ISSN 2277 – 6362
International Journal of Luminescence and Applications Vol.1 (II)

Optical Studies in Yb doped CaF_2 Single Crystals

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1. Introduction

Among alkali fluorides CaF_2 is a unique optical material that occurs naturally as the mineral fluorite. CaF_2 single crystals are used for variety of infrared and ultraviolet wavelength applications due to the fact that they are highly transmissive from 200-1100 nm. Rare earth doped CaF_2 exhibits a variety of novel properties. At low RE^{3+} ion concentrations, the dopants mainly form isolated centers whereas at higher RE^{3+} ion concentrations, the dopant ions aggregate and form complex clusters [1]. The Yb ion is interesting because of its strong IR luminescence.

2. Experimental

Yb (3 mol%) doped CaF_2 single crystal slices of 10 mm diameter and 1mm thickness were irradiated with γ-rays from a Co^{60} source for doses ranging from 97Gy to 9.72 KGy at room temperature. The irradiated samples were subjected to optical absorption measurements in the wavelength range 190-900 nm using V-570 UV/VIS/NIR spectrophotometer at room temperature. The PL emission spectra of the samples were recorded using a spectrofluoremeter (Jobin Yvon Fluorolog 3) equipped with a 450W Xenon lamp as the excitation source.

3. Results and Discussion

Figure1 shows the optical absorption spectra of pristine and γ-irradiated Yb doped CaF_2 crystals. The pristine samples showed minimal absorption indicating the purity of the procured samples. Two strong absorption peaks were observed in the irradiated samples at ~243 and 360 nm. The optical absorption was found to increase with increase in γ-dose. It is well established that when CaF_2 crystals are γ-rayed F-centers are formed at room temperature. γ-irradiation produces free electrons which get trapped at negative ion vacancies and form the F-centres. Literature reveals that electron irradiated CaF_2 crystals exhibit the fundamental absorption at 375 nm and it is attributed to F-center [2]. The absorption peak at 360 nm in the present studies is attributed to F-center [3]. The 243 nm peak is attributed to electron trapped by at Ca^{2+} interstitials [4].

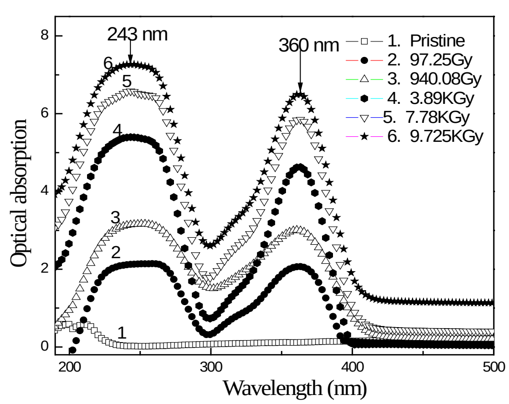

Figure 1. Optical absorption spectra of γ–rayed Yb doped CaF_2 single crystals

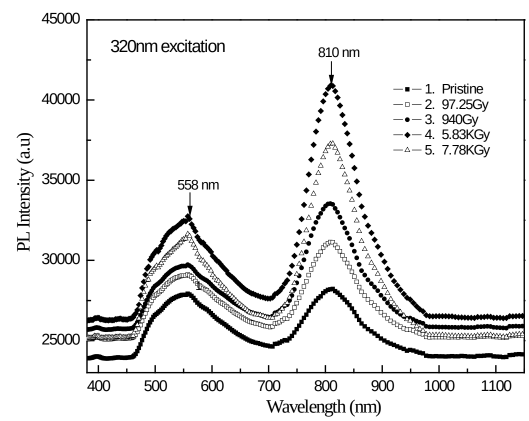

Figure 2. Photoluminescence spectra of γ–rayed Yb doped CaF_2 single crystals.

The photoluminescence emission spectrum of pristine and γ-irradiated pure CaF_2 crystals is shown in Figure 2. The spectrum shows two strong PL emissions – one in the visible region at ~558 nm and the other in the IR region with peak at ~810 nm when the samples were excited at 320 nm. The PL intensity was found to increase with increase in γ-dose. In CaF_2, the aggregation of point defects produced by energetic radiation play an important role in the emission of energy. It is known that irradiation of CaF_2 leads to the formation of F and F-aggregate centers in it. The 580 nm emission peak is attributed to aggregation of F-centers to form Mie absorption [5]. It is known from the optical and magnetic resonance measurements that, when CaF_2 crystal was doped with Yb, the trivalent Yb^{3+} ions substitute the Ca^{2+} ions, resulting the Yb^{3+} ions surrounded by eight F^{-} ions [6]. The replacement by Yb^{3+} gives a contribution to the creation of charge compensation, such as an interstitial F^{-} ion. Since the doping CaF_2 wtih Yb requires a mixture of YbF_3 and CaF_2 powders the number of Yb^{3+} ions present during the crystal growth is much higher than the number of Yb^{2+} ions.

It is reported that γ-irradiation results in the conversion of Yb^{3+} ions to Yb^{2+} state and this results in the formation of Yb^{2+} associated centers which luminescence in the red region of visible spectrum. The excitation of Yb doped CaF_2 crystals with suitable wavelength gives rise to IR luminescence in the wavelength range 800- 900nm [7]. Thus the emission of 810 nm band in the present studies may be due to Yb^{2+} associated centers.

4. Conclusions

Gamma irradiated Yb doped CaF_2 single crystals showed the generation of F and F-aggregate centers. A strong IR emission was observed at ~810 nm due to Yb^{2+} centers. The PL studies revealed the transition of Yb ions from triply charged (Yb^{3+}) state to the doubly charged (Yb^{2+}) state upon γ-radiation. The increase in optical absorption and PL intensities with γ-dose indicated the enhancement of defects in the Yb doped samples.

References

1. V. Petit, P. Camy, J.L. Doualan, and R. Moncorge, *J. Lumin*. **122-123** (2007) 5-7.
2. W. Hayes and R.F. Lambourn, *Phys. Stat. Sol(b)*, **57** (1973) 693-699.
3. Alok De, K.V. Rao *J. Mater. Sci.*, **7** (1988) 276-278.
4. Scouler and Smakula; *Phy.Rev* **120** (1960)1154-1161.
5. L. P. Cramer, B. E. Schubert, P. S. Petite, S. C. Langford, and J. T. Dickinson, *J. Appl. Phys.* **97**(2005)103533- 103539.
6. J. Kirton and S.D. Mclaughlan, *Phys. Rev.* **155** (1967)279-284.
7. Liangbi Su, Jun Xu, Hongjun Li, Lei Wen, Yueqin Zhu, Zhiwei Zhao, Y. D. Guoqing Zhou and Jiliang Si, *Chem. Phy Lett*, **406** (2005) 254-258