P30

ISSRNS 2010: Extended abstracts / Synchrotron Radiation in Natural Science Vol. 9, No. 1 – 2 (2010)

DOMAIN CONFIGURATIONS AND CONDUCTIVITY IN LSGM

T. Tataryn [1*], D. Savytskii [1], E. Schmidbauer[2], C. Paulmann [3], and U. Bismayer [4]

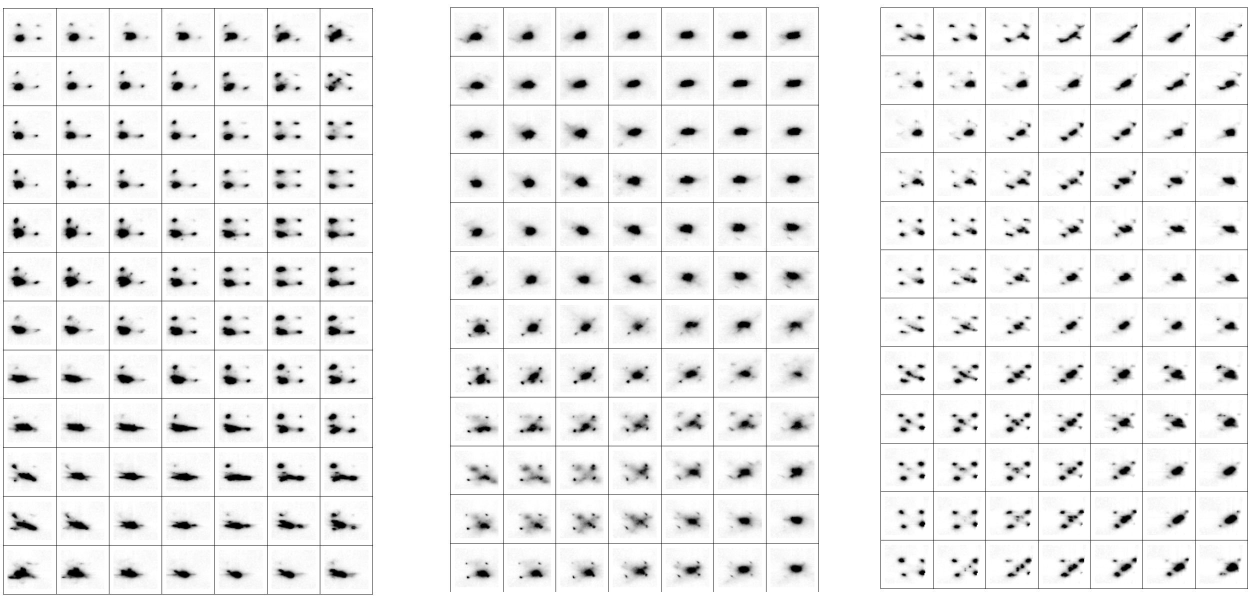
[1]Lviv Polytechnic National University, 12 Bandera St., 79013 Lviv, Ukraine
[2]Geophysics, Munich University, Theresienstr. 41, D-80333 Munich, Germany
[3]HASYLAB, DESY, Notkestr. 85, D-22603 Hamburg, Germany
[4]Mineralisch-Petrogrographisches Institut, Universität Hamburg, Grindelallee 48, D-20146 Hamburg, Germany

Keywords: twin structure, solid electrolyte, ionic conductivity

**) e-mail: tataryn.taras@gmail.com*

The aim of our investigations was to study the arrangement and distribution of twin boundaries during mechanical and thermal treatment in order to examine reversibility phenomena in larger ferroelastic crystal plates ($5\times6\times0.87$ mm^3) as well as the influence of the domain structure on ionic conductivity. In the selected plate of $La_{0.95}Sr_{0.05}Ga_{0.9}Mg_{0.1}O_{3-x}$ (LSGM) with thickness of 0.87 mm a submicron twin structure was abundant. Diffraction studies were performed using white synchrotron radiation and the Kappa-diffractometer, beamline F1 at HASYLAB, DESY in Hamburg. Using a MAR CCD-detector system the orientation of individual domains (twins) was determined. Scanning of the sample under the beam (0.05×0.05 mm^2) and collecting diffraction data at each step 45 micron spatial resolution was used to map thin domain patterns in the LSGM plate after mechanical as well as thermal treatment. Conductivity measurements were done between ~ 70^{o}C and 710^{o}C in air. Impedance spectroscopy was applied using a HP4284 LCR-meter in the range 20 Hz – 1 MHz. Data were recorded applying AC amplitudes of 80 mV and 1V to the electrode.

