Green electroluminescence from ZnS:Cu alternating current thick film electroluminescent devices

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Abstract
The color shifting from yellow to green of electroluminescent emission from ZnS: Cu alternating current thick film electroluminescent (ACTFEL) devices has been achieved by changing the Mg composition in the phosphor layers. The commission international de l'Eclairge (CIE) color co-ordinates of the ACTFEL devices prepared from these phosphor layers show a shifting from yellow (x=0.45, y=0.52) towards green (x=0.36, y=0.58). The various parameters influencing the emission intensity were also investigated.

1. Introduction
Although challenged by other green-light-emitting phosphors, ZnS:Cu is still one of the most widely used luminescent materials in display, sensor and illumination devices. The green phosphor materials find applications ranging from fluorescent lamps to immunoassay [1].These materials essentially convert one type of energy into visible radiations and hence, phosphors materials are called optical transducers. To gratify the prerequisites for the future display technique developments such as flat screens, low operating voltage, high resolution etc., and a primary focus of the research in this field is phosphor development including new systems designing and modification of existing and modification of existing phosphor systems. One good example is synthesizing ZnS particles with spherical shape, narrow size distribution and high luminescent efficiency at low voltage. New methods and meliorations have been developed for fabrication of ZnS-based phosphors [2-5]. The study of quantum size effect on the semiconductor particles has attracted more attention in recent years. The objective of this paper is to present a simplified process for the preparation of improved ZnS:Cu phosphors.

2. Experimental
High purity starting materials $CuSO_4.5H_2O$(99.9%), $MgCl_2.6H_2O$ (99%) were weighed according to the stoichiometry .ZnS is taken as the host material . In the first firing 1.5 weight % of $CuSO_4.5H_2O$ was mixed with ZnS. The chloride flux was blended with the above mixture in different amounts and various samples of different flux ratios of magnesium chloride with respect to the weight of zinc sulfide were prepared. The admixture was then fired in the covered crucible at varying temperatures from 500°C to 1200°C to convert into fine crystallized material. The crystallized material was then washed with de-ionized water and acids until all the halide impurities were removed. Finally to remove the excess copper the material was washed with 2% KCN solution. The phosphor was dried at a temperature of about 110°C for 2-3 hrs.

The above powder obtained from first firing was treated with 0.1 to 0.4 mole percent of copper sulfate and 0.3 to 0.7 mole percent of magnesium chloride. The blended powder was kept for second firing at different temperatures ranging from 600°C to 800°C for 2-5 hrs in the covered crucible. The material is treated at lower temperatures for the smoothening of the crystals. The washing and drying treatment of the obtained phosphor is unaltered.

Finally the electroluminescent device of the phosphor is made.

3. Results

The particle size of the phosphor obtained by the first firing (Fig.1a) and after second firing (Fig.1b) were analyzed by SEM and it is found around 25 µm. The crystalinity of the phosphor is investigated by the XRD. The XRD spectra of the powder sintered at different temperatures are shown in Fig 2. The CIE co-ordinates and PL intensity are analyzed by the emission spectra as indicated in Fig 3.

The electroluminescent emission peak shows a composition dependence of the ZnS:Cu phosphor layer. It has been observed that with the increase in the concentration of Mg incorporated into the phosphor, EL emission peak broadens. In addition to the main peak appearing at 565 nm, there is an another shoulder peak at 589 nm.This may be due to the phase segregation within the film

The cathodoluminescence brightness of the phosphor is a function of both applied voltages *V* and currents *I* due to the basic principle in elementary electronics. The brightness and brightness efficiency of the ZnS:Cu phosphor can be plotted as a function of the substrate current , it indicates that the brightness is a linear function of substrate current. However, no saturation behavior is observed when the substrate current exceeds 2000 nA in the fabricated ZnS-base phosphor. It is also indicated that the luminescence efficiency is reduced if more electron beams are applied on the fabricated phosphors.

4.Reference:

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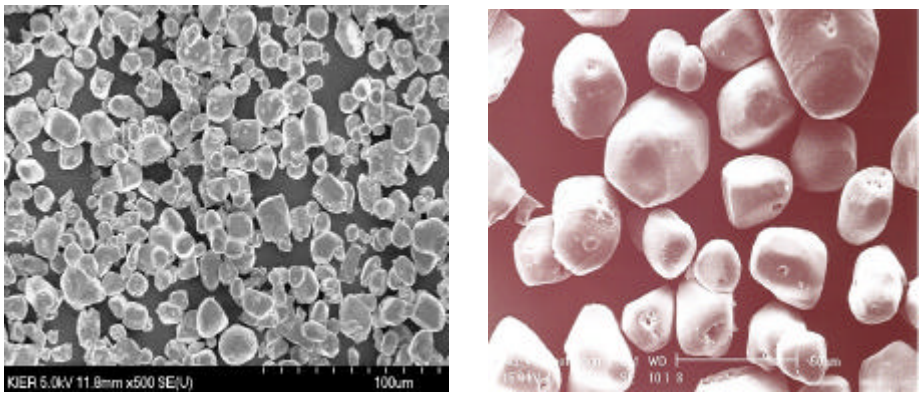

