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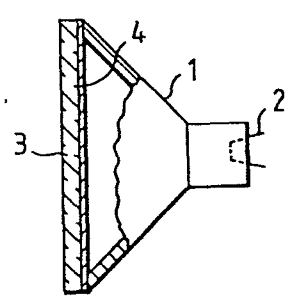
(54) Cathode ray tube screens.

(57) A cathode ray tube comprises an envelope (1) having a screen (3) of a single crystalline or polycrystalline material such as yttrium aluminium garnet. Dopants such as Tb^{3+}, Eu^{3+}, Ce^{3+} or Tm^{3+} are implanted to different depths or in different areas (7, 10) of the screen. Annealing the screen removes lattice damage caused by the implanting. Multicolour luminescence is obtained by scanning an electron beam over the differently doped areas (7, 10), or by varying the electron beam energy as it scans.

Fig.1.



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CATHODE RAY TUBE SCREENS

This invention relates to cathode ray tube (C.R.T.) screens.

A typical cathode ray tube comprises an evacuated glass envelope with an electrode structure at one end and a face plate at the other end. The face is internally coated with a phosphor screen formed of doped phosphor particles deposited by settlement from a suspension. An electron beam is caused to sweep acrcss the screen and form an observable image, e.g. a television display. A disadvantage with powder layers is their limited luminescence; increasing the electron beam current to obtain higher luminance is not possible without damaging the phosphor layer. Another disadvantage is the resolution, limited by the powder particle size for single colour screen and also by diffusion for double layer screens operating on the penetron principle.

Such disadvantages are particularly troublesome in projection cathode ray tube displays e.g. aircraft head up displays (HUD) where an image from a small cathode ray tube is projected in front of a pilot as an image ahead of the aircraft.

Patent Specification G.B. 2,000,173 A describes a cathode ray tube screen formed by a monocrystalline body including a luminescent layer containing an activator. The layer is grown by liquid phase epitaxy or diffusion of an activator into the body. This results in a single colour light output.

According to this invention a cathode ray tube screen comprises a single crystalline or a polycrystalline slice into which a dopant is inserted into the surface layer by ion implantation followed by annealing to remove the lattice damage caused by the implantation and to assist the diffusion of the dopant into the crystal.

The single crystsl slice may be a slice of yttrium aluminium garnet (YAG) and the surface layer may be produced by implanting Tb^{3+}, Eu^{3+}, Ce^{3+}, Tm^{3+}, or other suitable dopants, singly or sequentially over the whole crystal, or with different dopants in different areas. The slice or layer may be a single crystal or a thin film on a different substrate (e.g. of YAG on other garnets or sapphire). Other suitable crystals are compounds capable of incorporating rare-earth ions, e.g. oxides containing a lattice site of similar size and/or valency to rare-earth ions.

The invention will now be described, by way of example only, with reference to the accompanying drawings of which:-

Figure 1 is a general side view of a cathode ray tube:

Figure 2 is a graph of dopant level near the surface of the screen after annealing;

Figures 3, 4, 5 are sections of a cathode ray tube screen during processing to provide differently doped areas suitable for use in a beam indexed colour cathode ray tube.

As shown in Figure 1 a cathode ray tube comprises an evacuated glass envelope 1 with an electrode structure 2 at one end and a front face 3 at the other end. The face 3 may be a slice of single crystal yttrium aluminium garnet (YAG) on its own or bonded on the inside of a glass plate. The inside surface of the face is covered with a very thin evaporated layer of aluminium 4.

The yttrium aluminium garnet (YAG) crystal may be grown by conventional methods e.g. by the Czochralski technique of growth from a melt of yttrium oxide and aluminium oxide. A grown crystal of yttrium aluminium garnet is sliced and polished to the required dimensions.

The slice of yttrium aluminium garnet is placed in a vacuum chamber and implanted with Tb^{3+} ions from a terbium chloride source at 150 kV to give around 2×10^{16} ions/cm^2. Following implantation the slice is annealed at about 1750^{o}C for about 3 hours. This removes residual damage and diffuses the Tb^{3+} into the crystal; Figure 2 shows how the concentration decreases away from the surface.

In operation an observable image is displayed on the screen 3 where struck by a scanning electron beam. The light intensity varies with beam current. At a beam energy level of 5 kV the image appears green, the spectrum being dominated by an emission line at 544 nm of the Tb^{3+} ion in the high Tb^{3+} concentration region near the near surface. At higher voltages e.g. 40 kV the image appears blue caused by intrinsic defect luminescence of the bulk yttrium aluminium garnet in combination with blue lines from the Tb^{3+} ions in the low concentration region away from the surface. Thus a penetron two colour display may be achieved by the use of two beams at two different voltages.

A penetron type of screen may also be produced by ion implanting different activators to different depths using different implant energies.

