Imaging ferroelastic domain dynamics with nanoscale X-ray diffraction at the MAX IV synchrotron

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Metal halide perovskites (MHPs) have shown impressive results in solar cells, light emitting devices, and scintillator applications, but basic questions regarding its complex structure are still open [1]. The low symmetry of MHP crystal structures allows the formation of ferroelastic domains, whose ferroelectric nature is debated. Ferroelastic and ferroelectric materials show nanoscale domains with typical sizes ranging from 10 to 1000 nm. Imaging dynamics of ferroic domains require an experimentally challenging combination of high spatial resolution, strain sensitivity and long penetration depth.

We have developed nanoscale X-ray diffraction methods to study the dynamics of ferroelastic domains within MHP nanostructures, made available by recent developments in X-ray optics and synchrotron sources. $CsPbBr_3$ nanowires were imaged across the orthorhombic to tetragonal crystal phase transition using in situ temperature-dependent nanofocused scanning X-ray diffraction, with the 60 nm beam at the NanoMAX beamline, MAX IV [2]. The formation of highly organized domain pattern near 80 °C revealed the ferroelastic nature of the domains. To achieve improved temporal resolution, we used the newly developed Full-Field Diffraction X-ray Microscopy technique, available at the ID01 beamline, ESRF, France, to probe the domain evolution at 6 s time resolutions [3] . Twinned ferroelastic domains in single 500 nm $CsPbBr_3$ particles were studied with 3D Bragg coherent x-ray diffraction imaging [4]. A preferential double-domain structure was revealed, with one domain oriented along the [110] and the other along the [002] direction. These results demonstrate that X-ray methods now offer sufficient spatial resolution to image ferroic domains, allowing for in situ studies of their formation and dynamics in realistic conditions.

Finally, I will give an update of the status of the 4th-generation synchrotron MAX IV in Lund, Sweden (https://www.maxiv.lu.se/).

References

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