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Design And Development Of Hybrid Electroluminescent Lamp From Embedded Phosphor Material: A Survey

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Abstract: The phenomenon of production of visible light through a material when it is placed to electric field is called Electroluminescence (EL). Under the presence of high electric field which involves the injection of charge carriers the alternating current EL is produced. This consequently produces radiativeelectron hole recombination for the production of EL in the material considered. The technique of EL device design is veryimportant and the design needs to have the basic knowledge. For this purpose various researchpapers has been studied and important information has been collected and are presented in this paper. This paperpresents the techniques and methods adopted by various researchers to design the ELdevice.

Keywords: EL(Electroluminescence), CNT(Carbon Nanotube), white WLEDs Light Emitting Diodes (WLEDs), AC-EL(Alternating Current driven Electroluminescence).

I. INTRODUCTION

The phenomenon of production of visible light through a material when it is placed to electric field is called Electroluminescence (EL). Under the presence of high electric field which involves the injection of charge carriers the alternating current EL is produced. This consequently produces radiative electron hole recombination for the production of EL in the material considered. An EL device is prepared by sandwiching a light emitting phosphor layer between the two conductive electrodes. As a consequence of intense research in this field of illumination a variety of EL device structure is available. Among all the structure involving alternating current driven thick film has gained huge attention for the area including displays and illumination just because of its ease of fabrication for large area, no requirement of any type of vacuum processing and mostly due of low manufacturing cost involved. This has gained various advantages also like uniform illumination, good brightness and contrast with relatively low power consumption and the wide screen visibility. The EL devices are used in various practical applications like mobile phones, watches, exit lightning and many more filed of illumination engineering. Various researches have been presented to produce an effective EL device which consumes less power, provide more brightness and takes less area for their manufacturing. This paper presents a survey on some of the recent development in this field of light illumination. Some major researches which show remarkable contribution in presenting the effective EL device have been surveyed and their valued contribution has been presented and discussed in this paper. Recent publication presents the use of CNTs (Carbon Nanotube) for the design of EL devices. Some authors presents the high illumination on white light by absorbing the other light produced in the process of production of the luminescence. As discussed earlier the design of EL device is done with doping the materials with some of the light effective materials to enhance the yield of light form it. Below sections presents the major researches contributed for the design of such high light producing devices with their advantages and disadvantages.

II. DESIGN OFEL DEVICES

EL device is being developed continuously over the years. Various considerations have been done for the design so as to get higher luminescence. Different types of alloys, different types of sandwiching, and different ways of doing etc. have also been developed for the same. These developments have been surveyed and presented below.

Haranathet al. present a method to produce the luminescence from the material. The author says Eu3+ luminescence spectroscopy has been used to investigate the effective doping of alkoxide-based silica (SiO2) gels using a novel pressure-assisted sol-gel method. The results pertaining to intense photoluminescence (PL) from gel nanospheres can be directly attributed to the high specific surface area and hence remarkable decrease in unsaturated dangling bonds of the gel nanospheres under pressure can be observed. An increased dehydroxylation in an autoclave resulted in enhanced red (~611 nm) PL emission from europium and is almost ten times brighter than the SiO2 gel made at atmospheric pressure and ~50ºC using conventional Stober- Fink-Bohn process. The presented results are entirely different from those reported earlier for SiO2:Eu3+ gel nano spheres and the origin of the enhanced PL have been discussed thoroughly. The author highlight the importance of pressure assisted hydrothermal / solvothermal process for the preparation of variety of nanoparticles of oxides and chalcogenide materials. The solution based nanomaterial synthesis often involves reactions carried out near the boiling point of the solvent. This may lead to poor quality of the nanomaterial and less yield. In order to obtain crystalline, monodisperse nanoparticles, it is always necessary to work at relatively high temperatures and pressures. Author reported that the use of acid digestion bomb (commonly called Autoclave) is the best alternative to work with. Details of the autoclave synthesis of intrinsic silicagels have been reported extensively by Haranathet al. since 1996. In this paper the author presented a method of using RE gel in which rare-earth (RE) doped silica gels were made under pressure at elevated temperatures. This method of preparation, which is based on pressure-assisted sol-gel method, has compatibility in modifying the coordinating environment of RE (dopant) ions so that the loss in energy of the excited states via. non-radiative mechanism is minimum. This establishes the fact that high pressure and temperature leads to more closely packed structures and increased charge transfer energies that are efficiently transferred to the Eu3+ ions. Finally the author demonstrated a mechanism by which photoluminescence enhancement in SiO2:Eu3+ phosphor nanospheres could be successfully achieved using pressure- assisted sol-gelmethod.

