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Comparison of electrophoretic deposition of nano- and micron-sized $Ba_2SiO_4:Eu^{2+}$ phosphor particles

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White light generation using near-UV LEDs has been investigated, primarily due to reduced current drooping and better control over color qualities [1, 2]. Electrophoretic deposition (EPD) of red-, green-, blue-, yellow- and orange-emitting phosphors has been shown to be a promising and effective method for phosphor deposition in a remote phosphor configuration [3]. Nano-phosphors with comparable quantum efficiency to typical micron-sized phosphors may be superior due to a lower scattering loss, thereby improving the light extraction efficiency [4]. The objective of this work is to compare EPD of nano- and micron-sized phosphors for a near-UV LED-based light source.

In this work, Eu-activated Ba_2SiO_4 was selected and prepared by solid state reaction and a co-precipitation method, yielding micron- (~5 µm) and nano-sized (~500 nm) particles, respectively [5]. The micron-sized particles were deposited by cathodic EPD from a bath of isopropanol (IPA) with 10^{-5} M $Mg(NO_3)_2$ which resulted in uniform films [3]. However, when a suspension of nano-sized particles in this bath was used, EPD resulted in a non-uniform and porous film. A larger amount of water can be adsorbed onto the nano-sized particle surface than for micron-sized particles. With additional water in the bath, more hydrogen evolution can occur at the cathode during EPD, causing poor quality films. Therefore, amyl alcohol, which has a low water solubility, was used as the EPD solvent with 10^{-5} – 10^{-4} M $Mg(NO_3)$. The zeta potentials were 13 and 20 mV for 10^{-5} and 10^{-4} M $Mg(NO_3)_2$ in amyl alcohol, respectively.

The deposit thickness of nano- and micron-sized particles as a function of time is shown in Fig. 1. Particles were deposited from the amyl alcohol bath with 10^{-4} M of $Mg(NO_3)_2$ and 5 g/L phosphor using an applied voltage of 80 V. The deposit thickness increases nearly linearly with time and the film thickness for the larger sized particles was thicker at the initial stage of deposition, as expected. However, the thickness for the micron-sized particle leveled at 26 µm at 15 min, whereas the thickness of nano-sized particle plateaued at 33 µm at ~30 min. The larger particles settle from solution, decreasing their concentration, whereas the suspension with nano-sized particles was more stable. Fig. 2 shows SEM micrographs of phosphors films from 15 min deposition with (a) nano- and (b) micron-sized particles showing the deposit thickness and particle size. The packing fraction was ~45% for films of both nano- and micron-sized particles. EPD from the amyl alcohol bath was able to produce uniform films over a 6.45 cm^2 for both nano- and micron-sized Ba_2SiO_4 powders.

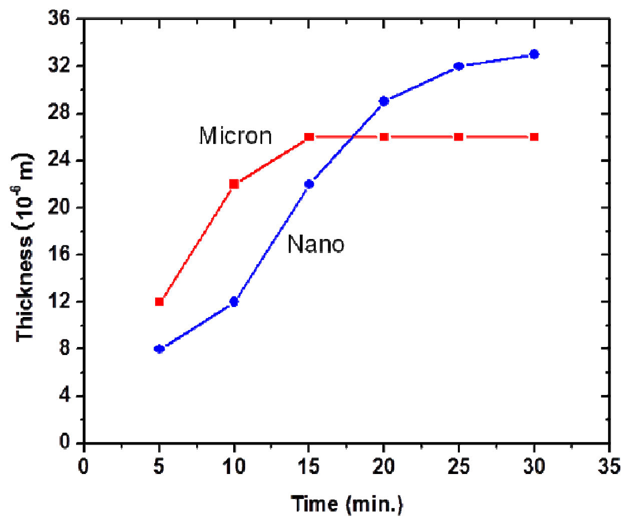
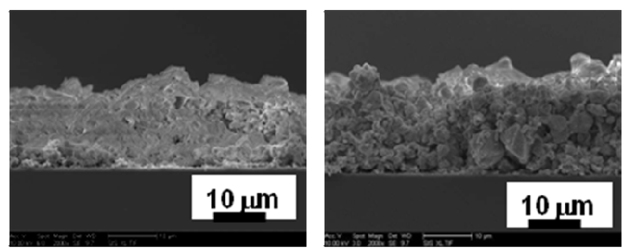


Figure 1. The deposit thickness of nano- and micron-sized particles as a function of time



(a) (b)

Figure 2. SEM micrographs of deposited phosphors films with (a) nano- and (b) micron-sized particles

Acknowledgements

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