Abstract

The optical characteristics of Low-Temperature Ce\textsuperscript{3+}:YAG doped glass are analyzed for high-power PCWLEDs. This Low-Temperature Glass powder exhibited a lower transition temperature about 567\,K. The 4-wt\% LTCeYDG glass particle size from 150\,\mu m to 50, the Du, QE and ACCCTD were measured 85\%, 34.5\% and 2400\,K, respectively.

I. INTRODUCTION

The high operation temperature of LED chip is resulted from the great demand of high output power of LED [1]. One of the consequent problems was the deterioration of the organic resin matrix for LED chip protection and the phosphor layer fixture onto the blue LED chip [2,3]. The chemical formula of polymer-based resin was \([\text{R}_2\text{SiO}]_n\). The high heat radiation from the GaN chip resulted in the Methyl R broken form Si-O frame [1]. This bond breakage created sub-band defects and consequently made the silicone yellowing and the transmittance decrease. These led to the lumen loss and the chromaticity shift of LED modules [4-6]. To overcome such thermal problem, phosphor layer’s polymer-based resin was substituted for glass-based [7-9]. Tanabe, et al., reported a novel durable YAG glass ceramic (YAG-GC) phosphor [7]. It is expected to be used especially for high power LED applications because of its excellent thermal properties. The YAG-GC phosphor was obtained by a heat treatment of a Ce-doping SiO\textsubscript{2}-Y\textsubscript{2}O\textsubscript{3}-Al\textsubscript{2}O\textsubscript{3}-CeO\textsubscript{2} mother glass between 1200\,\textdegree C to 1500\,\textdegree C. The quantum efficiency of Ce\textsuperscript{3+} emission in the YAG-GC was estimated 30\%.

In this study, we proposed a glass phosphor layer fabricated at low-temperature for replacing resin to alleviate the thermal stability problem. Furthermore, the correlation of the glass powder particle size and particulate distribution uniformity (Du) characteristics (Du), quantum efficiency (QE) and angular CCT deviations (ACCTD) were investigated.

II. EXPERIMENTS

The low-temperature Ce\textsuperscript{3+}:YAG doped glass were prepared with different glass particle sizes 1500–800\,\mu m (labeled as Range A), 300–200\,\mu m (named as Range B), 150–50\,\mu m (Range C) and less than 50\,\mu m (Range D). Then, these Ce\textsuperscript{3+}:YAG doped glass were heated on an alumina plate at 650\,\textdegree C for 4 hours. These samples were quenched to room temperature and polished to 0.5-mm thick. To investigate the glass powder particle size dependence of particulate uniformity characteristics. In this study, distribution uniformity Du was employed to calculate for glass phosphor. Du of a luminescence material is defined as the area ratio of Ce\textsuperscript{3+}:YAG phosphor observed on the LTCeYDG. The particulate distribution uniformity is defined by

\[ Du = \text{Avg'} \Sigma (\text{Low Quarter}) / \text{Avg'} \Sigma (\text{Total}) \]  

where \text{Avg'}\Sigma(\text{Low Quarter}) and \text{Avg'}\Sigma(\text{Total}) are the average of at least four sets area ratio and average of sum of total area ratio, respectively. Setup of photoluminescence spectra measurement was shown in Figure 1. An integrating sphere equipped with two baffles coated with barium sulphate, optical fiber, and CCD detector was employed to measure the spectra. A 5W GaN base blue LED was used as the pumping source. The GaN-based blue LED was covered with the glass phosphor completely.