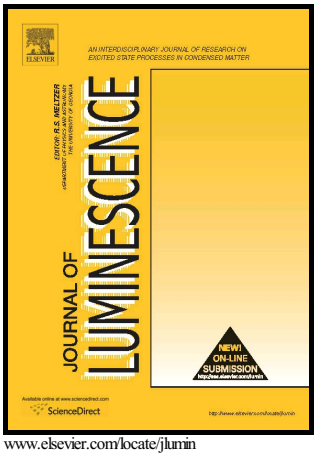

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The role of phonons in the luminescence characteristics of SICLOF♣ oxyfluoride glass and glass-ceramic fibers doped with Er^{3+}/Yb^{3+}

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Abstract

Recently developed SICLOF oxyfluoride glass and glass-ceramic fibers doped with Er^{3+}/Yb^{3+} have been prepared for fiber applications and optically characterized. The luminescence efficiency of glass-ceramic fiber appeared to be two times higher than that for glass fiber. An interesting dependence of the luminescence intensity around 1530 nm on temperature has been observed as the temperature was altered in the range of 5-350 K. For glass-ceramic fibers this dependence was different from that for glass fibers. The difference has been interpreted with use of kinetic equations and values of maximum phonon energies ($\hbar\omega_{max}$) different for glass-ceramic and glass fibers. The obtained fittings indicate that during thermal treatment the $\hbar\omega_{max}$ value decreases by 40-50 cm^{-1}. We also estimate how does such a change affect the luminescence efficiency and find that the phonon energy reduction can be responsible for at the most 28% of the luminescence efficiency improvement.

1. Introduction

Glass fibers doped with Er^{3+}/Yb^{3+} ions are being developed for years, serving as active fibers in optical communication or active media for fiber lasers. There is a common knowledge that such a glass as SiO_2 or other oxide glasses characterize by rather high values of the maximum phonons energy $\hbar\omega_{max}$ ($\geq$ 1000 cm^{-1}) which is detrimental for luminescence efficiency since the large phonons opens some paths for the non-radiative transitions. Other glasses based on fluorides (e.g. ZBLAN glass) are more attractive in this context because of distinctly smaller values of $\hbar\omega_{max}$ (for ZBLAN glass $\hbar\omega_{max} \cong$ 580-590 cm^{-1}). Even more interesting can be oxyfluoride glasses where $\hbar\omega_{max}$ energy can fall into the range of 300 – 500 cm^{-1} [1] and even 200 – 250 cm^{-1} for some systems with specific ion-matrix coupling [2-4]. Then there is a common belief that the smaller phonon energy, the better luminescence efficiency. On the other hand, there is another observation that the luminescence of rare earth ions located in structurally ordered host (single crystal) under the same excitation has usually higher efficiency than that located in disordered (amorphous) environment (homogeneous vs. inhomogeneous broadening) [5,6]. Hence there is also growing interest in the glass-ceramic fibers [7] being de facto the matrices of poly-crystalline structure and offering still good optical quality but better local environment for the doped ions. In the present work we observe such a situation: glass-ceramic fiber doped with Er^{3+}/Yb^{3+} provides distinctly higher (about twice) luminescence efficiency than glass (as made) fiber identically doped. Numerous

♣ Si, Ca, Lead, Oxyfluoride, see „Experimental"