CHAPTER 6

CONCLUSION

Upon studying the effect of argon dilutant on the properties of hydrogenated amorphous silicon (a-Si:H) films prepared by DC plasma glow discharge technique, several important information have been achieved by many researchers. In their studies on the effect of inert gas dilution of silane on plasma deposited a-Si:H films, J.C.Knights[1] and co-workers have indicated that under all sets of discharge parameters, argon dilution produced higher effect densities which they associated with microstructure in the film. By focusing on the effect of annealing, K.Tanaka[2] and co-workers have studied the role of argon involved in plasma deposited a-Si:H films and observed that argon atoms never evolved at least up to 400°C. They reported that argon atoms play the role of steric hindrance against hydrogen diffusion. U.K.Das[3] and P.Chandhuri had studied the effect of argon dilution on the structure of microcrystalline silicon deposited from silane and observed that argon acts as a passive diluent gas besides playing an important role in the growth of the amorphous and microcrystalline network. They proposed a model based on the energy exchange between the argon atom states and the growth zone of the materials to explain the structural changes observed in the presence of argon in the plasma.

In this work, the a-Si:H films were prepared from d.c. plasma glow discharge of argon and silane gas mixtures. Analysis of the results obtained from the optical and infrared spectra showed that the argon to silane flow-rate ratios had a strong influence on the optical, chemical bonding and microstructural properties of the material. The various trends of parameters derived from these spectra with argon to silane flow-rate ratios indicated these parameters consistently produced different behaviour trends when the argon to silane flow-rate ratios were less than one and larger than one. Thus, the low argon dilution films were referred to films prepared using argon to silane flow-rate ratios less than one and vice-versa. The low argon and the high argon dilution films were prepared using silane flow-rate ratios of 20sccm and 5sccm respectively.

In the high argon dilution films, argon dilution consistently had the effect of increasing the growth rate. The growth rate decreased when the argon flow-rate was increased. However, even when the argon to silane flow-rate ratio was the highest in this work, the deposition rate was still higher relative to the film produced from pure silane prepared at silane flow-rate of 5sccm. Low argon dilution reduced the deposition rate as observed in films prepared using silane flow-rate of 20sccm. The deposition rates were consistently lower than the film prepared from pure silane. Higher argon dilution in these films decreased the growth rate but when the argon to silane flow-rate rate ratio approached unity, the deposition rate increased slightly.

Argon dilution had the effect of reducing bulk density of the film as deduced from the decrease in refractive as the argon to silane flow-rate ratio was increased. The refractive index decreased to a minimum when this ratio increased to one and remained almost constant with further increase in argon to silane flow-rate ratio. Similar behaviour observed for the variation of the Urbach Tail band (E_e) width with argon to silane flow-rate ratio suggested that the decrease in the bulk density of a-Si:H films prepared from the discharge of argon and silane gas mixture could be contributed by restructuring of the structure of the film to a more ordered structure.

The FTIR spectra too showed interesting trend for low argon dilution and high argon dilution samples. The samples prepared from very low argon diluted silane showed a complex system of bands with increased intensity which is associated with inhomogeneity of the film structure. However, as the argon dilution increased and the ratio of argon flow rate to silane flow rate approaches unity, the homogeneity increased along with a decrease in the height of the absorption peaks in the wagging and the stretching region. For high argon diluted samples in which argon to silane flow rate ratio was larger than unity, the FTIR spectra showed homogeneity and the absorption peaks in the wagging and the stretching region increased. Despite the increase and decrease of the absorption bands, the oxygen contamination band was observed to change in contrasting manner thus suggesting that oxygen contamination in these films had resulted in low hydrogen content film.

In the stretching region, the normalized absorption coefficient spectra showed the presence of three stretching modes for samples prepared at the flow rate ratio 0.25 and 0.5 whereas only one peak was observed for the sample prepared at the flow rate ratio 1, two separated peaks appeared. For these samples the stretching peaks were biased to the polyhydride site which according to J.C.Knights[1] was the answer to the inhomogeneity of the films.