Sahaiet al. presented a novel, cost-effective and faciletechnique, wherein multi-walled carbon nanotubes (CNTs) were used to transform a photoluminescent material to exhibit stable and efficient electroluminescence (EL) at low voltages. The author demonstrated a commercially available ZnS:Cuphosphor (P-22G having a quantum yield of 65±5%) which was combined with a very low (~0.01 wt%) concentration of CNTs dispersed in ethanol. Along with this, its alternating current driven Electroluminescence (AC-EL) was also demonstrated. The mechanism of EL was discussed using an internal field emission model, its intra-CNT impact excitation and the recombination of electrons and holes through the impurity states. Author also presented the photoluminescence (PL) spectrum of commercial ZnS:Cu (P-22G) phosphor as shown below.

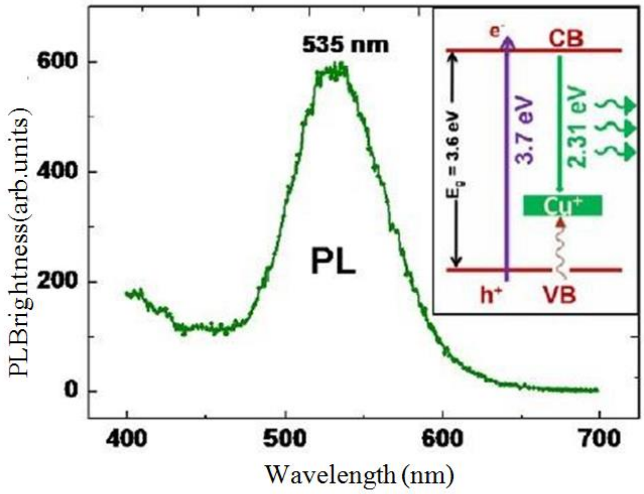

Figure 1: Photoluminescence spectrum ZnS:Cu

The figure shows bright green PL emission (quantumyield655%) having peak maximumat535 nm, whenobservedunderan excitation wavelength of 335 nm (3.7 eV). The insets hows the energy band scheme for copper-doped ZnS phosphor, exhibiting its well-known band gap 3:6 eV. Thisimpliesthatexcitation energies higher than the bandgap could very well be absorbed by the ZnS crystal. A radiative recombination of electrons and holes occurs as the Cu^{+} acceptor levelemits the desired green (535 nm) light. The author concluded that electrolumine scence from the non-electroluminescent ZnS:Cuwas sachieved with the introduction of CNT. Electro-optical properties such as brightness–voltage, brightness–frequency and brightness waveforms were also presented. It was anticipated that the idea will be very interesting and useful in the field of AC-EL. Mishra et al. in his paper says that there has been a stringent demand for blue (~450 to 470 nm) absorbing and red (~611 nm) emitting material systems in phosphor converted white light emitting diodes (WLEDs) available in the market. The conventionally used red-emitting Y2O3:Eu3+ phosphor has negligible absorption for blue light produced by GaInN based LED chips. To address this issue author presented a new red-emitting $Gd_2CaZnO_5:Eu^{3+}$ ($GCZO:Eu^{3+}$) Nanophosphor system having exceptionally strong absorption for blue (~465 nm) and significant red (~611 nm) photoluminescence. Strong absorption in the blue region is attributed to the quantum size effects. Apart from that, high external quantum efficiency obtained for blue light (~465 nm) absorption in $GCZO:Eu^{3+}$ nanophosphor is superior to the $Y2O3:Eu^{3+}$phosphor.

Yadav et al. presented a method to design a hybrid electroluminescent (EL) lamp by embedding carbonnanotubes (CNTs) inside the ZnS:Mn phosphor particles by conventional solid state diffusion technique. Byembedding the CNTs the phosphor particles exhibited increase in EL brightness and efficiency at low operating voltages (<80 VAC). The CNTs used form conductive paths

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inside the ZnS particle hence triggering EL due to electron injection to luminescent centers (Mn^{2+}) even at nominal voltages. Authors presented the fabrication, its characteristic, its XRD patterns and the mechanism of EL generation in CNT embedded ZnS:Mn phosphor hybrid material as shown below.

