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STUDY OF $SrLaAlO_4$ AND $SrLaGaO_4$ SUBSTRATE CRYSTALS BY RAMAN SPECTROSCOPY

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In this paper the study of $SrLaAlO_4$ and $SrLaGaO_4$ single crystals using the Raman scattering method is presented. The obtained results are discussed in terms of nature of the crystallografic imperfections and point defects which might arise during the crystal growth process.

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1. Introduction

A considerable interest has been noticed in the physical properties of strontium lanthanum alluminate, $SrLaAlO_4$ (SLA) and strontium lanthanum gallate, $SrLaGaO_4$ (SLG) single crystals [1–6]. They belong to the family of compounds with the general formula $ABCO_4$, where A = Sr, Ca; B = La, Y and C = Al, Ga or some transition element [1, 7]. The SLA and SLG crystallize in the perovskite-like, tetragonal K_2NiF_4-type structure of $I4/mmm$ space group with the lattice constants $a = 0.3756$ nm and $c = 1.2636$ nm [2, 8] and $a = 0.3843$ nm and $c = 1.2681$ nm [9, 10], respectively. There are two independent positions of oxygen atoms in the ab plane joined with C-O1 bonds and variable z-level position O2 in the c-direction. It is also known that the substitution by Ga ions involves a change in a value of the lattice parameter and the substitution of Sr^{2+}/La^{3+} ions and their stoichiometry causes a change in the c-parameter [1–5, 7, 11].

SLA and SLG crystals are interesting as a substrates for high temperature superconducting thin films from the stand point of lattice matching and their elastic properties [12, 13]. A good quality of epitaxial layers requires both crystallographic perfection and appropriate physical properties of substrate materials.

In this paper the Raman spectra obtained for SLA and SLG single crystals are presented. The obtained results are discussed in terms of the oxygen point defects which might arise in the $ABCO_4$ lattice during the crystal growth process.

2. Experiment

SLA and SLG crystals were grown from nonstoichiometric melt by the Czochralski method described by Gloubokov et al. [2]. Samples of sizes about 3 × 5 × 6 mm^3 used in the Raman experiment were cut from as-grown yellow colored single crystals. The samples were polished to an optical quality. The Raman polarized spectra of SLA and SLG were obtained at room temperature on a spectrometer described in details elsewhere [5]. An Ar ion laser operating at 488 nm was used to excite the Raman spectra. The scattered radiation was observed at the right angle to the incident beam. The measured data were loaded into the computer memory. The calculation of the Raman band parameters has been performed using a curve-fitting method. The experimental setup permitted the band positions in the Raman spectra to be estimated with an accuracy of ±2 cm^{-1}.

3. Results and discussion

The polarized Raman spectra of SLA and SLG single crystals obtained at room temperature for $x(zz)y$ and $z'(x'x')y$ scattering geometries are presented in Fig. 1 and Fig. 2, respectively. In this notation z' and x' refers to z+45° and x+45° direction, respectively. As it can be seen from these figures in the 100–700 cm^{-1} region we observe two spectral bands. The very strong band at 218 cm^{-1} for SLG and at 220 cm^{-1} for SLA is assigned to the librational L mode of Ga or Al ion, respectively. The broad band located at 490 cm^{-1} for SLG and the very weak band at 480 cm^{-1} for SLA is assigned to the translational T mode [14].

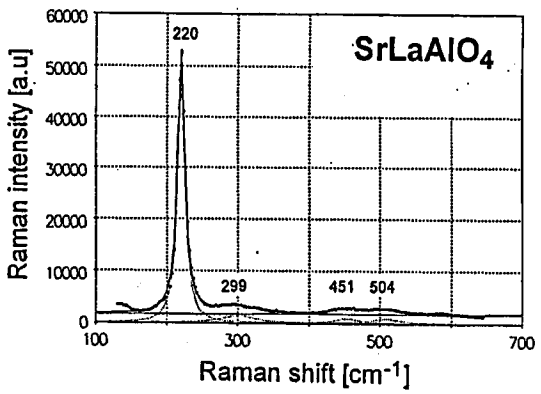

Fig. 1. Polarized Raman spectra of SLA single crystal obtained at room temperature for λ_{exc} = 488 nm; scattering geometries: $x(zz)y$ and $z'(x'x')y$.

