Energy transfer processes in Er^{3+}-doped and Er^{3+},Pr^{3+}-codoped ZBLAN glasses

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(Received 26 October 1999; revised manuscript received 10 February 2000)

We present a detailed characterization of energy transfer processes in Er^{3+}-doped and Er^{3+},Pr^{3+}-codoped ZBLAN bulk glasses. For several Er^{3+} (0.25–8.75 mol%) and Pr^{3+} (0.25–1.55 mol%) concentrations, we investigate energy transfer upconversion (ETU) and cross relaxation in Er^{3+} as well as energy transfer (ET) from Er^{3+} to the Pr^{3+} codopant. The measured parameters of ETU from the Er^{3+} $^4I_{13/2}$ and $^4I_{11/2}$ levels are comparable to those of $LiYF_4$:Er^{3+}. ETU from $^4I_{13/2}$, in particular, possesses a factor of 3 larger probability than ETU from $^4I_{11/2}$. The parameters of ET from the Er^{3+} $^4I_{13/2}$ and $^4I_{11/2}$ levels to the Pr^{3+} codopant are larger than the corresponding ETU parameters. ET effectively quenches the $^4I_{13/2}$ intrinsic lifetime of 9 ms down to 20 μs for the highest Er^{3+} and Pr^{3+} concentrations investigated, and is more efficient than ET from $^4I_{11/2}$, because the corresponding absorption transition in Pr^{3+} has a large oscillator strength and back transfer is inhibited by fast multiphonon relaxation from the corresponding Pr^{3+} level. In both cases, the ET parameters depend on Er^{3+} concentration in a similar way as the ETU parameters but depend only weakly on Pr^{3+} concentration. This shows that energy migration within the Er^{3+} $^4I_{13/2}$ and $^4I_{11/2}$ levels is fast. The presented results are important for the choice of the appropriate operational regime of the erbium 3-μm fiber laser.