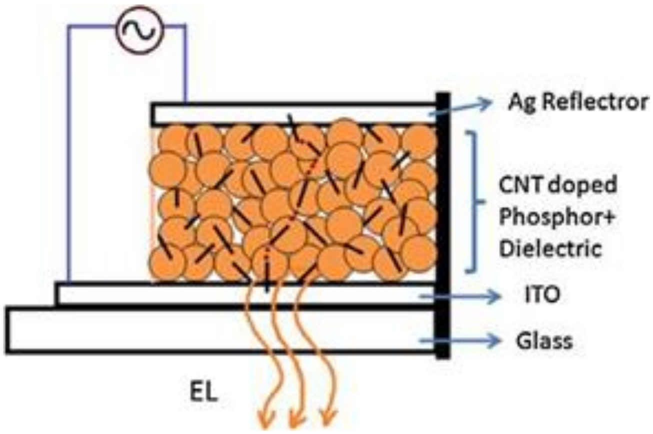

Figure 2: CNT embedded ZnS:Mn phosphor EL lamp

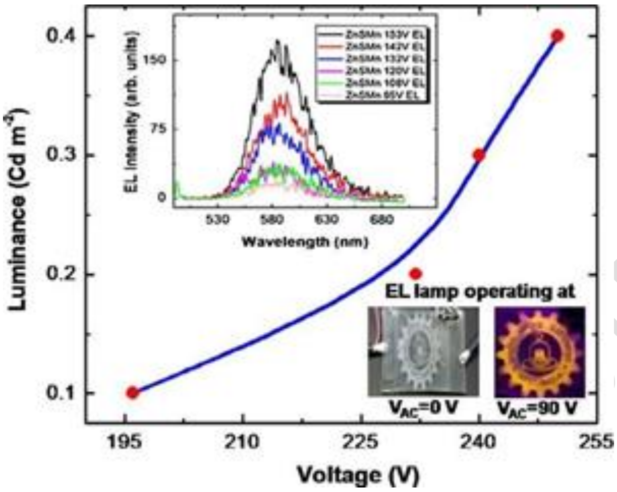

Figure 3: Luminance–voltage curve of the developed EL lamp

The above inset shows the spectral energy distribution of the EL lamp intensity at various wavelengths and below inset shows the photographs of EL lamp operating at 0 and 90 VAC.

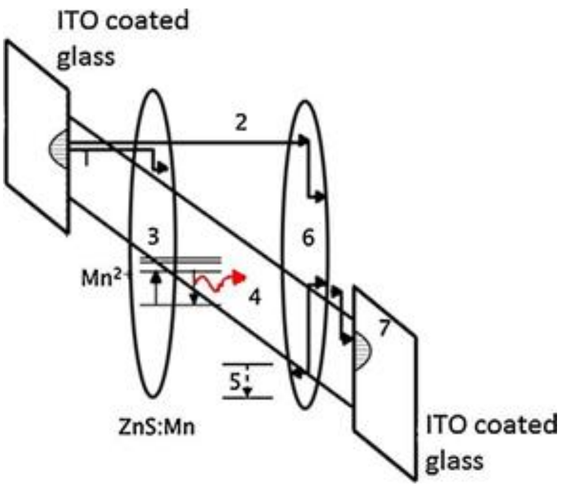

Figure 1: photoluminescence spectrum ZnS:Cu

Author concluded that the presence of CNTs have introduced efficient electron transport inside the ZnS:Mn phosphor exhibitting bright orange-red EL brightness at low operating voltages (<100 VAC). Also, the length of CNTs used for the lamp fabrication has a major influence on the field enhancement effect. The purpose of CNTs was to form conductive paths inside the ZnS particles for hot electron injection to luminescent centers at nominal voltages.

Dwivediet al. focuses on the effective doping of multi-walled carbon nanotube (CNT) in the ZnS:Cuphosphor nanocomposite and due to increased local field effects improvement in the optical performance of electroluminescent (EL) device has been identified. To facilitate doping of CNTs into the phosphor and decrease the operating voltage of the EL device the authors shortened CNTs by milling and incorporated it effectively using a flux assisted solid-state annealing reaction. Authors in this paper presented the way to prepare EL phosphor, fabrication of EL Device, and device characteristic. In this paper authors fabricated a series of AC driven EL devices by doping CNTs inside the ZnS:Cuphosphor nanocomposite. The doping is done by crushing the CNTs by high energy ball milling to decrease their aspect ratio. The EL performance was found to be improved with adequate doping of CNTs, indicating the importance of local field enhancement and prevention of undesired flow of current in the CNT networks inside the ZnS:Cuphosphor nanocomposite. CNT plays a role of local electric field enhancer and facilitator in the hot carrier injection to produce ultra-bright EL in the nanocomposite.

III. CONCLUSION

Based on the reviews of numerous researches that has been done on the Luminance and on the brightness of light emitting diodes (LEDs) it can be concluded that with the change in the phosphor material the brightness of the EL device can be enhanced. Also by embedding the CNTs also the brightness level can be enhanced and also the operating voltage can be reduced to significant level of desired value. Hence if the ZnS:Mnphosphor material is also replaced by another material the brightness can still be improved. Taking this as further scope of work we will try to identify the new phosphor material to further increase the brightness level compared to those developed earlier and also try to further reduce the requirement of voltage for operating the EL device.

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