

OUR SERVICES

Resources

Femtosecond Laser Lab

- Photoacoustics
- Thermoreflectance
- Time-Resolved PL / TDSPC
- THz Spectroscopy

Own Research

- Active X-Ray Optics
- Phase Transitions
- Ferroelectrics
- Nanomechanics



Services

Material Characterization

- Photoacoustics
- Time-Resolved X-Ray
- Ultrafast Optical Spectroscopy
- THz Spectroscopy

Synchrotron Service

- Beamtime planning and acquisition
- Experiment Support
- Data Analysis

Partners



Scope of the XRO group's methods, services and research activities

SYNCHROTRON MEASUREMENT SERVICE

We are happy to support our partners throughout their whole synchrotron experiment. Identifying your preferred scientific instrument and acquiring beamtime (commercial or academic proposal) is a first step. IKZ's crystal preparation facilities provide sample cutting and polishing services and our scientists perform advanced characterization to increase the efficiency of the synchrotron experiment. As regular synchrotron users we are familiar with operating complex experiments and with handling large datasets. We are invested in modern research data management aligned with FAIR (Findability, Accessibility, Interoperability and Reusability) principles, thus assuring the highest R&D standards.

MATERIAL CHARACTERIZATION

Our core competence is investigating structural dynamics in crystalline materials using optical and x-ray methods. A standard method for our laboratory is photoacoustics, i.e., the generation of sound waves with GHz or THz frequencies for surface and bulk acoustic waves (SAW and BAW, respectively). Other established measurement methods in our Lab are pump-probe thermoreflectance measurements to monitor nanoscale heat diffusion phenomena, second

harmonic generation as a probe of the local crystalline symmetry, time-resolved photoluminescence (TR-PL) and time correlated single photon counting (TCSPC). Finally, our optics laboratory hosts a setup for time-domain THz spectroscopy to measure the dielectric response up to 3THz.

In addition to the optical characterization methods available in our own laboratory, we are experienced users of synchrotron-based x-ray methods like high-resolution x-ray diffraction and scanning x-ray diffraction imaging.

CONSULTING

The researchers of the X-Ray Optics Group combine decades of experience in the field of solid-state physics, material science, optical spectroscopy and x-ray diffraction methods. We can provide our independent technical consultancy in many fields from basic feasibility studies over the characterization of thermal and elastic properties of nanoscale materials to the analysis of nonlinear properties of your samples. We consult on methods for material diagnostics for process monitoring and provide workshops and staff training on demand.



Photo: Sebastian Rost

THE LEIBNIZ-INSTITUT FÜR KRISTALLZÜCHTUNG IKZ

The Leibniz-Institut für Kristallzüchtung (IKZ) in Berlin-Adlershof is an international state-of-the-art competence center for science & technology as well as service & transfer for innovations in and by crystalline materials. The R&D spectrum thereby ranges from basic over applied research activities up to pre-industrial research tasks.

Crystalline materials are key technology enabling components to provide electronic and photonic solutions to today's and future challenges in society such as artificial intelligence (communication, mobility etc.), energy (renewable energies, power conversion etc.) and health (medical diagnosis, modern surgical instruments etc.).

The IKZ provides innovations in crystalline materials on account of its combined in-house expertise on plant engineering, numerical simulation and crystal growth, enabling it to achieve highest-quality crystalline materials with tailored properties.

Nanostructures, thin films and volume crystals are investigated, the latter being the unique selling point of the institute. Cutting-edge theoretical and experimental materials science know-how is a strong asset for IKZ's R&D activities.

Together with partners from institutes with technology platforms as well as industry companies, the institute will in future also drive innovation by crystalline materials, namely the reliable evaluation and benchmarking of innovative crystalline prototype materials for disruptive technology approaches.



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X-RAY OPTICS GROUP: SYNCHROTRON TECHNIQUES FOR ADVANCED MATERIALS CHARACTERIZATION





ADVANCED X-RAY ANALYSIS FOR NEXT-GENERATION MATERIALS

Synchrotron-based x-ray analysis is a powerful tool to investigate and characterize crystalline materials. X-rays offer nanoscale structural resolution, chemical element resolution, the ability to image nanoscopic to mesoscopic structures as well as in-situ / in-operando capabilities. Due to their high flux, synchrotron x-ray sources even enable time-resolved measurements with a temporal resolution of typically 100 picoseconds.

