

Electroluminescence from Phosphor-doped Nanocrystals

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Alternating current thin-film electroluminescent (AC-TFEL) devices already occupy a segment of the large-area, high-resolution, flat-panel-display market. The AC-TFEL displays, which consist of a phosphor layer, such as manganese doped-zinc sulfide (ZnS:Mn), vertically sandwiched between two insulators that are contacted by electrodes, are robust, possess long lifetimes, and offer high luminance with relatively low power consumption [1], [2]. While fabrication of AC-TFEL devices has been the subject of considerable study over the past three decades, significant challenges remain. Development of multicolor displays with balanced red, green, and blue (RGB) emission has proven difficult as the most efficient red, green, and blue phosphors comprise different materials systems that require different deposition and annealing steps. Transparent AC-TFEL displays have recently been demonstrated by Sharp, Inc.; however, the processing of the phosphor to achieve transparency is difficult and has not yet been developed for phosphors other than ZnS:Mn [3].

We present a novel materials system for solution processing of the active phosphor layer in transparent AC-TFEL devices. We use colloiddally-synthesized Mn-doped nanocrystals interspersed between RF magnetron sputtered ZnS layers to demonstrate electroluminescence (EL) from a solution-deposited active layer in an AC-TFEL device fabricated at room temperature [4]. We adapt the synthesis of Thakar *et al.* to make stable ZnSe/ZnS:Mn/ZnS nanocrystals with quantum yields of $(65 \pm 5)\%$ [5]. As Figure 1 shows, these wide band gap host nanocrystals along with sputtered wide band-gap metal oxides (Al_2O_3 , HfO_2 , and ITO) enable transparent AC TFEL devices without additional processing steps beyond the room-temperature layer-by-layer deposition of each material set. Our devices exhibit electroluminescence from the Mn dopants at frequencies greater than 10 kHz and with voltages as low as 110 V_{pp} (See Figures 1 and 2) [4].

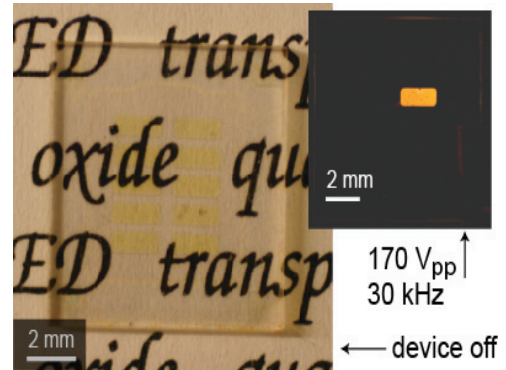


FIGURE 1: A photograph of a 0.5 in. x 0.5 in. glass substrate containing ten 1 mm x 2 mm AC-TFEL devices, with no bias applied. The substrate is pictured on top of printed text to demonstrate the transparency of our AC-TFEL device architecture. The inset shows the uniformity of pixel illumination (in the dark) with the device operating at 170 V_{pp} and 30 kHz.

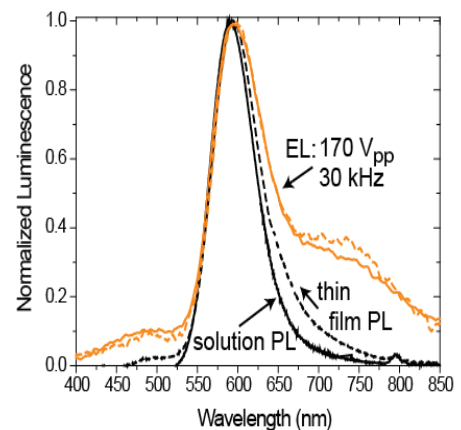


FIGURE 2: Electroluminescent (EL) spectra for devices with Al_2O_3 and HfO_2 insulating layers (solid and dashed orange curves, respectively). Photoluminescence (PL) spectra of the nanocrystal solution (solid gray curve) and a completed device (dashed black line). The overlap of the spectral peaks indicates that the emission is due to the Mn impurity dopants.

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