Thermoluminescence from europium doped gadolinium oxide aerosols

INTRODUCTION

High grade phosphors in the form of particles with a narrow size distribution, a spherical morphology and absence of agglomerates have been made using an aerosol approach with europium doped gadolinium oxide. High levels of Eu produce intense red emission. As initially fabricated the material lacks intensity and requires thermal treatments above 800°C, and then improves further with 12 hours above 1,200°C. Reasons include removal of unwanted trace materials, improvements in the crystallinity of the mixture, alterations in surface sites, and dispersion and homogenisation of the Eu dopants. Further, the phase of Gd2O3 Eu changes with annealing temperature. Dopant levels with a Gd to Eu ratio of 9:1 were first used. High dopant values can generate clustering of the Eu ions into non-radiative sites, lattice strains induce defects or induce phase separation and/or precipitation of the dopant ions into interacting clusters. All such scenarios can result in greatly reduced luminescence efficiency. Current results, with a higher dopant concentration of Gd:Eu of 8:2, are feasible because of the improvements from annealing. A monocrystal phase was observed after the sample powder was annealed above 1,100°C.

EXPERIMENTAL

Samples were prepared from solutions of Gd(NO3)3·8H2O and Eu(NO3)3·6H2O, with the Gd:Eu molar ratio of 8:2. The reactants were added to a high temperature tubular flow reactor with air as a carrier gas, and decomposed at 700°C. The gas flow rate was 1.5 l/min, and the corresponding droplet/particle residence time was 75 s. This resulted in a fine powder called "as prepared" which was subsequently thermally annealed. Annealing was made in air at temperatures of 800 to 1,200°C for periods of 12 hours. The TL emission spectra with a wavelength multiplied spectrometer. Above room temperature the heating rate was 0.5 degrees per second, but 0.1 K/s for low temperature data. TL was excited by X-ray irradiation with 40 kV X-rays using 200Gy.

The crystal phases and particle morphology were determined by X-ray diffraction (XRD), Field Emission Scanning Electron Microscopy (FE-SEM) and Transmission Electron Microscopy (TEM). All peak positions were used for the determination of microstructural parameters. Microstructural refinements were carried out using the Rietveld based programs Fullprof. A FESEM was used in order to identify particle morphology.

SUMMARY

An aerosol route was applied for the synthesis of nanosize submicron sized spherical Gd2O3:Eu3+ particles. The particle morphology and phase content were evaluated by different analysis techniques (XRD, FE-SEM and HR-TEM) and discussed in terms of the processing parameters and post-annealing temperature. XRD patterns implied the presence of two cubic phases in as-prepared powder: a main Ia3 phase and a secondary Fm-3m phase with the concentration of 12% wt. The latter phase is similar to Gd2 Te6 O15. The table above summarizes the parameters. Only the Eu3+ ion can occupy two Gd3+ sites with a coordination number of 6 with C2 and S5 symmetries.