CHAPTER 7

Conclusion and Suggestions for Future Works

7 CONCLUSION AND SUGGESTIONS FOR FUTURE WORKS

7.1 Conclusion

This thesis reports the fabrication of carbon nitride films composed of p-CN_x:H and vertically aligned CN_x:H nanorods. These films were successfully produced using a simple home-built rf PECVD employing a parallel-plate electrode configuration. The choice of rf PECVD to produce these films was proven to be appropriate. Using the simple difference in electrode distance two CN_x:H structures were obtained while maintaining other deposition parameters. These two vastly different structures with different unique characteristics were found. Although the deposition of p-CN_x:H films are common for rf PECVD, the unique characteristics of the p-CN_x:H films deposited in this work are seen in their high PL emission intensities and more importantly in the profile of their PL spectra. These motivated the PL study of these p- CN_x:H films and the determination of their recombination centers. In contrast a more fundamental approach was used in the study of the ns-CN_x:H films dealing more towards the understanding and determination of the growth mechanism of the vertically aligned CN_x:H nanorods. Each of these were studied separately which was done to emphasize the significant findings found for both types of structures.

In the studies of the p-CN_x:H films, the optimized deposition parameters in term of the P_{rf} and N_2:CH_4 for the deposition of films with high PL intensities are 80 W and 0.70, respectively. Also the resulting film is thermally stable up to a T_A of 500 °C. The recombination centers which produces these high PL intensity are attributed to the CH_n, C=N and the isolated and/or fused aromatic rings bonded to nitrile (−C≡N) which may contribute significantly as recombination centers.

In the studies of ns-CN_x:H, the optimized parameters for the formation of films containing vertically aligned CN_x:H nanorods were determined to be P_{rf} of 80 W and a N_2:CH_4 ratio of 0.70. This coincided with the maximum N content and preferential bonding of isonitrile bonded to fused or isolated aromatic rings in the films. These nanorods are made up of C nanographitic sp^2 clusters embedded in a carbon-nitrogen amorphous matrix which surrounds, encapsulates and holds them together. The growth mechanism of these vertically aligned nanorods was proposed.

Although these p-CN_x:H and ns-CN_x:H films were studied separately, one significant aspect was observed. In this, the optimum deposition parameters determined in the production of high PL characteristics of the p-CN_x:H films and optimal vertical alignment of the nanorods, were actually the same. Indeed both types of films were produced at P_{rf} of 80 W and N_2:CH_4 of 0.70. It is the simply the difference in electrode distance at these optimal P_{rf} and N_2:CH_4 ratio, which induces the formation of these two significantly different structured films.

7.2 Suggestions for Future Works

There are yet a number of different aspects of these films which required further investigation both in terms of fundamentals and applications. These were not carried out in this work due to the limitations in time, instrumentation and financial assistance. As regards fundamental studies, the films obtained in this work need to be further characterised especially in regards to the relative sp^1, sp^2 and sp^3 content, since these are found to greatly influence the properties of the films. This could be done using x-ray photospectroscopy (XPS), which unfortunately, was not available during the study of this work. The Raman results also need improving, using two different excitation wavelength that could reduce the PL background especially for the polymeric films. Similarly, HRTEM analysis should be carried out on the rest of the nanostructures and even the polymeric films. Apart from these the effect of some deposition parameters including deposition pressure, additional gas dilution such as hydrogen, argon or helium, substrate biasing and variation in substrate temperatures should be studied in the hope of obtaining films with improved properties. Also, since the whole concept of the nanostructured films was based on a simplified metal-catalytic/template free deposition method, it is important to study different ways of modifying the structures or to enable patterning and selective deposition, without compromising the concept.

Studies on the applications of these films should be taken. With the optimized parameters for the polymeric films, simple electroluminescence devices could be fabricated. Other areas of application should also be explored for these polymeric films, such as their electrical characteristics and even their applicability in photovoltaic devices. However, it is the nanostructured films which present the more intriguing potential in term of application. In a related unpublished work (not reported here) additional studies have shown that these nanostructures could be deposited on various substrates, although the structures vary according to the substrate used. This together with their low deposition temperature would allow such structures to be deposited on various types of substrates including temperature sensitive materials. Some of the suggested applications which could be explored include hydrophobic coatings, electron field emitting devices, and materials for hydrogen storage and oxygen reduction.