Photoluminesence of Carbonaceous Grain Mantle Materials with Silicon Impurities

T. Smith, B. Friedmann, A.N. Witt, R. Wang, X. Deng
The University of Toledo

D. Furton
Rhode Island College

The high abundance of carbon in the local universe and its ability to form refractory solids makes carbon a likely interstellar grain candidate. The abundance of carbon and the association of the 3.4 micron C-H stretch band with dust grains has lead to the adoption of hydrogentated amorphous carbon (HAC) as a major component of IS dust. HAC could therefore be responsible for the IS photoluminesence (PL) process known as Extended Red Emission (ERE). Astronomical ERE spectra exhibit peak positions in the 610 - 850 nm range, and the observed ERE intensities suggest a quantum yield of at least 10% in the diffuse ISM. HAC analogs produce efficient photoluminesence near 570 nm but become inefficient in the observed ERE wavelength range.

The technique of bandgap engineering was employed in an attempt to lower the lab HAC bandgap from ≈ 2.85 eV to ≈ 2.1 eV through the incorporation of silicon impurities (bandgap ≈ 1.1 eV). The goal is to shift the photoluminesence peak toward longer wavelengths. Fourteen a-Si(x)C(1-x):H thin films were made using chemical vapor deposition (CVD) in an RF glow discharge reactor with silane, a hydrocarbon gas and argon as feed gases. The films were then illuminated by a blue laser and then separately by UV laser light. The resulting PL peaks were compared for central wavelength and efficiency and to see if the "bluer" UV illumination caused a shift to the blue of the resultant PL peaks. Infrared absorption spectra of the films show the presence of the Si-H stretch band near 4.6 microns and confirm the incorporation of Si into the films.

We present spectral evidence showing that the CVD-produced a-Si(x)C(1-x):H films do not solve the band gap issue and that the resultant film PL is therefore still too blue to match interstellar ERE. Furthermore, the inclusion of Si into HAC leads to a strong absorption band (Si-H stretch) near 4.6 microns which is not observed in the diffuse ISM.

References:

Duley, W.W., Jones, A.P., and Williams, D.A. 1989, MNRAS, 236, 709

Pendelton, Y.J., Sandford, S.A., Allamandola, L.J., Tielens, A.G.G.M., & Sellgren, K. 1994, ApJ 437, 683

Furton, D.G., and Witt, A.N. 1993, ApJ, 415, L51

Acknowledgments:

Support through NASA Laboratory Astrophysics Grants NAG5-3790 and NAG5-4338 is gratefully acknowledged