Effect of radiation exposure on the scintillation characteristics of CsI:Tl Films

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Introduction

Films of CsI:Tl are widely used for the X-ray imaging in medical diagnostics [1]. These films grow in a columnar structure that provides a high special resolution required for the imaging application. The CsI:Tl exhibits an emission at 550 nm that matches with the photodiode and CCD readouts. Films of CsI:Tl can be deposited on different substrate like silicon, glass etc. by a thermal evaporation method [2]. Effect of gamma radiation exposure on the single crystal of CsI:Tl has been reported and 10Gy of dose can be significant to degrade the scintillation characteristics [3]. To the best of our knowledge the effect of film thickness and radiation exposure on the scintillation properties of films have not been studied in details.

In the present paper we report on the effect of film thickness and radiation exposure on the scintillation properties of the CsI:Tl films. The obtained results are compared with the scintillation characteristics of a single crystal.

Experimental

Films of CsI:Tl were deposited on silica glass substrates in a vacuum based thermal evaporation system by heating small piece of single crystal of 0.2 mol % Tl doped CsI in a molybdenum boat. The use of CsI:Tl crystal pieces for the evaporation ensures a uniform activator concentration in the deposited films. These crystals were grown in carbon coated quartz crucibles using a gradient freeze technique [3] or a modified Bridgman technique [4]. The base pressure of the vacuum chamber was maintained at about 1×10^{-5} mbar. In different experiments the film thickness was varied from 20 µm to 160 µm while substrates were maintained at 100ºC. For structural and morphological studies the deposited films were characterized by X- ray diffraction and scanning electron microscopy (SEM). These films and crystal were coupled to a PMT for alpha spectroscopy. Alpha spectra of an Am-Pu source were recorded using a pre-amplifier, spectroscopic amplifier and an MCA.

Results and Discussion

Fig.1 shows the XRD pattern of the 160 µm thick film. All the diffraction peaks matched with that of the cubic CsI (PCPDF data # 060311). The XRD peaks confirmed the crystalline nature of the film. Further, a prominent diffraction peak corresponding to the (200) planes was observed while other peaks were very small, suggesting that the films are preferentially oriented along the <200> direction.

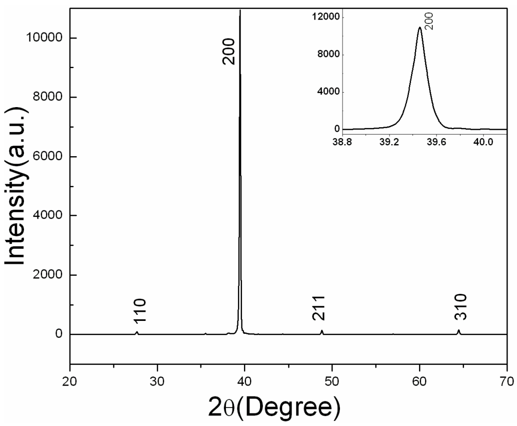

Fig. 1 XRD patterns of 160 µm thick film of CsI:Tl; Inset shows the XRD in the range (2θ = 39-40º).

The SEM images of the surface and cross section of the 160 µm thick film are shown in Fig.2. The surface of the films is continuous, compact and showed an average grain size of about 2-3 µm. While the cross sectional view revealed a columnar structure perpendicular to the substrate. A high resolution image revealed that the columns have a needle like tip and diameter of 2-3 µm.

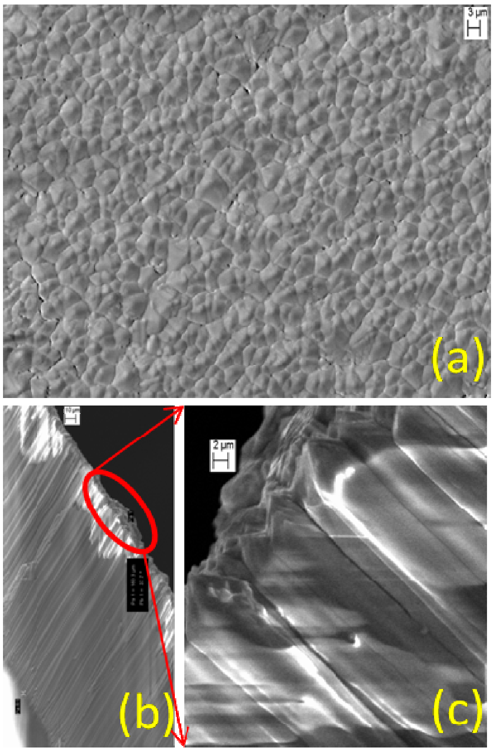

Fig. 2 SEM micrographs of (a) CsI:Tl film surface and (b)/(c) cross section of the 160 µm thick film showing the columnar growth.

To study the effect of radiation exposure on the scintillation properties of films and crystal, alpha spectra were recorded using an Am-Pu alpha source. Fig.4 shows the alpha spectra of films and single crystal before and after the exposure to different doses of gamma radiation (10, 160, 1000 Gy). The two alpha peaks (^{241}Am - 5.48 MeV and ^{239}Pu - 5.14 MeV) could be resolved by the single crystal, while films were not able to resolve these peaks. With increasing film thicknesses the pulse height decreases which may be due to higher scattering losses. The single crystal showed degradation in the pulse height and resolution with increasing radiation exposure while there was no measurable shift in the pulse height of the films. This may be attributed to the polycrystalline nature and lower thickness of the film. Gamma spectra recorded using ^{60}Co exhibited the Compton background confirming the interaction of gamma radiation with the film.

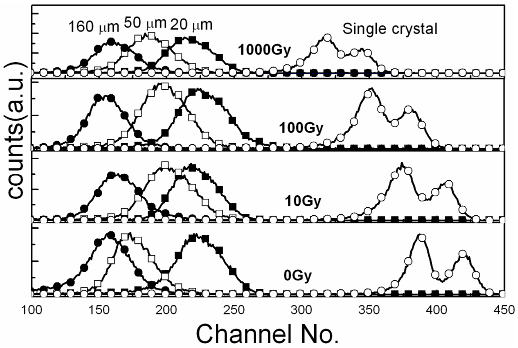

Fig. 3 Pulse height spectra using ^{241}Am-^{239}Pu alpha source for the CsI:Tl films (20, 50, 160 µm) and single crystal before and after the exposure to gamma radiation.

Conclusion

CsI:Tl films grown using the thermal evaporation method exhibited a columnar structure oriented along <200> direction with diameters of 1-2 µm. The pulse height for the alpha spectra shifted to lower channel numbers with increasing film thickness presumably because of increased light scattering. For single crystals the effect of radiation exposure has been pronounced as the pulse height and resolution degraded with increasing radiation exposure.

References

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