Controlled crystallization in luminescent lithium borate glass for LED applications

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Abstract

The majority of white light emitting diodes (LEDs) is based on a blue light emitting diode with a yellow phosphor on top. The phosphor powder, which converts a part of the blue light from the LED into yellow light, is usually embedded in an organic polymer and directly coated onto the LED chip. Heat-induced degradation of the polymer-based encapsulate, however, results in an efficiency decrease and colour temperature change. Here, luminescent lanthanide-doped borate glasses and glass ceramics represent a promising alternative as frequency-converter. The borate glass system provides high transparency in the visible spectral range, good lanthanide ion solubility, and high mechanical stability. Lithium borate glasses optically activated with the lanthanide ions terbium (Tb3+) and europium (Eu3+) show a bright luminescence therein with quantum efficiency values of approx. 60 % (486 nm excitation) and 90 % (396 nm excitation), respectively. However, since the absorption coefficient of the lanthanide ions is low, only a small amount of the excitation light is absorbed resulting in a poor conversion efficiency. To increase the optical absorption by prolonging the optical pathway through multiple scattering within the glass, the as-made luminescent borate glasses are processed to glass ceramics in a subsequent annealing step. The focus of this work is on the analysis of the crystallization process in lithium-borate glass and the conversion from glass to glass ceramic. With in situ x-ray diffraction (XRD) the crystal growth for different annealing protocols is monitored. In addition, the influence of the grown crystallites on the optical parameters is investigated by optical spectroscopy and quantum efficiency (QE) measurements.

Keywords: luminescent borate glass, crystallization, in situ XRD, light yield, light distribution

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