2-9 Mn-IMPLANTED ZnS THIN FILM ELECTROLUMINESCENT CELL

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New low energy ion implantation techniques are utilized effectively to fabricate a thin film electroluminescent cell. In the techniques combined implantation process of activator and deposition process of substrate material,not only the dose distributions of activator elements, but also the selection of elements can be controlled externally by adjusting ion beam current and accelerating voltage, and by changing ion source units. In this paper, the methods to fabricate Mn-implanted ZnS EL cell and fundamental properties of the cell are reported.

Fig. 1 shows the double layer type ac and dc EL cells. Two methods for fabrication of single and double layer type are used to form ac and dc EL cells. The one method is as follows: ZnS thin films are formed by electron-beam deposition on substrates of a glass conductively coated with tin oxide. These are deposited to a thickness of about 1 μm. Then ions are implanted. Ion doses to be implanted have ranged from 0.5×10^{15} to 5×10^{15} cm^{-2}.

The electroluminescence from the cell under ac excitation was detected by a photomultiplier tube and the intensity of the luminescence was observed. The brightness-voltage characteristics are shown in Fig. 2 where we can see that the luminescent intensity of the double layer type is stronger than that of the single layer type with the same total dose of activator.

Usually ZnS thin films activated by Mn only through the thermal diffusion processings show little or no emission under dc excitation. However strong light emission was obtained from the cell which was fabricated by the ion implantation techniques. The dependence of brightness B on dc voltage V is shown in Fig. 3. The current-voltage characteristic is shown in Fig. 4. The cell shows low impedance characteristic in spite of containing Mn only, and does not show the rectification property which is seen in the dc EL fabricated by the thermal diffusion

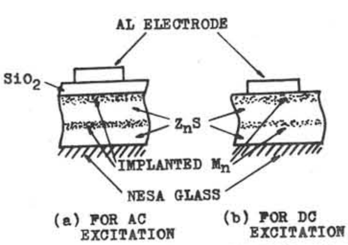


Fig. 1 DOUBLE LAYER TYPE M_n IMPLANTED Z_nS THIN FILM

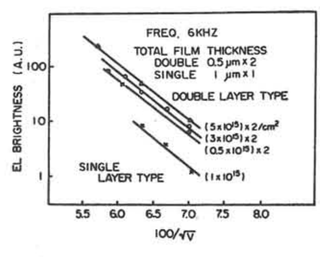


Fig. 2 Electroluminescent brightness as a function of applied ac voltage.

processings. The light output wave forms produced by pulsed voltage waves are shown in Fig. 5. The wave forms are very closely in phase with the applied voltage. The life test of the films under dc operation has been carried out with the unidirectional voltage pulses (25.5 v hight, 5 msec repetition time, and 1/5 duty factor). Maintenance characteristics for constant unidirectional-voltage-pulse operation are shown in Fig. 6 with a typical characteristics obtained from ZnS: Cu, Mn cell fabricated by the thermal diffusion processings. No remarkable change of brightness from the cell can be observed during 500 hours for Mn-implanted ZnS films. But the thermaly diffused cell showed the degradation in the brightness characteristics.

To make clear the difference between the Mn-implantation and the Mn-deposition processings, the diffusion of Mn near the cell surface has been observed by reflective electron-diffraction technique. Fig. 12 shows the diffraction patterns of ZnS films fabricated by (a) ion implantation and (b) vacuum deposition after the annealing. The pattern of Mn-implanted film indicates that the film consist of crystalline of cubic structure, whereas the pattern of Mn-deposited film indicates the presence of undiffused Mn on the surface of the film.

It is obvious that our ion implantation technique combined with the deposition of substrate material will be useful to fabricate a dc EL cell.

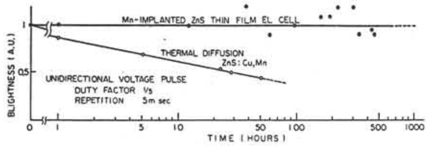


Fig. 6 Maintenance characteristics.

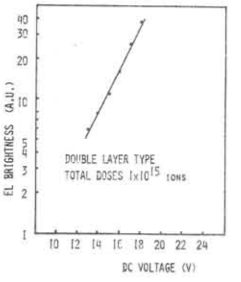


Fig. 3 Brightness vs. voltage characteristic under dc excitation.

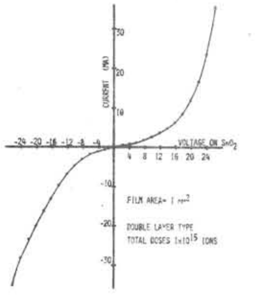


Fig. 4 Current vs. voltage characteristic of Mn-implanted ZnS dc EL cell.

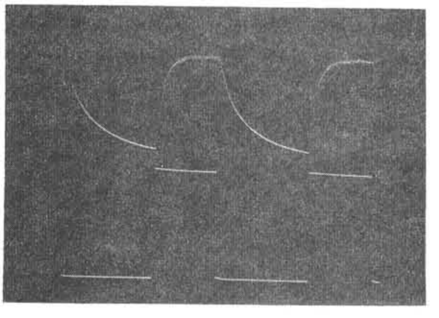
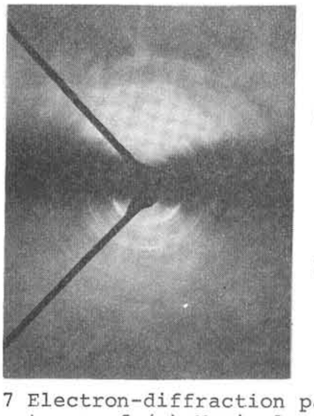


fig. 5 Light output (upper) produced by pulse wave voltage (lower).



(a)

(b)

Fig. 7 Electron-diffraction patterns of (a) Mn-implanted and (b) Mn-deposited cells.