Ce-, Dy-, and Mn-Doped Luminescent Glasses for White Light Emitting Diodes Applications

Zhu, C.F.; Wu, D.Q.; Zhou, Y.; Yue, Yuanzheng

Published in:
The 24th International Congress on Glass - Abstracts

Publication date:
2016

Document Version
Publisher's PDF, also known as Version of record

Ce-, Dy-, and Mn-Doped Luminescent Glasses for White Light Emitting Diodes Applications

C. F. Zhu[1], **D. Q. Wu**[1], **Y. Zhou**[1], **Y. Z. Yue**[1,2]

[1]*Key Laboratory of Processing and Testing Technology of Glass & Functional Ceramics of Shandong Province, Qilu University of Technology, Jinan, 250353, P.R. China*
[2]*Department of Chemistry and bioscience, Aalborg University, DK-9220 Aalborg, Denmark*

cfzhu@qlu.edu.cn

The phosphor-converted white light emitting diodes (W-LEDs) have recently attracted substantial attention because they are considered as an advanced lighting technology compared to conventional incandescent and fluorescent lamps for future general lighting.[1,2)] Luminescent glasses could be an alternative to phosphors for W-LEDs. Compared with powder phosphors, luminescent glasses demonstrate some advantages, such as homogeneous light emission, low fabrication cost, simple manufacturing procedure, excellent thermal stability, and epoxy resin-free in assembly process. [3,4)]

In this paper we report our recent findings about the Ce-, Dy-, and Mn-doped silicate glasses that can be used for W-LEDs. These glasses were prepared using the melt-quenching method, and studied in terms of absorption spectra, photoluminescence excitation and emission spectra, decay curves, Commission Internationale de L'Eclairage (CIE) color coordinates, correlated color temperatures (CCTs), and Fourier transform infrared (FT-TR) measurements.

The present study mainly concerns the influence of the excitation wavelengths as well as glass compositions on the luminescent properties of the glasses. By varying glass compositions (e.g., the relative content of SiO_2 B_2O_3, and Al_2O_3 in the glass matrix, as well as the concentrations of the doped rare earth ions) and excitation wavelengths, we have managed to tune the emission colors as well as CCTs of the luminescent glasses under the UV light excitation, including enabling the glasses to emit white light. This gives the flexibility to obtain smart lighting under the excitation of commercial wavelength-tunable UV-LEDs to meet special requirements. In addition, we have discovered that the energy transfer processes from Ce^{3+} to Dy^{3+} and Mn^{2+} ions occur in Ce/Dy/Mn co-doped glasses, which are analyzed using fluorescence spectra, decay lifetimes, and energy level diagrams. We have also found that the emission behavior of Ce^{3+} single doped glass is dependent on the excitation wavelengthes, i.e., emission red-shift occurs with increasing excitation wavelength (see Figure 1), which is due to a distribution of the emission centers (Ce^{3+}) at various sites in the glass structure. Furthermore, the red-shift of the emission peak of Mn^{2+} has also been observed with increasing Mn^{2+} content. This red-shift is attributed to the enhancement of the ligand field strength surrounding Mn^{2+} ions, making the excited state of Mn^{2+} energetically closer to its ground state and thus gives a longer wavelength emission.

Our study shows that the as-prepared luminescent glasses may provide a new platform to design and fabricate novel luminescent materials for LEDs lighting in the future.

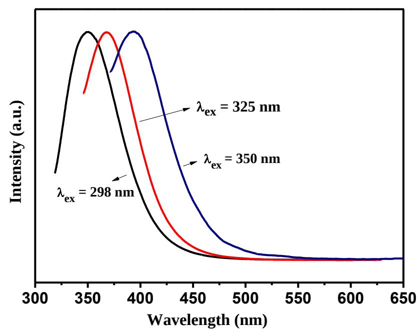

Figure 1. The normalized emission spectra of the glass $40SiO_2$-$35B_2O_3$-$5Al_2O_3$-$10Na_2O$-$10CaF_2$:0.5 Ce^{3+} (in mol%) upon different excitation wavelengths.

1) A. Kalaji, M. Mikami, A.K.Cheetham, Ce^{3+}-activated γ-Ca_2SiO_4 and other olivine-type $ABXO_4$ phosphors for solid-state lighting, Chem. Mater., **26** (2014) 3966-3975.
2) Y. Chen, Y. Li, J. Wang, M. Wu, C. Wang, Color-tunable phosphor of Eu^{2+} and Mn^{2+} codoped $Ca_2Sr(PO_4)_2$ for UV light-emitting diodes, J. Phys. Chem. C, **118** (2014) 12494-12499.
3) C. F. Zhu, J. Wang, M. Zhang, X. Ren, J. Shen, Y. Z. Yue, Eu-, Tb-, and Dy-doped oxyfluoride silicate glasses for LED applications, J. Am. Ceram. Soc., **97** (2014) 854-861.
4) M. Vijayakumar, K. Marimuthu, Structural and luminescence properties of Dy^{3+} doped oxyfluoro-borophosphate glasses for lasing materials and white LEDs, J. Alloys Compd., **629** (2015) 230-241.