A main advantage of x-rays methods in comparison to other nanoscale imaging techniques is their ability to penetrate buried structures. Many materials, e.g., multiferroics display structural order that extends over micro- or millimeter distances and that influences the materials functional properties. The functional properties of thin film heterostructures are strongly influenced by the strain incorporated from the substrate during growth. Thermal conductivity or charge and phonon scattering depend on the stoichiometry and morphology of the structure and of the quality of the interface between layers. Synchrotron-based x-ray analysis can yield a holistic understanding of a material and its interaction with the environment. This holistic approach is particularly useful when it comes to nonequilibrium dynamics because the relaxation timescales strongly depend on coupled energetic pathways between subsystems of the solid.

Photoacoustics is a relatively new technique complementary to time-resolved x-ray methods. It employs ultrashort laser pulses to generate and monitor bulk and surface acoustic waves (BAW and SAW, respectively). Both types of waves are used in signal processing for mobile communications, in sensorics or in other technological applications. In contrast to conventional electromechanical schemes, photoacoustics can generate sound waves up to THz frequencies and monitor their propagation without external circuitry.

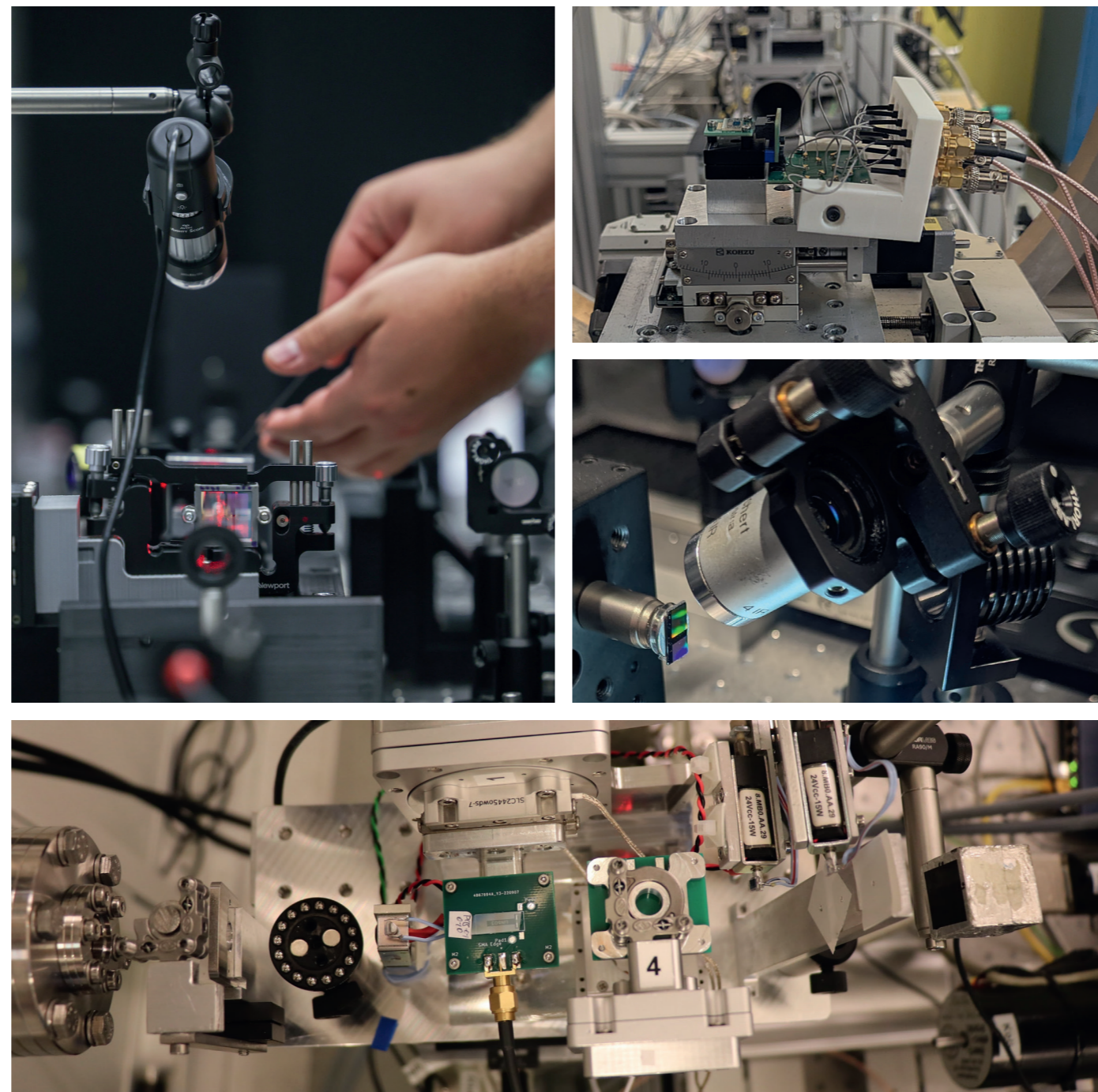
❖ **If you are interested in our research and services, please contact us:**

