while n-type μc-Si to improve the contact performance. The almost same fabrication processes as those for making a-Si:H TFT were employed to fabricate μc-Si TFT . The resulted TFTs without any other treatment and LDD structure show good performances. The ratio of on state current to the off state current (I_{on}/I_{off}) is up to 6, the mobility is around 0.7cm^2/V-sec, and the threshold voltage is lower than 5V. The TFT characteristics are comparable to that of the μc-Si TFT reported by other research groups. We are convinced that with the further optimization of the μc-Si film quality, such as the grain size, the film density, or says free of void, μc-Si TFT performance can be further improved.

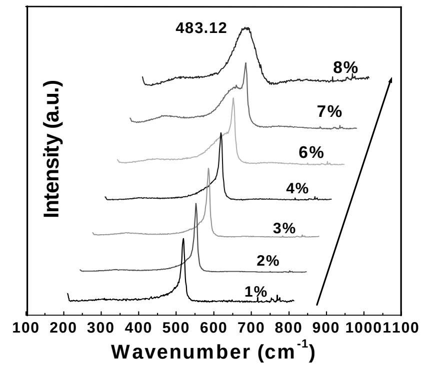

Figure 1 Raman spectra of μc-Si thin films made with different ratio of $SiH_4/(SiH_4+H_2)$

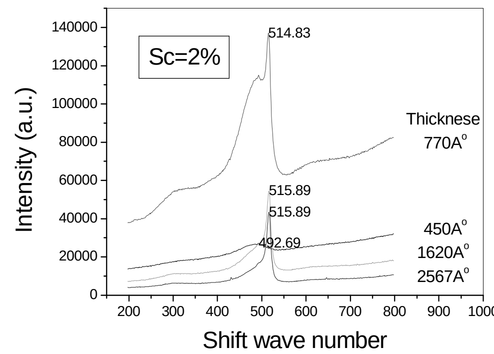

Figure 2 Raman spectra of μc-Si thin film with different thickness deposited at $SiH_4/(SiH_4+H_2)$=2%

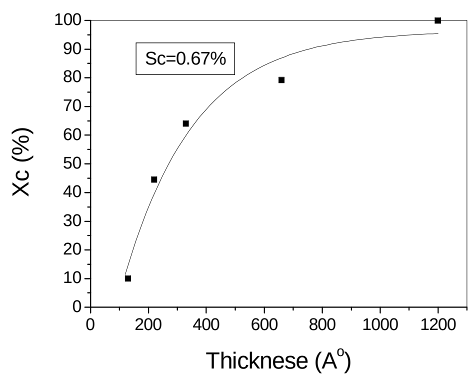

Figure 3 Variation of crystalline volume fraction with the thick ness of μc-Si thin film

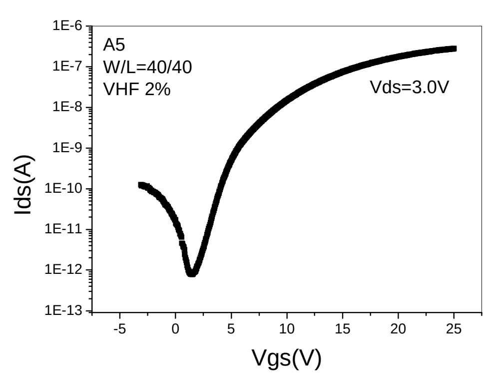

Figure 4 Transfer Characteristics of μc-Si TFT