Doped lanthanum gallate $\text{La}_{1-x}\text{Sr}_{x}\text{Ga}_{1-y}\text{Mg}_{y}\text{O}_{3-x}$ appears highly promising as a new solid electrolyte for use at intermediate temperatures in solid oxide fuel cells [1,2]. In doped $\text{LaGaO}_3$ oxygen transport occurs by way oxygen vacancies, which implies that the transport properties critically depend on the kinetics of oxygen motion and on trapping processes. If the vacancies order in some cooperative manner, they become trapped even more effectively than in the case of random distribution of defects. For a successful adoption of $\text{La}_{1-x}\text{Sr}_{x}\text{Ga}_{1-y}\text{Mg}_{y}\text{O}_{3-x}$ compounds as solid electrolytes, the knowledge of its real structure is clearly needed. Investigations of the diffuse scattering from ordered defects in $\text{La}_{1-x}\text{Sr}_{x}\text{Ga}_{1-y}\text{Mg}_{y}\text{O}_{3-x}$ at different temperatures will allow to understand and to control the ionic conductivity of the doped compounds of $\text{LaGaO}_3$.

$\text{La}_{1-x}\text{Sr}_{x}\text{Ga}_{1-2x}\text{Mg}_{2x}\text{O}_{3-y}$ ($x = 0.05$) single crystal was grown from the melt in Ar atmosphere using the Czochralski technique. The obtained crystal showed twinned structure that complicates interpretation of the diffuse scattering. For the purpose to determine the sample orientation and to identify twinning Laue method was been used. In particular the facilities of F1 beam station allow to receive Laue patterns as well as to analyze the diffuse scattering in the investigated crystals.

Diffraction was performed using Laue transmission geometry. During the experiment the incident X-ray beam was limited to a aperture 0.7 mm. The detector (a cassette containing Kodak SR5 high resolution film) was set perpendicular to the incident white X-ray beam at distance from the sample $s=4.3$ cm. Positive images from Kodak films were enlarged using an optical microscope equipped with a camera.

$\text{La}_{0.95}\text{Sr}_{0.05}\text{Ga}_{0.9}\text{Mg}_{0.1}\text{O}_{2.92}$ has a perovskite-type structure, which experiences a few phase transitions. At high temperature $\text{La}_{0.95}\text{Sr}_{0.05}\text{Ga}_{0.9}\text{Mg}_{0.1}\text{O}_{2.92}$ undergoes three phase transitions: orthorhombic-to-monoclinic ($\text{Imma} – \text{I}_2/\text{a}$) at 520 K - 570 K, monoclinic-to-trigonal ($\text{I}_2/\text{a} – \text{R}-\text{3c}$) at 720 K and trigonal-to-trigonal ($\text{R}-\text{3c} – \text{R}-\text{3c}$) at ca 870 K [3]. The room-temperature orthorhombic structure is considered as a perovskite cubic cell slightly stretched along the face diagonal [110]p. The stretching along the other five equivalent face diagonals of the cube results in equivalent distortions of the perovskite cell. The spontaneous strain of the twin states in the room-temperature phase determines 10 possible orientations of the domain walls between 5 different pairs of domain states $D_1$ and $D_i$ ($i=2...6$). The twin state $D_2$ is connected with the state $D_1$ by mirror reflection from (101) or (10\(\overline{1}\)) and 180° rotation around [10\(\overline{1}\)] or [101]. Domain walls are $W12’$ (101) or $W12’’$ ($10\overline{1}$) planes, respectively. The twin orientation states $D_3...D_6$ are connected with the $D_i$ via mirror reflection of a plane from the \{121\} family or via 180° rotation around a direction from the <111> family. For reflection twins, the interface boundary between matrix and twin crystal parts are planes \{121\} ($WI_i$, $i=3...6$), whereas for axial twins they have non-integer Miller indices ($SI_i$, $i=3...6$).

Figure 1 shows an example of Laue pattern taken at room temperature from the $\text{La}_{0.95}\text{Sr}_{0.05}\text{Ga}_{0.9}\text{Mg}_{0.1}\text{O}_{2.92}$ sample. The sample shows definite twinning which translate in the Laue pattern as apparent splitting of the peaks into 2 reflections (domain A and B). Using OrientExpress...
V3.3 programmm the pattern was indexed as an orthorhombic crystal with lattice parameters \(a=5.449\,\text{Å}, b=7.794\,\text{Å}, c=5.538\,\text{Å}\) and the orientation matrix was determined for domains A and B.

Using the experimental orientation matrix for domain A and matrices of twin law relationship, we calculated the orientation matrices for all 10 possible domain walls. It allowed to determine the coordinates of the Laue spots for all allowed 10 domain pairs and their deviations relatively to the Laue spots for \(D_1\) (domain A) by the method reported in [4]. Fig. 2 shown a comparison of the calculated and experimental spot shifts relatively to the (-200) reflection of domain A for allowed and observed domains. Clearly, the shifts associated with domain B are consistent with \(W13\) (121) domain wall. Note that the Miller indices for the reflections of two domains are different: for example, for domain A\(\sim\) (-200), for domain B – (-121), and correspond to ferroelastic shifts of domain A in domain B, at which some planes turn into other ones. Furthermore, these indices agreed with the pre-indexation of Laue patterns for the two observed domains A and B.

By comparing measurements of the mutual shift between domain images with calculated values, it has been shown that \(\text{La}_{0.95}\text{Sr}_{0.05}\text{Ga}_{0.9}\text{Mg}_{0.1}\text{O}_{2.92}\) crystal was twinned relatively to (121) mirror plane. At the same time the Laue technique gives the orientation of observed domains providing important information for the further study of diffuse scattering in twinned ionic conductor \((\text{La,Sr})(\text{Ga,Mg})\text{O}_{3-x}\).

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