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WHO WE ARE

The X-Ray Optics (XRO) Group at the Leibniz-Institut für Kristallzüchtung (IKZ) has longstanding expertise in time-resolved material characterization. We employ time-resolved optical and X-ray methods at our ultrafast optics laboratory and at different Synchrotron and Free Electron Laser beamlines around the world to perform in-house and collaborative research on crystalline materials and nanostructures together with our partners. The group is located on the DESY Campus in Hamburg Bahrenfeld in close vicinity to the Petra III Synchrotron, the Flash and XFEL Free Electron Laser facilities and the physics and chemistry departments of the University of Hamburg. We foster close collaborations between IKZ and partners on the DESY campus via the IKZ-DESY JointLab.

The IKZ-DESY JointLab facilitates your access to the powerful material analysis tools at large-scale research facilities. We are ready to guide you through all steps of the entire workflow from planning the experiment including acquisition of beamtime, performing the actual measurement and the final data analysis. We collaborate closely with our group's Startup company TXproducts, which is also located on the DESY campus. With the combined capabilities of IKZ in-house characterization, the IKZ-DESY JointLab and TXproducts we support our partners with a multitude of research and development techniques.

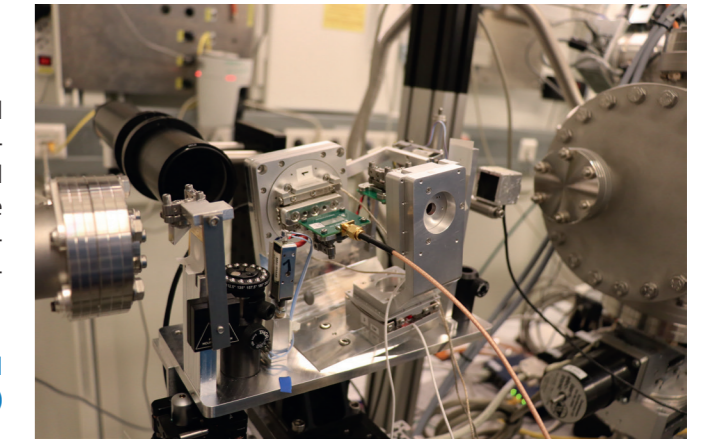


OUR RECENT RESEARCH WORK

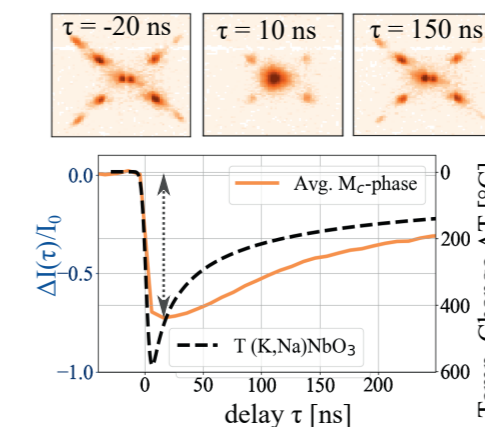
ACTIVE X-RAY OPTICS

The XRO group has pioneered the development of so-called Active X-Ray Optics for tailoring the time structure of synchrotron beams. We employ photoacoustic, electroacoustic and thermomechanical excitations of crystalline materials to realize different functionalities like x-ray pulse shortening or synchrotron pulse selection. Our development lays the foundation of the group's Spin-off company TXproducts.

