FM 14: Focus Session: Materials Research in Polar Oxides – From Domain Engineering to Photonic and Electronic Devices II

chair: Conor McCluskey (Queen's University Belfast, UK)

The focus session is dedicated to bridge the gap between materials research in polar oxides and research fields that apply those materials, such as nonlinear and quantum optics, electronics or sensoring, spanning experimental studies and first-principles simulations.

Time: Wednesday 15:00–16:00 Location: BEY/0138

FM 14.1 Wed 15:00 BEY/0138

Probing ferroelastic domain properties of lanthanum aluminate via spontaneous Raman scattering — •Robin Buschbeck[1], Susanne C. Kehr[1], Lukas M. Eng[1,2], and Samuel D. Seddon[1] — [1]TU Dresden, Institute of Applied Physics, Nöthnitzer Strasse 61, 01187 Dresden, Germany — [2]ct.qmat: Dresden-Würzburg Cluster of Excellence EXC 2147, TU Dresden, 01062 Dresden, Germany

Lanthanum aluminate ($LaAlO_3$, LAO) is a rhombohedrally distorted oxide perovskite, exhibiting ferroelastic twinning at room temperature. Frequently employed as a thin film substrate [1], it is often overlooked [2] for being optically uniaxial and thus birefringent. The effect of the ferroelastic twins sees an in-plane rotation of this optical axis, with regions of opposing optical axes coexisting (delineated by twin walls).

Here, we present a detailed experimental analysis of LAO(100) using spontaneous Raman scattering (SR). SR is a widely employed technique for obtaining spectral information from a broad range of materials [3]. Using SR, we demonstrate several spatially resolved nontrivial, three-dimensional intrinsic properties of LAO. Special attention is given to the different LAO(100) domains and their behaviour under various SR measurement conditions, including polarization-dependent and spatially resolved in-plane or depth-dependent measurements.

[1] R. W. Simon et al., Springer, Boston, MA (1989)
[2] S. Kustov, et al., Applied Physics Letters 112, 042902 (2018)
[3] A. Orlando et al., Chemosensors 9, 262 (2021)

FM 14.2 Wed 15:15 BEY/0138

Strain Driven Ferroelastic Switching and Barkhausen Type Behavior in $LaAlO_3$ — •Vladyslav Kovtunovych, Matthias Roeper, Lukas M. Eng, and Samuel D. Seddon — Institut für Angewandte Physik (IAP)- Nöthnitzer Str. 61, 01187 Dresden

Lanthanum aluminate ($LaAlO_3$; LAO) is an oxide perovskite widely used in nano-electronics, and frequently employed as a thin-film substrate therein due to its convienient lattice match to many multiferroic and/or ferroelectric materials. Although oftentimes overlooked, LAO is an improper ferroelastic, posessing crystallographic domains delineated by twin walls, responding to the global application to strain akin to ferromagnetic or ferroelectric materials to magnetic or electric fields respectively. This study focuses on twin wall motion, which was induced and recorded using a commercial Razorbill strain cell with a high-resolution capacitive sensor. Measurements of $LaAlO_3$ under increasing uniaxial compression, revealed the expected jerky domain wall motion indicative of Barkhausen noise, the stochastic stepped reordering of local ordering parameters common among all ferroic materials. This scale invariant physics acts as a power law governing all length scales, from avalanches on mountains down to the nanoscale. Complementary XRD measurements of the expected Bragg peak splitting are correlated with polarised light microscopy imaging all as a function of lattice strain, to observe this effect in a whole new light.

FM 14.3 Wed 15:30 BEY/0138

Single crystal growth of stoichiometric lithium tantalate — •Sebastian Inckemann, Roberts Blukis, Angélique Hoffmann, Matthias Bickermann, and Steffen Ganschow — Leibniz-Institut für Kristallzüchtung, Max-Born-Straße 2, 12489 Berlin, Germany

A material isomorphous to the intensively investigated lithium niobate (LiNbO3, LN) that has the same inherent non-stoichiometry is lithium tantalate (LiTaO3, LT). Despite similar characteristics to LN, the properties of LT are significantly less studied, even though there are notable differences that favor the use of LT in certain applications. Of special interest is the investigation of stoichiometric LT (sLT) compared to congruent LT (cLT), as the lithium deficiency in cLT causes a high concentration of defects (Kim et al., 2001). Literature describes multiple methods to achieve stoichiometric LN single crystals, exemplary via the double crucible method. However, the growth method reporting a crystal composition closest to the stoichiometric ratio is the growth via the flux method (Polgár et al., 2002). Due to the similarities between LN and LT an analogous approach is the most promising, with the use of K_2O as a solvent showing the best results in the case of LN (Polgár et al., 1997). To ensure an efficient single crystal growth in this system, knowledge about the Li_2O-K_2O-Ta_2O_5 phase diagram is vital (Mühlberg et al., 2008). As there is no literature regarding this phase diagram, this presentation will present our current progress by combining DTA, PXRD and SEM measurements. Furthermore, results regarding the single crystal sLT growth attempts will be presented.

FM 14.4 Wed 15:45 BEY/0138

Poling and acoustic characterization of near-stoichiometric Li(Nb,Ta)O_3 crystals — •Éva Tichy-Rács[1], Stepan Hurskyy[1], Steffen Ganschow[2], Fatima El Azzouzi[1], Holger Fritze[1], and Yuri Suhak[1] — [1]Clausthal University of Technology, Goslar, Germany — [2]Leibniz Institut für Kristallzüchtung, Berlin, Germany

Li(Nb,Ta)O_3 solid solutions bridge the high Curie temperature of $LiNbO_3$ and the thermal stability of $LiTaO_3$, while maintaining a strong piezoelectric performance, making them attractive for high-temperature sensing and actuation. The intrinsic properties of $LiNbO_3$, $LiTaO_3$ and, consequently, their Li(Nb,Ta)O_3 solid solutions are well known to be highly sensitive to lithium stoichiometry. In the present work the acoustic properties of near-stoichiometric $LiNb_{1-x}Ta_xO_3$ (x=0; 0.45; 1) single crystals are investigated as a function of temperature and time by resonant piezoelectric spectroscopy. The near-stoichiometric compositions were obtained by the vapor transport equilibration (VTE). Subsequently, the samples were electrically poled to ensure a single-domain state. The study shows that acoustic losses in nsLT remain in the range of 10^{-4}–10^{-3} up to 620 °C, i.e., within the ferroelectric phase, and increase monotonically with temperature, though only weakly, with an activation energy of about 0.05 eV. In contrast, nsLN and nsLNT45 exhibit a pronounced loss increase above 600 °C, attributed to the conductivity-related relaxation mechanism. Under constant operation at 600 °C for 350 h, all samples demonstrate excellent long-term stability, with resonance frequency deviations not exceeding ± 100 ppm of the initial value.