138-Inorganic wavelength conversion materials for high power solid-state lighting (INVITED TALK)

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Phosphor converted-Light Emitting Diodes / Laser Diodes (pc-LEDs/LDs) have become popular in a variety of solid-state lighting devices. Most of the conventional white pc-LEDs/LDs consist of a blue-LED/LD and Ce doped $Y_3Al_5O_{12}$ (YAG) phosphor dispersed in a resin matrix. White light is obtained by mixing the fluorescent yellow light and the exciting blue light. The resin matrix tends to be damaged by heat from a higher power blue-LED/LD[1)] during a long time use. The damages are undesirable color changes and deformations of resin, resulting in short lifetime of pc-LEDs/LDs devices. To solve these problems, we have developed translucent glass ceramics (GC) of YAG:Ce^{3+} micro-crystals in 2004[2)]. Since this material consists of all inorganic material, excellent stability is expected.

For the wavelength conversion materials, emission color control is important as well as its reliability or efficiency. However, "warm white emission" was not realized by this YAG-GC. Because precipitated YAG crystals emit only yellowish fluorescence when they are excited by a blue light source. For the realization of "warm white emission", development of a wavelength conversion material with red fluorescence is required. Therefore, we have developed the 'phosphor-glass composites' in which powdered phosphors are dispersed homogeneously in the glass matrix[3)].

Figure 1 shows an example of emission colors of the phosphor-glass composites with the appropriate mix of $La_3Si_6N_{11}$(LSN):Ce^{3+} and α-SiAlON:Eu^{2+} when it is excited by a blue LED. The emission color of the phosphor-glass composites can be arbitrarily controlled within a region surrounded by the chromaticity point of LSN, α-SiAlON and the blue-LED(460nm) and be adjusted on the locus of the black body radiation by simply changing the ratio of the two phosphors.

The change of relative total luminous flux of the phosphor-glass composite in HAST (Highly Accelerated temperature and humidity Stress Test) was shown in Fig. 2 compared with a phosphor-resin composite. The phosphor-glass composite did not show any change at all even if the sample was exposed in HAST for 300 hours. The appearance of the sample also did not change. On the other hand, the relative total luminous flux of the phosphor-resin composite decreased with increasing test time.

The phosphor-glass composites are expected as the reliable wavelength conversion material for high power solid-state lighting. In this talk, the history of developing the phosphor-glass composites and their characteristics will be introduced.

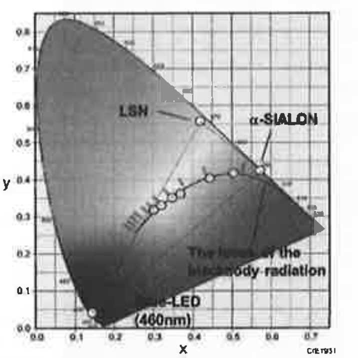

Fig. 1 The emission colors of the phosphor-glass composites with the appropriate mix of LSN and α-SiAlON in the CIE chromaticity diagram. (excitation: 460 nm)

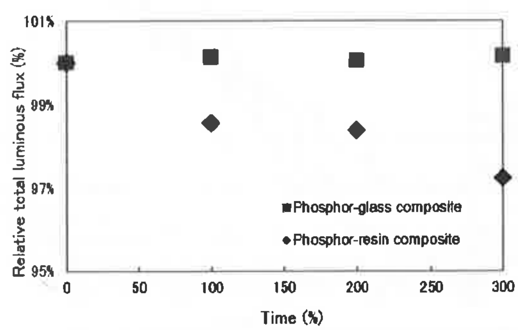

Fig. 2 The change of relative total luminous flux in the phosphor-glass composite compared with the phosphor-resin composite in the HAST under the conditions of 121°C, 95% RH and 2 atm. (Phosphor: YAG :Ce^{3+})

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2) S. Fujita, S. Yoshihara, A. Sakamoto, S. Yamamoto, and S. Tanabe, "YAG Glass-Ceramic Phosphor for White LED ( ) : Background and Development", Fifth International Conference on Solid-State Lighting, Proc. SPIE, San Diego, (2005) 594111-1-7.

3) M. Iwao, Y. Umayahara, A. Sakamoto, "Fluorescent Glass Composites for White LEDs", Proc. of International Conference on Optical and Optoelectronic Properties of Materials and Applications (ICOOPMA 2006).