Analysis of Laue patterns collected in the same area of the plate has shown that the twin structure changed after the treatments described above. For example, a chevron-like 4 domain configuration was observed in 89% of the scanned area in the virgin sample, after grinding and polishing the plate in 37% and after further heating/cooling in approximately 69% of the same sample area (Fig. 1). It was shown that before mechanical treatment mainly twin walls normal to the largest surface of the plate occurred. The observed domain structure was partially switched to another twin configuration with domain walls parallel to the surface or to certain domain states during polishing. After annealing the domain configuration with prevalent domain walls normal to the largest plate surface was fully restored. The mechanism of twinning under mechanical treatment is shown in Fig. 2.



a b c

Figure 1. The part of scanned area of the plate (a) before treatment, (b) after grinding and polishing and (c) after further heating/cooling.

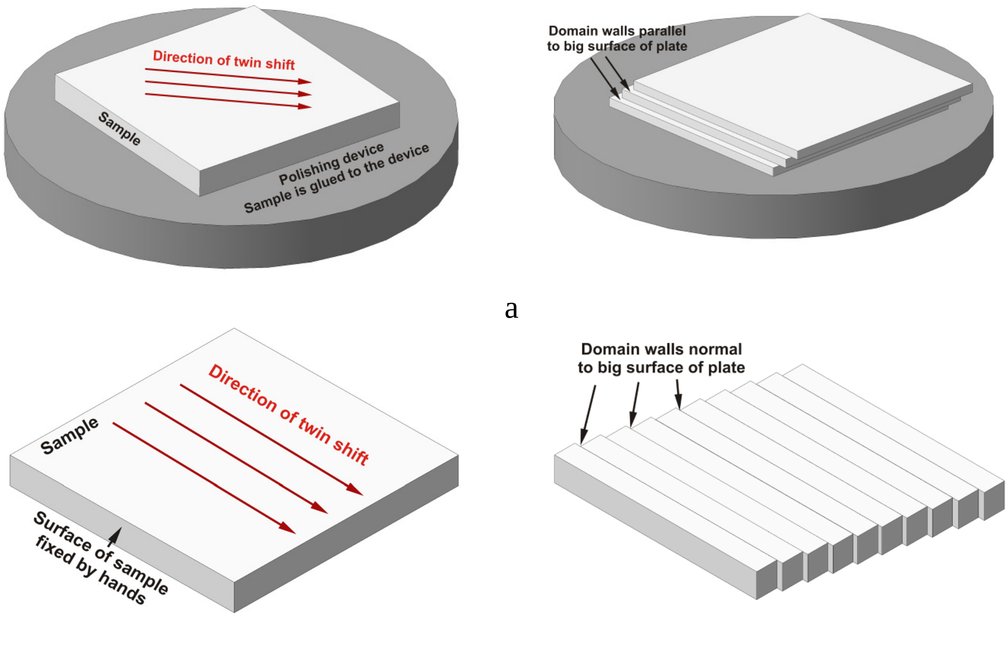


Figure 2. Twinning of a plate under mechanical treatment: a) the crystal plate is glued to the metal cylinder; b) the surface of the plate is simply fixed by hand.