The formation of the point defects, of color centers ("D"-type defects) in policomponent oxide crystals is still discussed in the literature [1, 2, 11]. It is known that the formation of "D" defects depends on preparation and crystal growth conditions [2]. Grown at pure nitrogen atmosphere SLA and SLG crystals were light yellow-colorless, sometimes at the top SLG was light green [11].

According to the literature data the different colors observed in SLA and SLG crystals can be related to the oxygen defects [2, 11]. Considering the distribution of

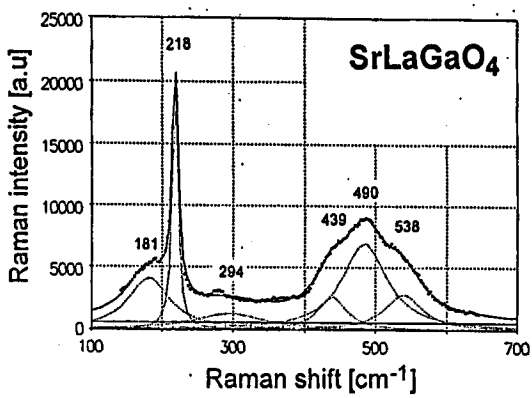

Fig. 2. Polarized Raman spectra of SLG single crystal obtained at room temperature for $\lambda_{exc} = 488$ nm; scattering geometries: $x(zz)y$ and $z'(x'x')y$.

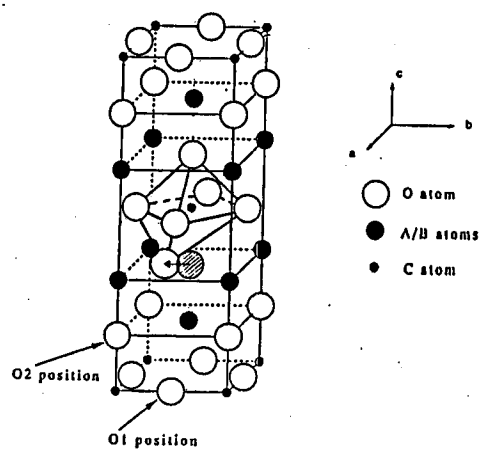

Fig. 3. Distribution of atoms in disordered $ABCO_4$ unit cell, where A = Sr, B = La and C = Al or Ga.

atoms in $ABCO_4$ lattice, one can assume that Ga–O octahedrons are distorted due to migration of both, an oxygen O1 in *ab* plane and oxygen O2 in the *c*-direction. Moreover, a substitution of Al ion in Ga position causes that Al–O octahedrons are more rigid and the deformation of oxygen octahedrons surrounding C-type ions along *c*-direction is very small. The different Raman intensity of the translational T mode for SLA and SLG can be joined with the above-mentioned phenomena (see Fig. 1 and Fig. 2). In Fig. 3 we present the distribution of atoms in distorted $ABCO_4$ unit cell (the change of the position of the oxygen O1 has been marked).

Our Raman scattering experiment seems to confirm the results obtained for SLA and SLG crystals from Brillouin scattering studies [6, 15]. The anisotropy of the elastic and elastooptic properties of SLG crystal has been found. The velocity of the acoustic waves propagating in *ab* plane is different in *a* and *b* directions. Also,

the observed integrated intensity of the Brillouin line representing TA phonons propagating in (001) plane is different in a and b directions. The lower value of the integrated intensity of TA phonon propagating in a-direction with its component of the atomic displacement vector in [001] direction is involved in a lower value of the appropriate elastooptic constant p_{ij}. The different values of the velocity and the lower value of the integrated intensity of the phonon propagating in a-direction can be caused by the dumping of the elastic waves propagating in this direction due to the existence of oxygen point defects, which can be created during the crystal growth process.

Acknowledgments

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