ROOM TEMPERATURE PHOTOLUMINESCENCE FROM NANOSTRUCTURED AMORPHOUS CARBON THIN FILMS

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Pulsed Excimer laser ablation of a high purity graphite target has been used to grow nanostructured amorphous carbon thin films. By varying the background pressure of argon in the chamber it is possible to reduce the momentum of the energetic carbon species in the carbon plume. As a consequence it is possible to grow carbon films with different morphologies as well as different sp^2 fraction – see Figure 1. At low background pressures hard scratch resistance diamond-like carbon thin films are produced – Fig. 1(a). Time-resolved plume imaging suggests that the energy of the carbon species is about 100 eV, close to the carbon ion energy for films grown via cathodic arc methods.

As the background pressure increases carbon clusters of different diameters and distributions are found – Fig. 1 (b) and (c). The coalescence of the clusters produces the rough surface observed in Fig. 1 (b) and (c). At the highest pressures investigated (340 mTorr) filamentary carbon films with high porosity and high surface area – Fig. 1 (d).

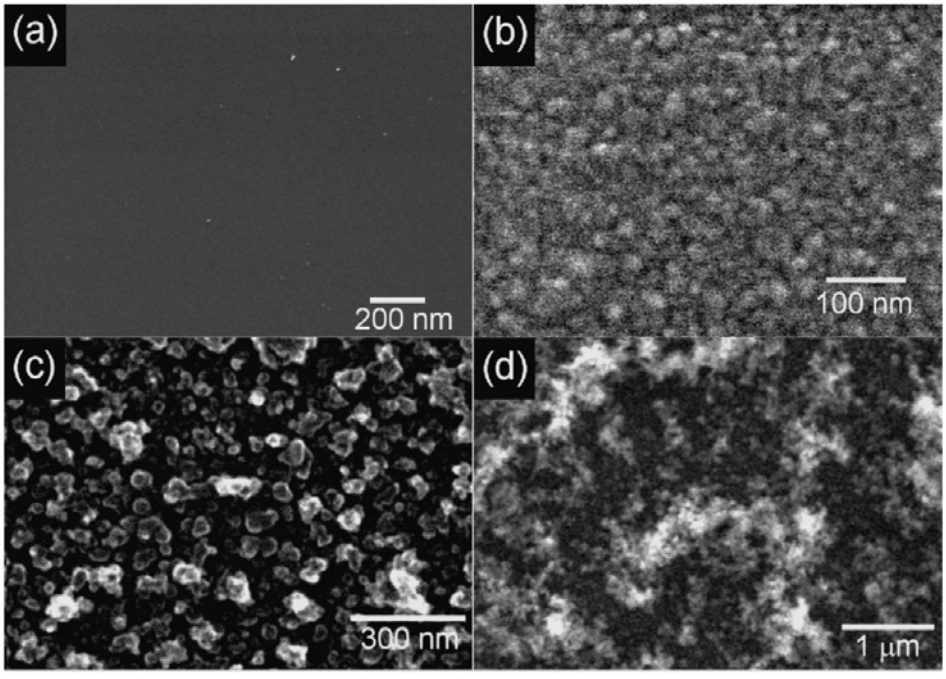

Figure 1 Scanning electron microscope images of nanostructured carbon films at different background pressures of argon (a) 5 mTorr, (b) 40 mTorr, (c) 100 mTorr and (d) 340 mTorr. Note the change of scale bar.

The bonding within the carbon phase was investigated using visible Raman spectroscopy and photoluminescence. [1] It was observed that room temperature photoluminescence could be observed from all the samples investigated. Preliminary electron spin resonance measurements

indicate that all sample possess a high spin density (~10^{20} cm^{-3}). The Raman spectra shows the characteristic G band in all the samples. The intensity of the D band (I_D) is seen to increase with the increasing background pressure. Figure 2 (a) shows the variation of the ratio of intensities of the D band to the G band with gas pressure. Furthermore, the variation of the room temperature PL intensity is shown in Figure 2(b).

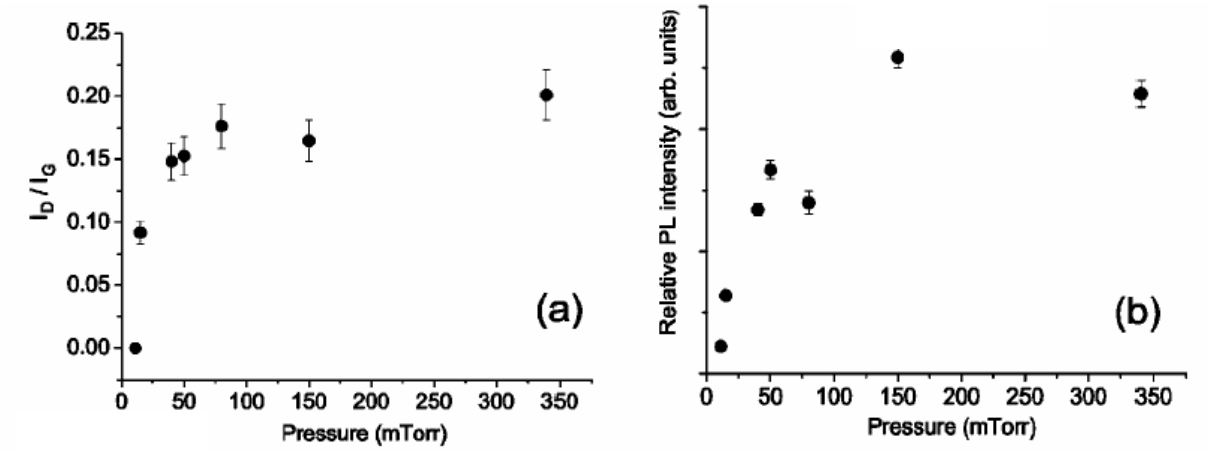

Figure 2 (a) Variation of the ratio of the intensities of the D band to G band and (b) room temperature PL as a function of background gas pressure.

From Figure 2 is apparent that the trend in the I_D/I_G ratio with gas pressure is similar to the trend in the PL intensity. Since D band in carbon films is associated with changes in the ordering within the sp^2 phase, we believe that increased PL is due to changes associated with the degree of ordering in sp^2 cluster. Efficient room temperature PL is observed in these films despite the high defect density (10^{20} cm^{-3}) in these films. Analysis of the spin resonance line width suggests that delocalization of the electron wavefunction is likely to be occurring. Delocalization of the electron wavefunction has been previously reported in sp^2 rich flat films [2]; this is an occurrence when delocalization is occurring in filamentary carbon films.

In summary we have produce nanostructured porous carbon films with exhibit room temperature photoluminescence. By varying the gas pressure we are able to tailor the porosity of the films. High surface area films carbon based films may be useful gas sensors. Currently we are also examining the effects of metal inclusion in these films.

References

[1] S. J. Henley, J.D. Carey and S.R.P. Silva, Appl. Phys. Lett. **85**, (2004) 6236.
[2] J. D. Carey and S. R.P. Silva, Phys. Rev. B. **70**, (2004) 235417.