

Photoluminescence enhancement in electron-beam irradiated polystyrene using ambient gas

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Abstract

It is known that electron irradiation transforms polystyrene (PS) from a non-luminescent polymer into a luminescent material. Photoluminescence (PL) from irradiated PS results from the formation of polycyclic aromatic hydrocarbons (PAH) or carbon dots assumed to be composed of PAH. In unrelated work, water vapor has been shown to modify chemical processes during electron-beam irradiation of Teflon AF and water vapor also alters the sensitivity and contrast of PMMA in electron-beam lithography. These prior efforts motivated us to study the effect of ambient gas on the electron-beam induced synthesis of fluorophores in PS.

Here we describe the effect of dose and ambient gas on the photoluminescence spectra and yield of electron irradiated PS films on insulating and conductive substrates. $100 \times 100 \mu\text{m}$ square patterns were exposed in an environmental scanning electron microscope using a 20 keV electron-beam. The gas pressure ranged from high vacuum to 3 mbar, and the dose ranged from 1.8 to 45 mC/cm². Emission spectra were collected using a confocal microscope with 405-nm laser excitation.

This study led to up to 10x enhancement in fluorescence yield using water vapor and the peak emission wavelength could be tuned over 451–544 nm range. This study also provided evidence that (i) electron scattering in gas is not solely responsible for the change in PL, (ii) the infrared absorption spectra of the irradiated PS only changes slightly with different gases, (iii) the electrical conductivity of the substrate substantially influences the gas dependent PL, and (iv) the thermal conductivity of the gas may also influence PL.

Biography of Presenter: Deepak Kumar is a PhD candidate in Electrical Engineering at the University of Kentucky. Deepak has years of experience in the fabrication and characterization of thin film: over 5 years of hands-on experience with physical vapor deposition and solution-based deposition systems. After earning his undergraduate degree in Electrical Engineering from BIT Sindri, India, he completed his master's degree in Electrical Engineering from the University of Kentucky.

