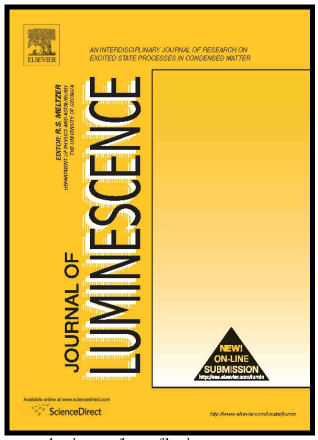
Author's Accepted Manuscript



www.elsevier.com/locate/jlumin

Optical properties of Dy^{3+}-doped $CaYAlO_4$ crystal

Hengjun Chen, Pascal Loiseau, Gérard Aka

PII: S0022-2313(18)30184-4
DOI: https://doi.org/10.1016/j.jlumin.2018.03.077
Reference: LUMIN15496

To appear in: *Journal of Luminescence*

Received date: 29 January 2018
Revised date: 23 March 2018
Accepted date: 25 March 2018

Cite this article as: Hengjun Chen, Pascal Loiseau and Gérard Aka, Optical properties of Dy^{3+}-doped $CaYAlO_4$ crystal, *Journal of Luminescence*, https://doi.org/10.1016/j.jlumin.2018.03.077

Optical properties of Dy^{3+}-doped $CaYAlO_4$ crystal

Hengjun Chen [a], Pascal Loiseau [a], and Gérard Aka [a,*]

[a]PSL Research University, Chimie ParisTech, 11, rue Pierre et Marie Curie 75005 Paris France

* Corresponding author, E-mail: gerard.aka@chimie-paristech.fr

Keywords: Dysprosium; Optical spectroscopy; Judd-Ofelt calculation; Visible laser

Abstract

Optical spectroscopic properties of Dy^{3+} ions in Dy:$CaYAlO_4$ single crystals were investigated, aiming at evaluating the potential for visible laser applications. The crystals were grown by the Czochralski technique in reducing atmosphere in order to circumvent the color-center formation in this host material. Chemical compositions of the as-grown crystals were determined by electron probe micro-analysis. Absorption and emission spectra were recorded in the visible and near infrared spectral range at room temperature. Experimental oscillator strengths derived from the ground-state absorption transitions were used to fit the electrostatic, spin-orbit coupling as well as Judd-Ofelt intensity parameters. The theoretical electric dipole as well as magnetic dipole oscillator strengths, fluorescence branching ratios, and radiative lifetime were calculated in the framework of Judd-Ofelt theory. Experimental and calculated results showed that the yellow $^4F_{9/2}\rightarrow{}^6H_{13/2}$ transition features the largest branching ratio and emission cross-sections under 453-nm excitation. Fluorescence decay profiles were recorded to analyze the fluorescence lifetime of the $^4F_{9/2}$ level. Anisotropy of magnetic-dipole transitions was observed in the spectroscopic study and discussed in detail.

1. Introduction

Visible lasers in the yellow spectral range are of great interests especially in the medical fields, such as the treatment of skin and eye diseases [1–4]. In spite of the great demand, techniques to achieve yellow laser emission are to date limited. Sum frequency mixing or frequency doubling of Nd^{3+}-doped gain media provides laser emission in the yellow spectral range [5,6]. This way, however, suffers from the complexity of the system and the low efficiency which is typically a few percent. Novel frequency-doubled optically pumped semiconductor lasers (2ω-OPSLs) are able to generate watt-level yellow laser outputs [7]. Nevertheless, they are bulky and expensive.

Trivalent dysprosium (Dy^{3+}), which is well-known for its characteristic yellow fluorescence deriving from the $^4F_{9/2}\rightarrow{}^6H_{13/2}$ transition, can serve as an active ion to obtain yellow laser output. Several ground-state absorption transitions can be found in the blue spectral region which are suitable for efficient semiconductor laser pumping without requiring frequency conversion. In addition, the large energy gap (> 7000 cm^{-1}) between the upper laser level $^4F_{9/2}$ and the next lower energy level $^6F_{1/2}$ indicates inefficient multi-phonon relaxation from the $^4F_{9/2}$ level which would impede population inversion. Diode-pumped laser performances have been demonstrated on Dy^{3+}-doped oxide and