Blue -to-green wavelength conversion processes in Er^{3+}- and Ho^{3+}-ion-doped fluoride glasses

[1]Yoh Mita, [1]H. Sumita, [1]Y. Miyamoto, [2]O. Ishii and [2]N. Sawanobori
[1] Tokyo University of Technology,1404, Katakura, Hachioji, Tokyo, 192-0982 JAPAN
[2]Sumita Optical Glass Co., Saitama, JAPAN
E-mail mita@cc.teu.ac.jp

Photoluminescence characteristics of Er^{3+}- and Ho^{3+}-ion-doped fluoride glasses have been examined for possible application to blue-to-green wavelength conversion materials. It has been shown that both glasses are good green emitters at low doping level. The experimental results have been compared with simulation results, based on rate equation model.

Most of the prevailing white LEDs are composed of yellow-white emitting YAG:Ce phosphors. More efficient conversion of blue light into yellow-white light can be achieved by using YAG:Ce single crystal having proper shape under polarized coherent light excitation.[1]

In this work, Er^{3+}-and Ho^{3+}-ion-doped fluoride glasses are examined, since both ions have emission in green region and absorption band at blue region. The drawback of these materials for this purpose is low absorption constant of rare earth ions. Microcrystalline phosphors doped with these ions strongly scatter incident exciting light and emissions having different wavelengths are difficult to be observed. This is principally due to low absorption constants of rare earth ions. However, in transparent materials such as fluoride glass, efficient generation of green emission may be expected due to long optical pass.

Typical compositions of the glasses are $20PbF_2$-$35AlF_3$-$(12-x)YF_3$-$4MgF_2$-$19CaF_2$-$9BaF_2$-$xLnF_3$ (Ln=Er or Ho) with x ranging from 0.25 to 2.5mol%. The emission spectra are measured using Ar laser 488 nm line as excitation sources from visible to infrared regions. Excited state lifetimes of several energy levels are measured using pulsed YAG THG light as excitation source.

Emission spectra for Er^{3+}-and Ho^{3+}-ion-doped fluoride glasses were measured under Ar laser 488 nm excitation. The green emission is predominant at low Er^{3+}- and Ho^{3+}-ion doping level. However, in Er^{3+}-doped materials, the green emission becomes weak and is replaced with infrared emissions at 1.0 and 1.5 micron wavelength with increasing doping level.

Simulation experiments are performed using a set of rate equations to analyze the excitation and relaxation processes. Energy transfer processes are taken into calculation at first considering all of the conceivable combinations of cross relaxations by Miyakawa-Dexter relation.[2] Even with such a simple model, it is possible to present quantitative explanation for the wavelength conversion processes. Attempts have been made to determine predominant cross relaxation processes. However, it is still not possible to determine all of the relevant energy transfer processes, since there are fundamental difficulties in analyzing cross relaxation processes in ions having many energy levels.

These Er^{3+}-and Ho^{3+}-ion-doped materials are interesting for their high conversion efficiency and small Stokes shift. But the practical use is limited with low and narrow absorption band of rare-earth-ion. Absorption peak at blue region is situated at 490nm and 450nm and peak intensities are 0.8 and 2.2 cm^{-1} for Er^{3+} and Ho^{3+} ions, respectively, for 1mol%. Half-widths of emission spectra of commercially obtained LEDs are generally more than three times broader than the absorption bandwidth. Hence, it will be necessary to adopt blue LEDs with small bandwidth or LD for realizing efficient optical coupling.

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