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Luminescence properties of Nd_2BaZnO_5

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Abstract

The complete fine structure of the first multiplets $^4I_{9/2}$, $^4I_{11/2}$, $^4I_{13/2}$ and $^4F_{3/2}$ of the crystal-field levels of Nd^{3+} ion in Nd_2BaZnO_5 was identified using temperature-dependent photoluminescence measurements.

Keywords: Temperature-dependent photoluminescence; Crystal-field level; Nd

1. Introduction

The Nd_2BaZnO_5 structure is tetragonal, with space group I4/mcm (D_{4h}^{18}), Z = 4 [1]. Some of the optical properties of this material have already been studied: the Raman phonons in Ref. [2], light absorption in the visible and UV range in Ref. [3] but no published luminescence data are available. In this study we focus on luminescence spectra of Nd_2BaZnO_5 which originate from electric dipole crystal-field transitions of Nd^{3+}.

2. Experimental

The Nd_2BaZnO_5 sample is a 1 g pellet obtained by solid-state reactions [4]. The luminescence was photocreated by the 514 nm line of an Ar ion-laser and detected in the infrared (IR) region with a Ge photodiode.

3. Results and discussion

The luminescence spectra corresponding to transitions from the $^4F_{3/2}$ doublet to ^4I_J multiplets (2J = 9, 11, 13), which are centered about 11 000, 9200 and 7200 cm^{-1} and known as normally being free of other transitions, were recorded at different temperatures from 5 K to room-temperature. The spectral resolution, which amounts at worst to 5 cm^{-1}, is far better than the emission line widths (FWHM ~ 20 cm^{-1}) Fig. 1 presents the results concerning the $^4I_{13/2}$ multiplet.

As shown in the inset, we have labeled the transitions thought to arise from the lower $^4F_{3/2}$ level with odd numbers, those from the upper level with even numbers. The transitions origin-

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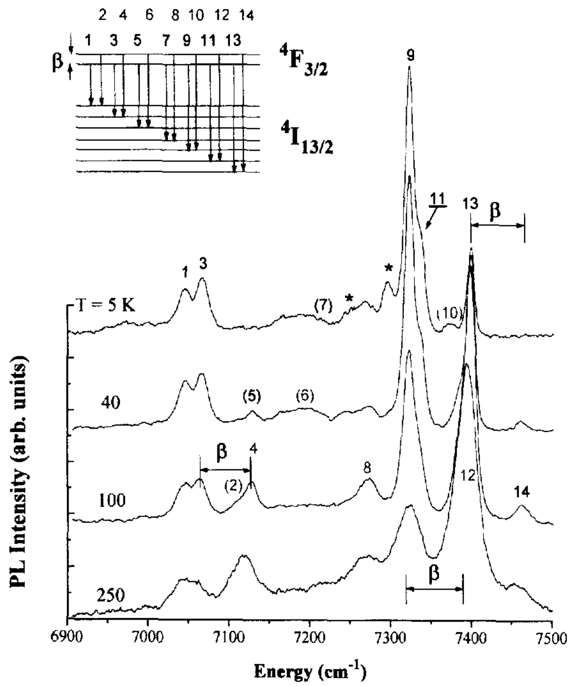

Fig. 1. Photoluminescence spectra of Nd_2BaZnO_5 at 5, 40, 100 and 250 K in the spectral range corresponding to the transition from $^4F_{3/2}$ to $^4I_{13/2}$. The lines marked with an asterix are not attributed to the Nd ion in the 8(h) site of Nd_2BaZnO_5.

ating from the lower $^4F_{3/2}$ level have in common that they are seen down to the lowest temperatures measured. On the other hand, when the temperature was increased from 5 to 100 K, the intensity of some lines increased and some new lines appeared. We attribute these new lines to emission transitions from the upper, thermally excited level of the $^4F_{3/2}$ doublet. The temperature dependence occurred mostly below 100 K. The transitions 1, 3, 9, 11 (as a shoulder) and 13 are identified in the spectrum obtained at the lowest temperature (5 K). Transitions 5 and 7 are not clearly seen in luminescence, but their assignment was confirmed with far-infrared reflectivity measurements published elsewhere [5]. The transitions 4, 8, 12 and 14 have a clear temperature dependence. We thus determined directly the splitting of the $^4F_{3/2}$ doublet to be $\beta = 60 \pm 5\ cm^{-1}$. Knowing this splitting, we could look for β-split pairs of lines (supposed to have the same final state), and thus find the

Table 1
Experimental energy levels of Nd^{3+} in Nd_2BaZnO_5 (experimental accuracy $\pm 3\ cm^{-1}$).

Multiplets	Energy (cm^{-1})
$^4I_{9/2}$	0
	65
	216
	288
	455
$^4I_{11/2}$	1928
	1985
	2007
	2117
	2170
	2233
$^4I_{13/2}$	3865
	3928
	3942
	4050
	4133
	4200
	4220
$^4F_{3/2}$	11263
	11323

transitions 2 and 7. Lines 4 and 5 are accidently superimposed as well as lines 12 and 13 because two pairs of states of the $^4I_{13/2}$ multiplet have an energy difference similar to the β-splitting.

Two additional lines labeled with an asterix at 7250 and 7295 cm^{-1} could not be assigned to the set of transitions of Nd^{3+}. Their intensity is largest at low temperature, and they vanish above 40 K. They reveal the presence of a second phase, the origin of which is discussed in Ref. [5].

The transitions from $^4F_{3/2}$ to $^4I_{11/2}$ and from $^4F_{3/2}$ to $^4I_{9/2}$ were also measured and analyzed in a similar context. The absolute energies of the two $^4F_{3/2}$ states were directly measured. Knowing these values, we were able to work out the absolute energies of ^4I_J (2J = 9, 11 and 13) from the luminescence data by simple difference (see Table 1).

Note the crucial importance of the temperature dependence in the investigation. The investigation of the $^4I_{15/2}$ multiplet by PL spectroscopy was not possible simply because we did not have a suitable detector available ($\sim 2\ \mu m$).

In summary, we have reported the absolute energies of the three lowest-energy multiplets as well as the $^4F_{3/2}$ doublet of Nd in Nd_2BaZnO_5.

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