The hydrogen content of the a-Si:H films produced in this work was high in the films prepared from low argon diluted silane plasma. The hydrogen content decreased as the ratio of argon flow rate to silane flow rate approached unity but increased again as the ratio was increased further. This result in which hydrogen content was high for low argon dilution is similar to J.Shirafuji[7] and co-workers who deposited a-Si:H films at 200°C by radio frequency glow discharge and noted that the total hydrogen content in the films increased as the silane fraction increased.

The microstructure parameter, R which was derived from the FTIR spectra increased with the increase in argon to silane flow-rate ratio in the low argon dilution films and this trend was also produced by the variation of the optical energy gap with argon to silane flow-rate ratio. Thus, in these films the increase in optical energy gap could be contributed by the increase in the microstructure content in the film. This effect ceased to be observed in the high argon dilution films.

Contrasting behaviour of H content in the film with argon to silane flow-rate ratio was observed in the low argon dilution films. When the argon to silane flow-rate ratio was half and less, argon dilution increased the H content in the film. However, with further increase in argon dilution the effect was reversed where the increase in argon dilution significantly decreased the H content in the film. In the high argon dilution films, the H content in the film increased slowly towards the H content of the film produced from pure silane.

Although in this work deposition rate does not affect the value of optical energy gap significantly, it has an interesting effect on the refractive index and the Urbach tail bandwidth. An increase in deposition rate resulted in a decrease in refractive index and a similar trend was observed on Urbach tail bandwidth.

The result indicated that at high deposition rate (>3Ås^{-1}), a-Si:H films produced have low bulk density with less disordered structure.

As observed from the FTIR spectroscopic studies, increase in the deposition rate reduced the total hydrogen content in the film. The microstructure parameter, however, increased with increasing deposition rate. In previous studies, Ross and Messier[4,5] who grew a-Si:H films by sputtering from silane in a hydrogen and argon plasma had noted that argon pressure determined the film microstructure in which low argon pressure implies bombardment with energetic argon ions, giving uniform and dense films whereas high argon pressure produced films with columnar structures. The results obtained in this work suggested that the films produced at high deposition rate were subjected to ion bombardment which was responsible for the decrease in hydrogen content of the films thus resulting in less disordered structures.

The integrated intensity of the monohydride bonds was high and showed domination for argon to silane flow rate ratio less than unity and the contrary occured for argon to silane flow rate ratio higher than unity. It was earlier observed that in amorphous samples prepared from argon diluted silane at low or moderate radio frequency power density, hydrogen bonding was predominantly monohydride type[6]. It was also noted that in argon diluted samples, bonded hydrogen remained high in amorphous samples.

The microstructure parameter showed an increasing value as the ratio of argon flow rate to silane flow rate approached unity but as the ratio was increased further, the microstructure parameter decreased. The relation showed between the microstructure parameter and the Urbach tail bandwidth depicted that the film structure became more disordered as the microstructure content in the film increased. The microstructure parameter was also observed to have a linear relationship with optical energy gap of the a-Si:H films. These results lead to the conclusion that as the microstructure content increased, the optical energy gap widens along with increasing amount of disordered structure. The disordered structure might be due to the microstructure of the films as suggested by J.C.Knights[1].

In this work, the results obtained showed interesting relations between the parameters especially when the ratio of argon flow rate to silane flow rate was high. Although the results were conclusive, some of the parameters observed depicted a slight change in trend as the ratio of argon flow rate to silane flow rate goes beyond unity. Therefore it is suggested for future research to concentrate on a-Si:H produced with argon to silane flow rate ratio higher than unity. In addition, the samples prepared at this ratio showed good quality for device applications such as low optical energy gap, low disordered structure, low microstructure and the most important, the films was proved to have high degree of homogeneity.

References:

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