(a) (b)

Figure .1. SEM photograph of the phosphor (a) phosphor synthesized after first firing (b) phosphor synthesized after second firing

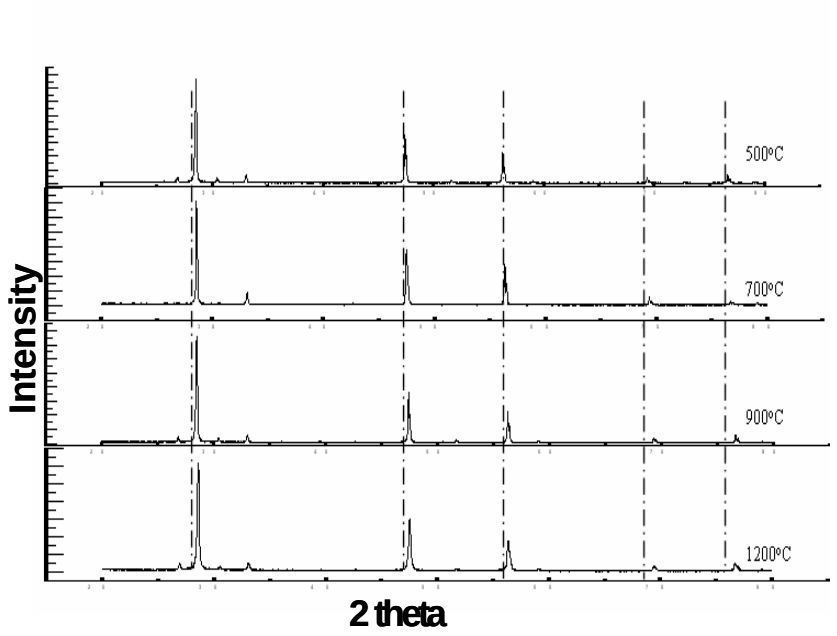

Figure 2 XRD spectra of the ZnS:Cu powder sintered at different temperatures.

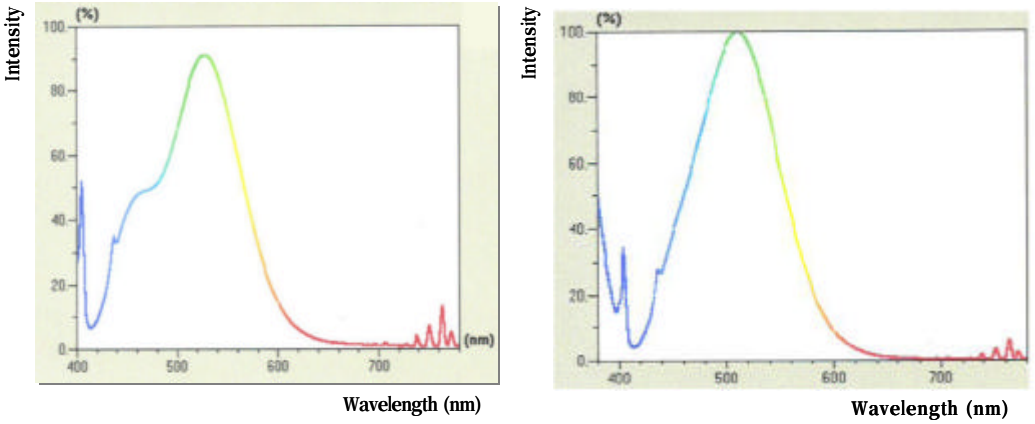

Figure 3. Emission Spectra of ZnS:Cu powder prepared with different Cu concentration

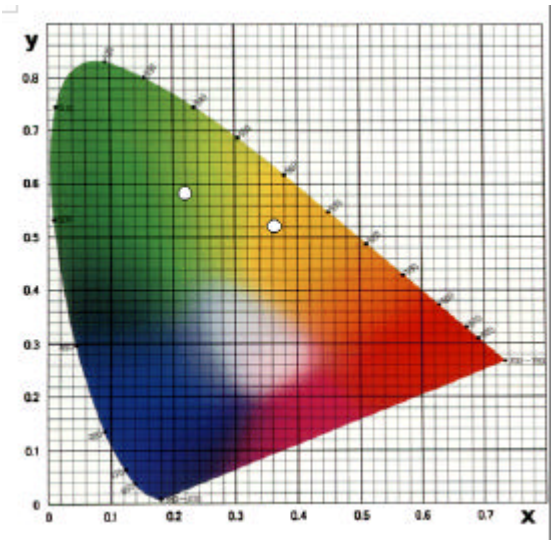

Figure 4. CIE coordinates for phosphor showing the color transition from yellow to green