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Journal of Alloys and Compounds 323–324 (2001) 692–695

Journal of ALLOYS AND COMPOUNDS

www.elsevier.com/locate/jallcom

EPR and optical spectroscopy of SrF_2 doped with Yb^{3+}

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Abstract

Results of EPR and optical spectroscopic investigation of the trigonal paramagnetic Yb^{3+} ion in SrF_2 ('oxygen' paramagnetic center — T_2) are presented. The energy level scheme of the center is determined from its optical spectra and the parameters of the crystal field potential are calculated.

Keywords: Insulators; Crystal growth; Point defects; Crystal and ligand fields; EPR and optical spectroscopy

1. Introduction

It is known that depending on the conditions of crystal synthesis, the Yb^{3+} ion in a CaF_2 single crystal forms up to 13 paramagnetic centers (PC) with different symmetry [1]. The Yb^{3+} ion in this matrix has been extensively studied by EPR, ENDOR and optical spectroscopy (including Zeeman spectroscopy). Yet, considerable discrepancies in the interpretation of the optical absorption and luminescence spectra of the PCs still remain, and the Stark structures of these centers are not unambiguously identified. Systematic optical data for Yb^{3+} in crystals of the homologous series MeF_2 (Me=Sr, Pb, Ba) are practically absent. In comparison with the CaF_2 lattice, a considerable decrease in the number of PCs with different symmetries is observed in these latter systems and the study of their optical spectra may thus enable an unambiguous identification of some of them. As-grown crystals of SrF_2 and BaF_2 show two Yb^{3+} PCs: a cubic one (non-local compensation of the excess positive charge) and a trigonal one [1]. In the latter case, the excess positive charge is compensated by an additional fluorine ion located in the center of the normally empty cube next to Yb^{3+} along a C_3-axis (this is the so-called 'fluorine' trigonal PC — T_4). By special thermal treatment (hydrolysis) these PCs may be partially transformed into a trigonal 'oxygen' PC (T_2), where the oxygen ion substitutes one of the fluorine ions in the nearest cubic environment of Yb^{3+} [5]. Thus the number of different PCs in SrF_2 and BaF_2 crystals may be increased to three. This process is controllable providing additional means for identification of the spectral lines. The structural models have been experimentally established, by the radiofrequency discrete saturation method (analogous to ENDOR) [2–4]. In the PbF_2 host, only one cubic PC is usually observed [1], although there is a report that a trigonal PC may also exist [6].

In view of these facts, we chose to study those systems which show a minimum number of PCs. This paper presents EPR and optical spectroscopy results on the T_2 center formed by the Yb^{3+} ion in SrF_2. Data from preliminary optical experiments on BaF_2:Yb^{3+} were published in an earlier paper [7].

2. Experimental results and discussion

SrF_2:Yb crystals were grown by the Bridgman method in graphite crucibles in a fluorine atmosphere. Some crystals were subsequently hydrolyzed during several hours according to the method described [8]. EPR experiments were carried out on an X-band spectrometer at 4.2, 77 K. Optical spectra were recorded at T=2, 300 K on a home built multifunctional computerized spectrometer [7]. A cooled photomultiplier formed the detector, and the light from a xenon lamp dispersed by a monochromator was used as an excitation source. The luminescence and excitation spectra were recorded by time delayed (stroboscopic) detection.

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0925-8388/01/$ – see front matter
PII: S0925-8388(01)01040-4