LOW TEMPERATURE DEPOSITION OF MICROCRYSTALLINE SILICON FILMS BY PLASMA ASSISTED CVD

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The development of a low temperature thin film silicon technology is of great interest for applications in large area electronics and optoelectronics especially on flexible plastic substrates. Hydrogenated microcrystalline silicon, µc-Si:H, is an interesting material for these applications because of its stability and electron mobility higher than amorphous silicon, a-Si:H. Thin layers (<100nm) with a low hydrogen content (<2%) and a high crystalline volume fraction (>90%) are required. However, the growth of µc-Si:H thin layers with these characteristics by conventional deposition techniques (PACVD from SiH_4-H_2 mixtures) is still a challenge (1). Halogenated silicon precursors, e.g. SiF_4 and SiH_2Cl_2, are investigated to enhance the crystallinity of silicon thin films (2). We performed the growth of undoped µc-Si:H layers from SiF_4-H_2-He plasmas in the temperature range RT-180°C.

The analysis of the films has been performed by X rays diffractometry, XRD, Fourier transform infrared, FTIR, spectroscopy, and spectroscopic ellipsometry, SE. It has been found that a pure microcrystalline film, Fig. 1-2, can be prepared at the substrate temperature of 100°C. Another interesting feature of all deposited films was the very low hydrogen content, c_H<1 at.%, calculated from the FTIR Si-H wagging peak.

The film microstructure can be related to the growth kinetics as shown in Fig. 3. A decrease in the growth rate from 0.12 to 0.38 Å/sec and an increase in crystallinity from 75% to 90% is obtained by lowering the substrate temperature from 180 to 100°C. This behavior is different from conventional SiH_4/H_2 systems where the increase of deposition temperature favors the growth of crystalline materials. These data can be explained on the basis of the opposite temperature dependence of the etching processes operated by hydrogen and fluorine atoms, that also results in the opposite temperature dependence of the amorphous to microcrystalline selectivity.

Therefore, µc-Si:H depositions from SiF_4-H_2-He plasmas represent an approach to get highly ordered silicon films in the low temperature regime.

1. J. Bailat, E. Vaiullat-Sauvain, L. Feoitknecht, C. Droz and A. Shah, *J. Non-Cryst. Sol.,* **299-302**, 1219 (2002)
2. M. Losurdo, R. Rizzoli, C. Summonte, G. Cicala, P. Capezzuto and G. Bruno, *J. Appl. Phys.*, **88**, 2408 (2000)

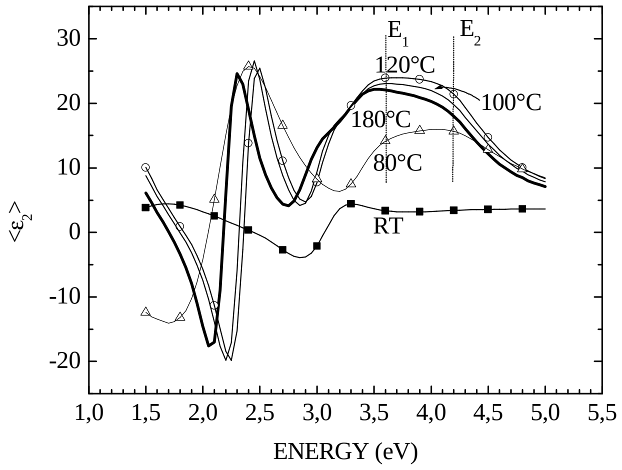

Figure 1. Ellipsometric spectra of the imaginary part, $<\varepsilon_2>$, of the pseudielectric function of µc-Si:H films deposited at various temperatures.

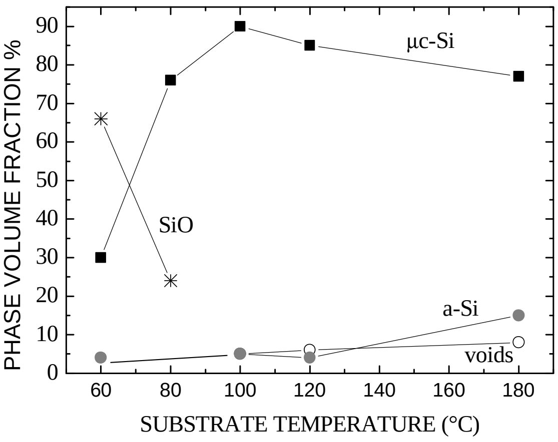

Figure 2. Composition of films deposited at different temperatures in terms of volume fraction of the µc-Si, a-Si, SiO phases and voids.

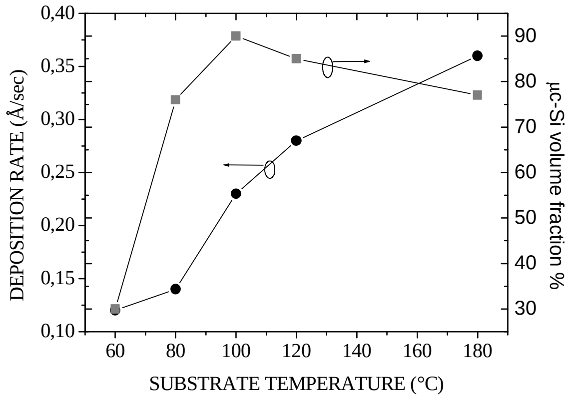

Figure 3. Temperature dependence of the deposition rate, r_D, and of he crystalline volume fraction.