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Photoluminescence of ion-implanted phosphors

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Abstract. Ion-implanted phosphors were prepared by implanting Sb in CaS at 25 keV with concentration ranging from 0·05 to 0·2% by weight. Samples of similar concentration were also prepared using the conventional technique. The spectral response under UV excitation of both types of samples is compared.

Keywords. Photoluminescence; ion-implanted phosphor; spectral response.

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1. Introduction

The advent of the technique of ion-implantation at comparatively lower temperatures and better reproducibility has given a new dimension to the problem of doping a variety of ions in various lattices to form luminescence systems. Both the elemental semiconductors (Kirkpatrick *et al* 1976; Picraun and Stein 1974; Lin *et al* 1974), and the wide band gap semiconductors II–IV compounds (Arginskaya *et al* 1972; Hon and Marley 1970) can be doped with various impurities by the ion-implantation technique for producing luminescent devices.

In the present work phosphors were prepared by ion-implantation technique by implanting Sb into CaS at various concentrations ranging from 0·05% to 0·2% by weight and similar samples by the conventional technique. A comparison of the spectral response under UV excitation of both types of samples is also presented.

2. Experimental

The ion-implantation set-up (Virdi 1983) was used to prepare CaS:Sb phosphors by implanting Sb^+ beam at 25 keV into CaS substrate. The concentration of Sb doped was varied from 0·05 to 2% by weight. Samples of similar concentrations were also prepared by the conventional technique by mixing CaS powder with varying amounts of Sb (using antimony sulphide solution) at a temperature of 900 ± 20°C in the furnace. The spectral response under UV excitation was studied at room temperature with a constant deviation spectrometer. The output from the photomultiplier (RCA, LP21) coupled to the spectrometer was fed to a d.c. microvoltmeter (Philips Gm 6020/90). The wavelength drum D was gradually set and the corresponding current in the d.c.

microvoltmeter was observed for each wavelength setting. The schematic diagram of the arrangement used for photoluminescence spectra is given in figure 1.

3. Results and discussion

A plot of current versus wavelength gives the spectral response of the phosphor and the same is shown in figure 2. (a′), (b′), (c′), (d′) in the figure represent the conventionally prepared samples and (a), (b), (c), (d) represent the implanted samples. Figure 3 shows the luminescent peak intensity vs activator concentration.

The peak emission intensity of both implanted and conventionally (diffusion) prepared phosphors initially increases and then decreases with increase in Sb concentration. The maximum was obtained for 0·1% of Sb in CaS. The initial increase is due to the creation of a larger number of emission centres but the subsequent decrease is caused by the well-known phenomenon of concentration quenching. A somewhat lower efficiency for the ion-implanted samples relative to those prepared conventionally is probably due to radiation damage following ion-implantation as we could not study the effect of thermal annealing in the phosphor samples. Another possible reason could be due to the impurity implantation doping being limited to near surface region of the sample whereas the conventionally (diffusion) doped phosphors exhibit bulk response with impurity distributed throughout the samples.

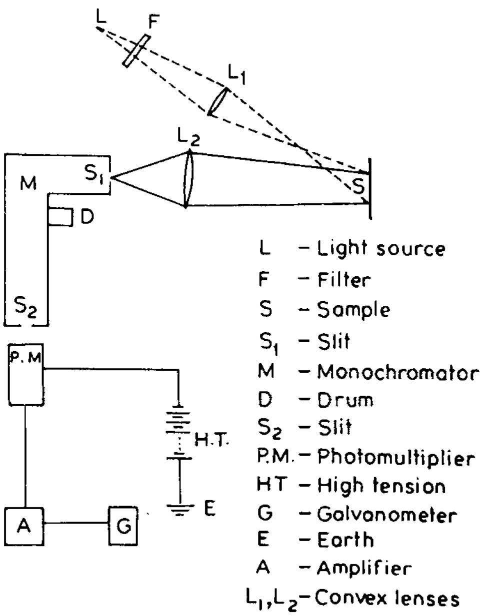

Figure 1. A schematic diagram of the apparatus used for observing emission spectra of phosphors.

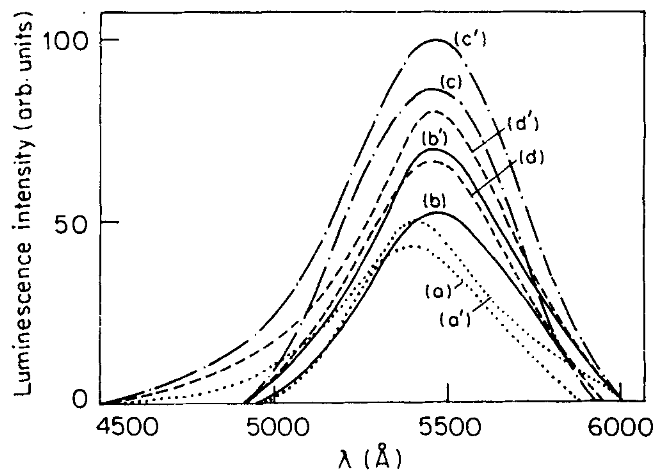

Figure 2. Emission spectra. **a.** Ion-implanted (a') diffused 0·05%; **b.** Ion-implanted (b') diffused 0·075%; **c.** Ion-implanted (c') diffused 0·1%; **d.** Implanted (d') diffused 0·2%.

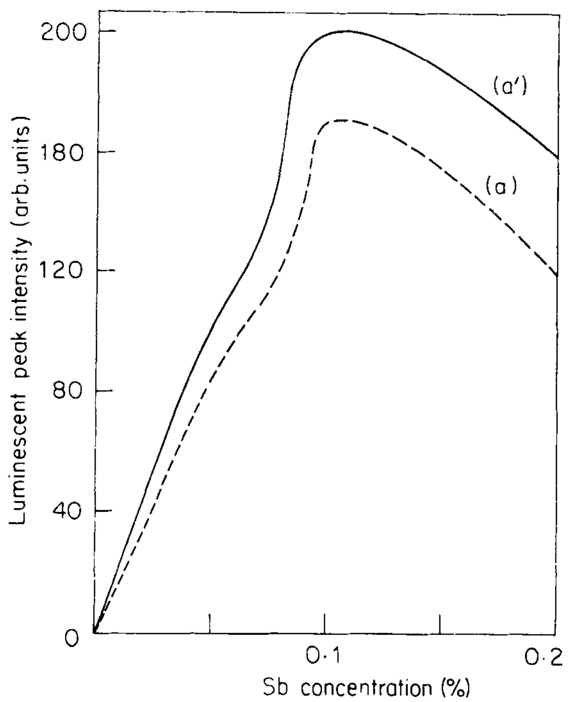

Figure 3. Luminescent intensity vs activator concentration (a) ion-implanted (a') diffused.

The present results demonstrate that there is a wide scope for producing useful phosphors under controlled conditions by the ion-implantation technique.

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