D. Schmidt et al., *WaveGate: a versatile tool for temporal shaping of synchrotron beams*, *Optics Express* 22, 7473 (2024) <https://doi.org/10.1364/OE.515884>



Test of an active crystal for fast X-ray switching.



Time-resolved reciprocal space mapping of a potassium-sodium niobate thin film.

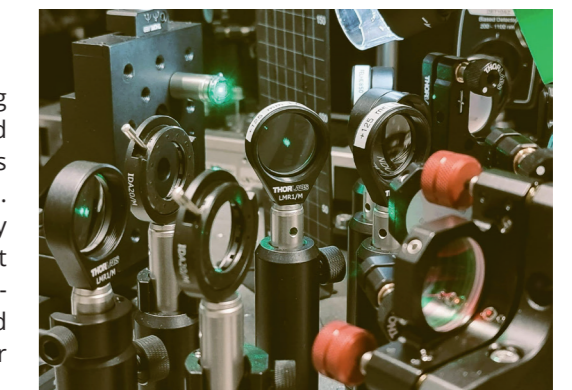
SPEED OF MARTENSITIC PHASE TRANSITIONS

Martensitic Phase Transitions play a crucial role for the functional properties of materials, e.g. in FeRAMs, in Phase Change Materials or in solid-state cooling applications. We investigate the dynamics of this structural transition using time-resolved optical spectroscopy as well as x-ray diffraction and imaging. Our studies showed various intriguing phenomena such as an energy dependence of the speed of the phase transition and a self-stabilization mechanism of the domain structure.

P.Gaal et al., *Self-stabilization of the equilibrium state in ferroelectric thin films*, *Applied Surface Science* 613, 155891 (2022) <https://doi.org/10.1515/ESRF-ES-594730606>

SOLID STATE PHOTOACOUSTICS

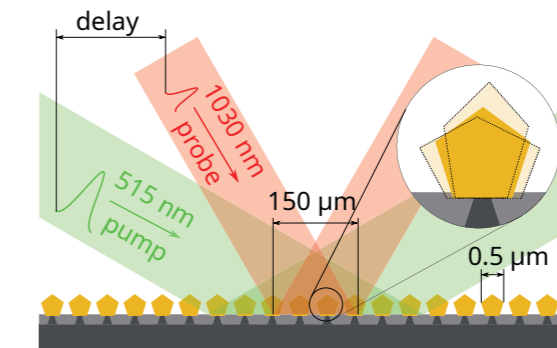
The XRO group has longstanding experience in generating and monitoring the propagation of high-frequency sound pulses in solid materials. These pulses can reach frequencies in the THz range and are localized to only few nanometers. With tailored optical excitations, we can design the frequency and wavevector spectrum of the sound wave inside the host material. Thus, sound can become an ideal probe for nanoscale structures, thin films and interfaces. Our time-resolved spectroscopy setup at the IKZ-DESY JointLab is optimized for studying such bulk and surface acoustic waves in solids.



Photoacoustics setup at the IKZ-DESY joint laser laboratory.

NANOSCALE MECHANICS OF SEMICONDUCTOR NANOPARTICLES

Semiconductor nanocrystals are highly interesting materials for solid state lasers or single photon sources. With our ability to tailor and control the spectral properties of a coherent acoustic phonon wavepacket, sound becomes a powerful tool to manipulate and control the functional properties of the nanocrystal. We have employed photoacoustic techniques to study the nonlinear elastic properties of InP nanocrystals with the aim of controlling the recombination dynamics of exciton transitions via picosecond strain pulses.



Pump-probe measurement of the nanomechanical properties of semiconductor nanocrystals.