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Full Length Article

Thermoluminescence studies of CaF_2: Dy irradiated with gamma rays and ion beams

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ABSTRACT

In this study, the nanophosphor CaF_2: Dy was prepared by the chemical co-precipitation method with different concentrations of Dy (0.0 to 0.4 mol%). The material was irradiated with gamma rays from Co-60 and proton beams of energy 2 MeV and 9 MeV. Proton irradiation was carried out at the Oslo Cyclotron Laboratory, University of Oslo, Norway. The thermoluminescence (TL) glow curves for different concentrations of dopant Dy irradiated with 100 Gy gamma dose reveal the optimized concentration to be 0.3 mol%. The average crystallite size was found to be 49 nm using X-ray diffraction analysis. TEM studies revealed that the particles were spherical in shape and with size in the range of 30–80 nm. It has a batch homogeneity of 22 %. The TL dose response was studied from 10 Gy to 15 kGy dose of gamma rays and it shows a wide linear response up to 7 kGy beyond which saturation is observed. CaF_2: Dy has two different TL glow peaks for proton beam irradiation and shows a linear dose response for both the energies of proton beams. The material needs to be studied further for its energy dependence using gamma rays and proton beams. It shows potential to be used as a dosimeter for gamma rays.

1. Introduction

Thermoluminescence (TL) is the emission of light after the heating of material previously exposed to ionizing radiation [1]. TL has applications in the dosimetry of ionizing radiation for personal, clinical, and environmental dosimetry.

Ion beams are being preferred over conventional photon beams due to their better dose deposition profile which allow for the effective dose exposure in the tumour region while sparring healthy tissues [2,3]. It is important to measure the radiation dose effectively that is delivered to the affected areas.

CaF_2: Dy microphosphor is a standard TLD material which has been studied extensively as a dosimeter and is commercially available as TLD-200. Nanophosphors have shown a wide linear dose response and better sensitivity as compared to the conventional micro-phosphor [4].

Previous research on CaF_2 based phosphors irradiated with ion beams has revealed intriguing phenomena such as the formation of defect complexes, energy transfer processes, and the role of dopants in modulating the TL response. For instance, studies by Yuho Hirata et al [5]demonstrated the influence of ion beam energy and fluence on the TL sensitivity of CaF_2:Ce phosphors, highlighting the importance of irradiation parameters in tailoring their dosimetric properties. Furthermore, investigations by Bhadane et al [6] shed light on the correlation between defect structures induced by low ion beam irradiation and the TL kinetics of CaF_2: Dy phosphors, providing valuable insights into the underlying mechanisms governing their luminescent behaviour.

In addition to ion beam irradiation, the TL characteristics of CaF_2:Dy phosphors under gamma ray irradiation have also been studied. Notably, several studies [7–10] have demonstrated the potential of CaF_2:Dy phosphors as gamma ray dosimeters with excellent sensitivity and dose response characteristics. Moreover, studies by N.Salah et al [11] investigated the effect of various parameters such as dopant concentration, annealing conditions, and irradiation dose on the TL properties of CaF_2 based phosphors, contributing to the optimization of their

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