Sub kGy photon irradiation alterations in graphite

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1. Introduction

Over the past 90 years and more the various effects of ionizing radiation have been well documented, typically in regard to deterministic and stochastic biological risks and mostly at sub-Gy levels, notably in as much as these concerns reach the public eye. From as long ago as 50 years, irradiations of mammalian tissues have been associated with DNA alterations, not least cancer and genetic mutation stochastics (Hall and Giaccia, 2006). Less well publicized have been the very large efforts, specifically x-ray doses ranging from 1 to 10 Gy, extended to 30–200 Gy through use of 60Co gamma-ray source. Trapping parameters such as order of kinetics, activation energy and frequency factor are estimated using Chen’s peak-shape method for a fixed-dose of 30 Gy. X-ray diffractometry was used to characterize the crystal structure of the PPLG, the aim being to identify the degree of structural order, atomic spacing and lattice constants of the various irradiated PPLG samples. The mean atomic spacing and degree of structural order for the different diameter PPLG are found to be 0.3332 nm and 26.6° respectively. Photoluminescence spectra from PPLG arising from diode laser excitation at 532 nm consist of two adjacent peaks, 602 nm (absorption) and 1074 nm (emission), with mean energy band gap values within the range 1.113–1.133 eV.

Present work concerns polymer pencil-lead graphite (PPLG) and the potential use of these in elucidating irradiation-driven structural alterations. The study provides detailed analysis of radiation-induced structural interaction changes and the associated luminescence that originates from the energy absorption. Thermally stimulated emission from the different occupied defect energy levels reflects the received radiation dose, different for the different diameters PPLGs. The PPLG samples have been exposed to photon irradiation, specifically x-ray doses ranging from 1 to 10 Gy, extended to 30–200 Gy through use of 60Co gamma-ray source. Trapping parameters such as order of kinetics, activation energy and frequency factor are estimated using Chen’s peak-shape method for a fixed-dose of 30 Gy. X-ray diffractometry was used to characterize the crystal structure of the PPLG, the aim being to identify the degree of structural order, atomic spacing and lattice constants of the various irradiated PPLG samples. The mean atomic spacing and degree of structural order for the different diameter PPLG are found to be 0.3332 nm and 26.6° respectively. Photoluminescence spectra from PPLG arising from diode laser excitation at 532 nm consist of two adjacent peaks, 602 nm (absorption) and 1074 nm (emission), with mean energy band gap values within the range 1.113–1.133 eV.