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## EPR and optical spectroscopy of SrF<sub>2</sub> doped with Yb<sup>3+</sup>

M.L. Falin<sup>a,\*</sup>, K.I. Gerasimov<sup>a</sup>, A.M. Leushin<sup>b</sup>, H. Bill<sup>c</sup>, D. Lovy<sup>c</sup>, T. Sanadze<sup>d</sup><sup>a</sup>Zavoisky Physical-Technical Institute, 420029 Kazan, Russia<sup>b</sup>Kazan State University, 420008 Kazan, Russia<sup>c</sup>Group PCB, University of Geneva, 1211 Geneva 4, Switzerland<sup>d</sup>Tbilisi State University, 380028 Tbilisi, Georgia

### Abstract

Results of EPR and optical spectroscopic investigation of the trigonal paramagnetic Yb<sup>3+</sup> ion in SrF<sub>2</sub> ('oxygen' paramagnetic center — T<sub>2</sub>) 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. © 2001 Elsevier Science B.V. All rights reserved.

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### 1. Introduction

It is known that depending on the conditions of crystal synthesis, the Yb<sup>3+</sup> ion in a CaF<sub>2</sub> single crystal forms up to 13 paramagnetic centers (PC) with different symmetry [1]. The Yb<sup>3+</sup> 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<sup>3+</sup> in crystals of the homologous series MeF<sub>2</sub> (Me=Sr, Pb, Ba) are practically absent. In comparison with the CaF<sub>2</sub> 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<sub>2</sub> and BaF<sub>2</sub> show two Yb<sup>3+</sup> 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<sup>3+</sup> along a C<sub>3</sub>-axis (this is the so-called 'fluorine' trigonal PC — T<sub>4</sub>). By special thermal treatment (hydrolysis) these PCs may be partially transformed into a trigonal 'oxygen' PC (T<sub>2</sub>), where the oxygen ion substitutes one of the fluorine ions in the nearest cubic environment of Yb<sup>3+</sup> [5]. Thus the number of different

PCs in SrF<sub>2</sub> and BaF<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> center formed by the Yb<sup>3+</sup> ion in SrF<sub>2</sub>. Data from preliminary optical experiments on BaF<sub>2</sub>:Yb<sup>3+</sup> were published in an earlier paper [7].

### 2. Experimental results and discussion

SrF<sub>2</sub>: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.

\*Corresponding author. Fax: +7-8432-765-075.

E-mail address: falin@kfti.knc.ru (M.L. Falin).