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Enhancement of Light Extraction of Luminescent Coating by Nanostructuring

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Abstract : Energy-saving lighting devices based on LightEmitting Diodes (LEDs) combine a semiconductor chip emitting in the ultraviolet or blue wavelength region to one or more phosphor(s) deposited in the form of coatings. The most common ones combine a blue LED with the yellow phosphor $Y_3Al_5O_{12}:Ce^{3+}$ (YAG:Ce) and a red phosphor. Even if these devices are characterized by satisfying photometric parameters (Color Rendering Index, Color Temperature) and good luminous efficiencies, further improvements can be carried out to enhance light extraction efficiency (increase in phosphor forward emission). One of the possible strategies is to pattern the phosphor coatings. Here, we have worked on different ways to nanostructure the coating surface. On the one hand, we used the colloidal lithography combined with the Langmuir-Blodgett technique to directly pattern the surface of YAG:Tb^{3+} sol-gel derived coatings, YAG:Tb^{3+} being used as phosphor model. On the other hand, we achieved composite architectures combining YAG:Ce coatings and ZnO nanowires. Structural, morphological and optical properties of both systems have been studied and compared to flat YAG coatings. In both cases, nanostructuring brought a significative enhancement of photoluminescence properties under UV or blue radiations. In particular, angle-resolved photoluminescence measurements have shown that nanostructuring modifies photons path within the coatings, with a better extraction of the guided modes. These two strategies have the advantage of being versatile and applicable to any phosphor synthesizable by sol-gel technique. They then appear as promising ways to enhancement luminescence efficiencies of both phosphor coatings and the optical devices into which they are incorporated, such as LED-based lighting or safety devices.

Keywords : phosphor coatings, nanostructuring, light extraction, ZnO nanowires, colloidal lithography, LED devices
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