THERMAL ANNEALING OF HIGH-EFFICIENCY AC THIN-FILM ELECTROLUMINESCENT DEVICES

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ABSTRACT

The present paper reports the fabrication of an efficient ACTFEL device using a thermal annealing technique. The intensity of an alternating current thin-film electroluminescent (AC-TFEL) device depends on the applied voltage. With the drive voltage at 1 Khz for the thermal annealed devices an increase of electroluminescence with growing fluence of the thermal annealing pulse is determined. With incident fluencies of about 1 Joule/cm2, the thermal annealed devices exhibit luminance over that produced by the thermal annealed devices.

INTRODUCTION

Alternating current thin-film electroluminescent (AC-TFEL) devices already occupy a segment of the huge area, high resolution, flat panel display marketplace. AC-TFEL displays are strong, possess long lifetimes, and offer high luminance with relatively low power consumption [1] AC-TFEL devices consist of a phosphor layer, which includes manganese-doped zinc sulfide (ZnS: Mn), vertically sandwiched between two insulators that are contacted through electrodes. When a sufficiently high voltage is applied across the electrodes, electrons trapped at interfaces between the layers are injected into the conduction band of the phosphor, where they are accelerated by the field and might excite the luminescent dopant centers inside the phosphor layer via impact excitation and ionization mechanisms.[2,3]

The temperature dependence of electroluminescence (EL) is interesting no longer simplest because it modifies the EL emission however it yields facts to understand the nature of the phosphors and the effective lure depths that can be decided. Destriau (1947) was probably the first who studied the temperature dependence of ZnS-ZnO phosphors and determined that the threshold voltage of excitation falls as the temperature is lowered. The effect of temperature on electroluminescence output has been studied by numerous workers [4-5].

The annealing process is carried out in ACTFEL devices to activate the dopant within the phosphor-thin film, by effectively incorporating the luminescent dopant ions in the host lattice. This annealing process is conventionally carried out as a post-deposition thermal treatment in a vacuum, normally at 500°C for 1 hour. However previous work2) has shown that thermal annealing of electro-luminescent devices also results in a amendment of the electron transport properties inside the device, limiting the performance. To overcome the limitations that thermal annealing introduces, Thermal annealing has been proposed, and after determining the quality experimental conditions we have successfully produced thermal annealed TFELs with better characteristics than thermal annealed.

EXPERIMENTAL METHOD

The TFEL devices, developed consists of a ZnS: Mn phosphor layer sandwiched between two MgF2 insulating thin films, as shown in figure 1. Then the 'sandwich' structure of two 300nm MgF2 layers and a 600nm ZnS: Mn layer are deposited via RF magnetron sputtering. Before deposition of the second insulating layer, the phosphor thin film is thermally annealed. Finally, the top electrode is deposited and dry-etched to form the individual devices. This structure of an electroluminescent device permit surface viewing by reflecting laterally emitted light due to the internal wave guiding impact while allowing resolutions up to 1200 lines per inch.

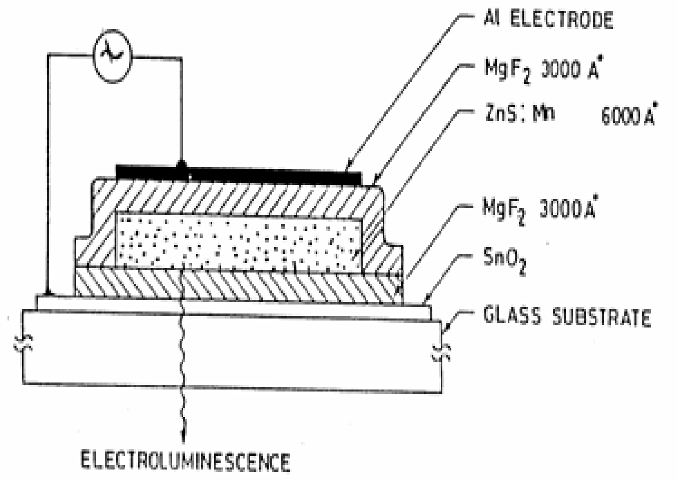

Figure. 1. Schematic cross-section of Thin Film electroluminescent (TFEL) devices

In the past, aluminum has been used as the top electrode but the present work Ti/W was also investigated[6-7]. Aluminium, having a melting point (660°C) close to the thermal annealing temperature, has been found to diffuse into the dielectric, leading to EL devices that break down easily. On the other hand, Ti/W has a very high melting point (melting points are Ti:16600C, W:34100C), allowing thermal annealing after completing the fabrication (deposition, making, and plasma each) Hence, with Ti/W as a top electrode both thermal and thermal annealed TFEL devices can be fabricated from some wafer for direct comparison.

