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EPR and optical spectroscopy of Yb^{3+} ions in CaF_2 and SrF_2

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Abstract

The Yb^{3+} paramagnetic center of the trigonal symmetry (“oxygen” paramagnetic center T_2) in CaF_2 and SrF_2 single crystals is studied by EPR and optical spectroscopy. The Stark level energies of the Yb^{3+} multiplets are established from absorption, luminescence and excitation luminescence spectra and the crystal field parameters are calculated.

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1. Introduction

Optical studies of crystals MeF_2 ($\text{Me} = \text{Cd}, \text{Ca}, \text{Sr}, \text{Pb}, \text{Ba}$) having the fluorite structure and doped with trivalent rare-earth ions are complicated due to the formation of many paramagnetic centers (PCs) there. Their appearance is due to different mechanisms of the excess charge compensation, conditions of the growth and the following treatment of samples. Identification of the low-symmetry centers is complicated because different orientations result in the averaging effect. Yb^{3+} ions in CaF_2 [1–4] are the most studied ones from the homologous fluorite series, 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. In contrast to fluorite, other MeF_2 crystals do not

exhibit many types of PCs, which considerably simplifies identification of the optical lines. Earlier we have studied Yb^{3+} PCs of the cubic symmetry (T_C) in PbF_2 [5], SrF_2 , BaF_2 [6] and Yb^{3+} PCs of the trigonal symmetry (T_4) in SrF_2 , BaF_2 [6]. As-grown crystals of SrF_2 and BaF_2 show two Yb^{3+} PCs: a cubic one (nonlocal 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. By special thermal treatment (hydrolysis or heating to up 850°C in air) this PC 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+} [2]. 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. In this manner the preliminary identification of PC T_2 in SrF_2 [7] was carried out. This paper presents results of the subsequent study

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