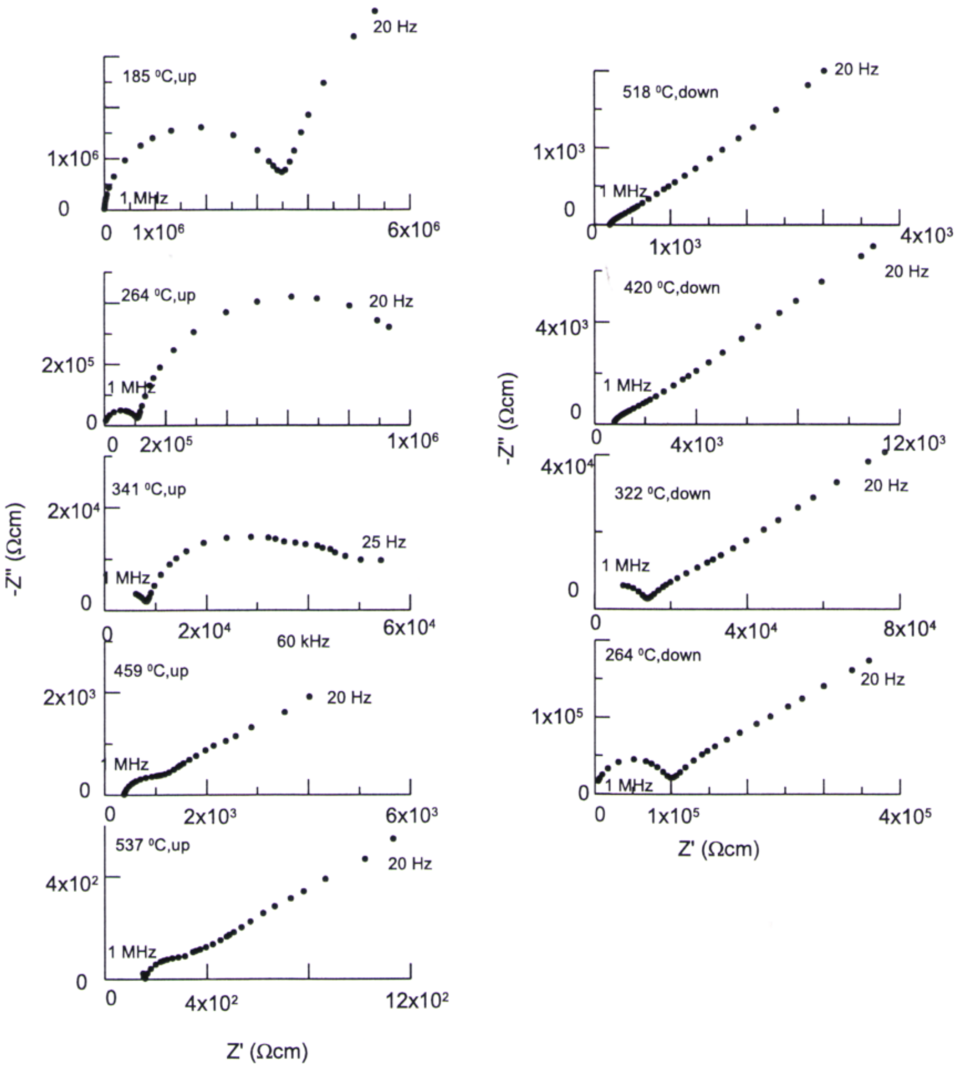


Figure 3. Complex plane impedance plots as a function of temperature during heating and cooling in air.

Impedance plots show two semicircular arcs (Fig. 3). The first high frequency arc corresponds to the bulk conductivity while the second low frequency one corresponds to the conductivity on domain boundaries.

Our results show that the specific chevron-like twin pattern allows for reproducibility of wall configurations in heavy defect LSGM crystals [1]. The stress can relax completely by forming phase-specific domain wall configurations, and hence, reorientations occur duringthermal cycling. This feature may be of practical use as the preparation of electrolyte and electrode ceramics for SOFC includes compaction during one of the synthesis stages. Compaction, however, leads to unidirectional mechanical stress. Ceramics of LSGM can be approximated by an ensemble of small crystallites. Mechanical pressure imposed to such an electrolyte pellet causes the rearrangement of the twin structure of "chevron cells" in ceramic grains along the direction parallel or nearly parallel to the imposed pressure. Hence, such pressure will cause memory texturing of twin "chevrons" in electrolyte layers along the direction of oxygen diffusion in the SOFC structure. Keeping in mind the influence of twin walls on the conductivity and the high density of twin walls in LSGM solid solutions, it is supposed that texturing of the twins, e.g. reorientation of "chevron cells" increases the conductivity of the perovskite-type electrolyte LSGM along the cathode-anode direction. The improved knowledge of twin distributions allows to tailor conductivity properties of electrolyte materials.

Acknowledgments: The work was supported by WTZ (UKR 07/009) and the Ukrainian Ministry of Education and Science (project "Tern"). T. Tataryn acknowledges financial support of the Deutscher Akademischer Austauschdienst (Leonhard-Euler program).

References

[1] D. Savytskii, U. Bismayer, "Strains at junctions in multidomain configurations", *Phase Transi.* **81** (2008) 431–447.