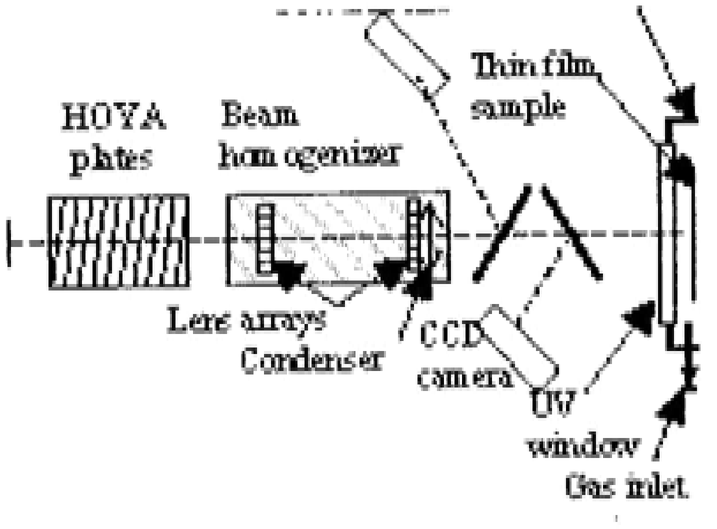

Figure 2. Optical bench for Thermal annealing

For thermal annealing, the experimental system illustrated in Figure 2 was used. For thermal heating, high-intensity rays from a diode laser deliver 270 nanometer pulse of 25 nanosecond duration. A variable number of Hoya plates (fused silica plates) are used to attenuate the beam. In the experiment a spot size of 6 x 6 mm is obtained with any fluence up to 1.2 joules/cm2. Two additional Hoya plates are introduced after the beam homogenizer to reflect a small portion of the beam to the online diagnostics: a photo-thermal converter for monitoring the energy of each pulse and a CCD camera for monitoring the uniformly of the thermal spot.

To have high-performance thermal annealing, ablation must be limited by the housing of the sample in a Stainless steel pressure cell allowing a highly pressurized environment (150 psi) of an inert gas (Ar). For accurate positioning of the sample, the cell is mounted on an X-Z translation stage, with motions driven by two stepper motors controlled by a computer.

Finally that TFEL devices are tested in terms of electroluminescence, by measuring the luminance vs voltage characteristics. Measurements are performed on a probe located in a dark enclosure and while driven by a sinusoidal wave the Luminance is measured by coupling the emitted light to a photomultiplier tube via an optical fibre positioned 1 cm above the test device.

RESULTS AND DISCUSSION

Figure 3 the EL intensity vs. Voltage curves shown, with the drive voltage at 1 kHz for the thermal annealed devices an increase of electroluminescence with increasing fluence of the thermal annealing pulse is observed. With incident fluencies of approximately 1 Joule/cm^2, the thermal annealed devices exhibit luminance over that produced by the thermal annealed devices. Furthermore, the thermal devices can be driven at higher voltages than the thermal annealed without breaking down. Additionally, the voltage threshold is determined the decrease fluence of the annealing pulse.

The lower threshold voltage for thermal annealed devices might be attributed to some surface ablation. At the same time, the thermally annealed devices were found to be more stable than the thermally annealed. This technique is hence of interest each in terms of interesting luminance and device reliability.

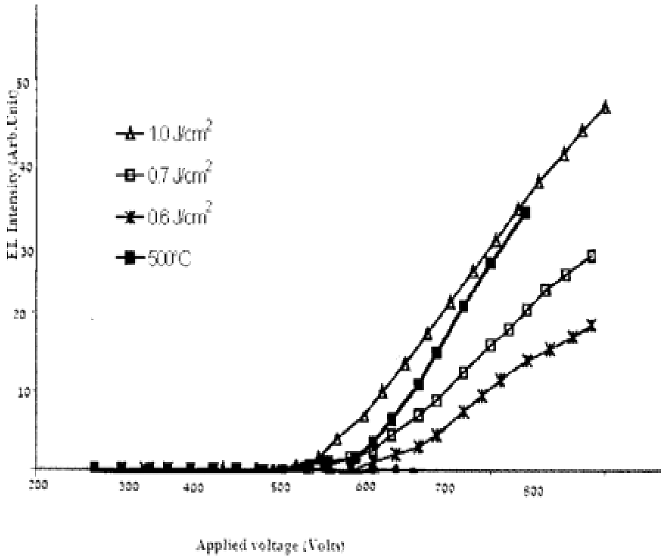

Figure 3. Characteristic luminance vs voltage curves of ACTFEL devices with different annealing conditions

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