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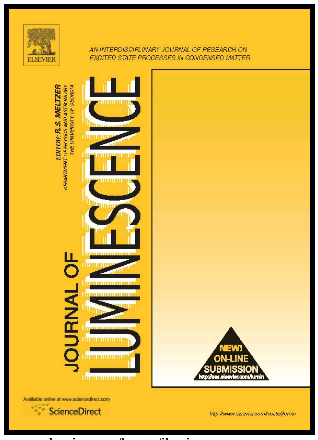

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Excited-state absorption and fluorescence dynamics in $Er:CaF_2$

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Abstract:

Emission, ground- and excited-state absorption spectra of $Er:CaF_2$ single crystals were registered from the visible to the mid-infrared. These spectra were calibrated in unit of cross section and analyzed to derive purely radiative lifetimes and branching ratios. Fluorescence decays were then recorded to determine effective emission lifetimes and branching ratios including non-radiative multiphonon relaxations. These fluorescence data along with population ratios and emission intensity measurements performed versus pumping rates were finally confronted with a rate equation model to derive energy transfer rates.

Keywords: Erbium, CaF_2, fluorescence, excited-state absorption, laser

1. Introduction

Depending on the host material and the energy of the involved lattice phonons, most of the Er^{3+} energy levels lying in the mid-infrared up to the green already gave rise to more or less efficient laser emissions, the most important ones (see in Fig. 1) being the well-known emission around the telecom wavelength of 1.55µm ($^4I_{13/2}\rightarrow{}^4I_{15/2}$ transition), the emission around 2.8µm ($^4I_{11/2}\rightarrow{}^4I_{13/2}$), the emission around 4.5µm ($^4I_{9/2}\rightarrow{}^4I_{11/2}$), the emission around 3.5µm ($^4F_{9/2}\rightarrow{}^4I_{9/2}$) and the emission around 550nm ($^4S_{3/2}\rightarrow{}^4I_{15/2}$). Other rare earth ions like Ho^{3+} or Pr^{3+} also exhibit such extraordinary multi-wavelength emission properties. However, Er^{3+} ions present the advantage of having emitting levels which can be all excited (see in Fig. 1) either directly or via multi-step absorption processes with the aid of standard and commercially available semiconductor laser diodes and diode-pumped solid-state lasers operating around 1500nm, 980nm, 800nm, 650nm and 530nm.

The aim of this article is to report on the majority of these excitation and emission processes in the case of $Er:CaF_2$. Indeed, CaF_2 is a crystal which has been known since a long time but which is arising more and more interest nowadays because of a number of attractive properties. It can be grown rather easily in very large size with an excellent optical quality. Moreover, when it is doped with a rare-earth ion like Nd^{3+} [1], Er^{3+} [2], Tm^{3+} [3], or Yb^{3+} [4], it gives rise to quite broad near- and mid-infrared optical bands suitable both for diode pumping and the production of ultra-short pulses, thus characteristics close to that found with standard laser glasses, but with much better thermo-mechanical properties, which is a crucial issue in the development of high peak power laser chains operating at high repetition rates [5, 6].