Alternatively strips of different activators may be implanted as shown in Figures 3, 4, and 5. An aluminium mask 5 is formed on the yttrium aluminium garnet slice 6 by conventional photo lithographic techniques Figure 3. The Tb^{3+} ions are implanted 7 in the YAG slice through slots 8 in the mask 5 and the mask removed. A second mask 9, Figure 4, is formed on the yttrium aluminium garnet slice 6 and ions of Eu^{3+} implanted 10. The second mask 9 is then removed, Figure 5, and the slice annealed to give a yttrium aluminium garnet slice 6 doped in with Tb^{3+} and Eu^{3+} in strips 7, 10 for use e.g. in a beam indexed type of colour cathode ray tube. Beam index and penetron cathode ray tubes are described for example in Microelectronics Journal Vol. 11, No. 3, pp. 10-23, D. J. Robbins. A thin e.g. 300Å thick layer of aluminium is evaporated onto the yttrium aluminium garnet slice to prevent screen charging during operation, and is etched into two interdigital comb shaped structures 11, 12 respectively overlying the Tb and Eu doped strips 7, 10 to provide a beam index signal.

What I claim is:

1. A method of making a cathode ray tube comprising the steps of providing a single crystalline or polycrystalline slice forming a front face of the tube, ion implanting at least one dopant into the slice, and annealing the slice to remove lattice damage.

2. The method of claim 1 wherein different dopants are implanted to different depths in the slice.

3. The method of claim 1 wherein different dopants are implanted in different areas of the slice.

4. A cathode ray tube formed by the method of claim 1 comprising an envelope with a single crystalline or polycrystalline slice forming a front face, the slice having different dopants implanted in different parts of the slice whereby different colours can be emitted from the different parts of the slice when illuminated by an electron beam.

5. A cathode ray tube according to claim 4 wherein the different dopants are implanted in different areas of the slice.

6. A cathode ray tube according to claim 4 wherein the different dopants are implanted to different depths in the slice.

7. A cathode ray tube according to claim 4 wherein the slice is the material yttrium aluminium garnet.

8. A cathode ray tube according to claim 4 wherein the dopants are selected from Tb^{3+}, Eu^{3+}, Ce^{3+}, or Tn^{3+}.

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Fig.1.

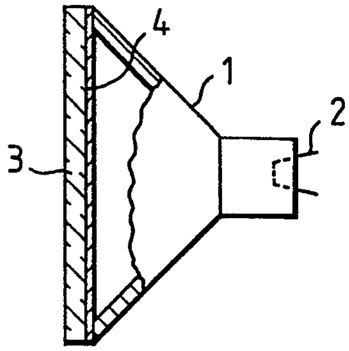

Fig.2.

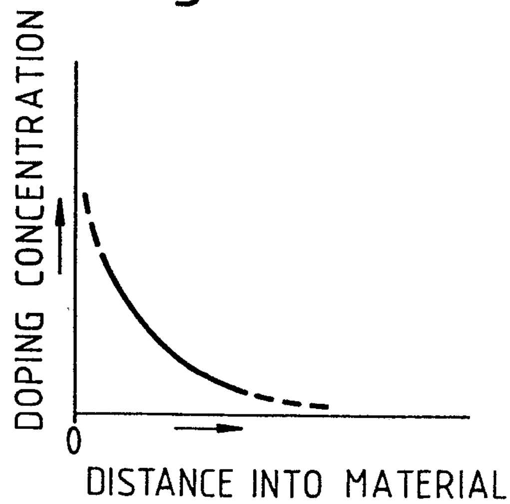

Fig.3.

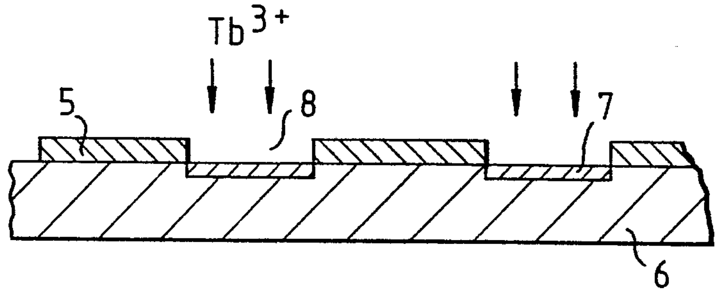

Fig.4.

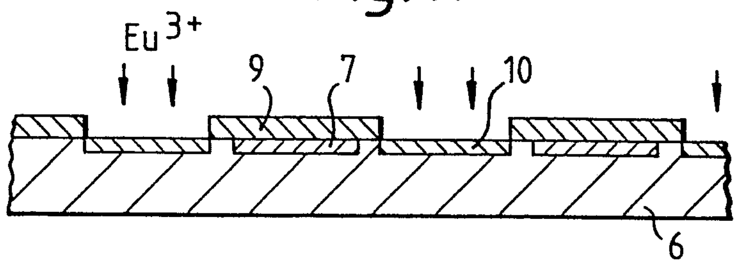

Fig.5.