Laser-assisted polarization switching of ferroelectric nanolayers HC-3970

We started our beamtime with the alignment of the sample holder that we brought with us. This holder allows us to apply electrical fields to the sample using a tungsten needle and laser excite the sample from (through) its polished backside using the 800 nm laser installed at ID09.

First experiments were done without laser on a polycrystalline Pt/$Pb_{0.52}Zr_{0.48}TiO_3$/Pt sample on Si (Radiant Technologies). This sample was then measured with applied electric field sequences (PUND – Positive Up, Negative Down) with different field amplitudes at a field repetition rate of 2 kHz. It turned out that the shift due to the ferroelectric switching is small and “only” 5 powder rings could be collected on the detector.

Then we changed the sample to a $BaTiO_3$/(La,Sr)MnO_3//$SrTiO_3$ sample that was also laser excited from the backside: We hope that the short laser pulse generates an ultrafast longitudinal acoustic phonon in the metallic (La,Sr)MnO_3 layer that then propagates into the ferroelectric $BaTiO_3$ layer. From our characterization measurements we were aware of the fact that the coercive field of this sample is rather large on the order of 10 V. Thus, we also expect that the soundwave alone will not be sufficient for the FE switching. We therefore applied an electric field of +/- 15 V in order to see the “static” switching of the sample.

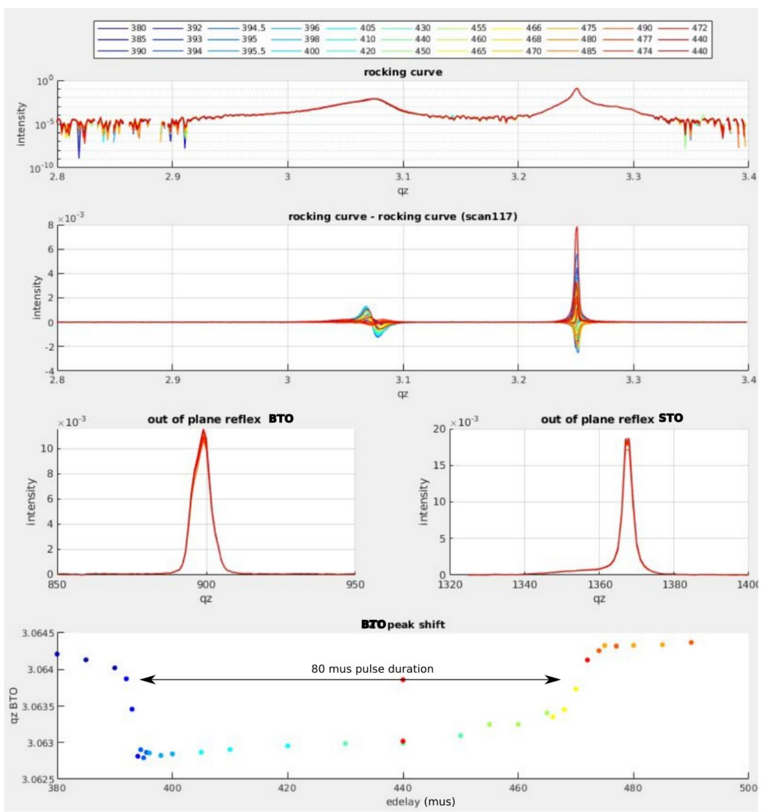

Figure 1: Top: Extracted qz vs. intensity scans at different times between X-ray pulse and electric field onset (numbers given in µs between field onset and X-ray pulse). Middle: Difference between the different scans at various times and without applied field. Bottom: Plot shows the change of qz as calculated from the center of mass of the BTO reflection at different delays between field and X-ray probe. The electric field pulse begins at 475 µs and ends at 395 µs on this axis!

Then we repeated the experiment with the additional laser illumination. We found out that we could not move the laser and electric field pulse trigger independently as they were intrinsically coupled by the timing card at the beamline and thus, we were not changing the delay between field onset and laser pulse arrival. An easy solution would be to use a fast photo diode that catches some straylight from the laser and use this as "independent" trigger source – or a reconfiguration of the trigger card might also be possible. Nevertheless, we measured manually some different delays between the applied electric field pulse and the illumination with the laser. However, the signal is dominated by thermal heat transport on ns time scales. We observe at early times an additional feature that we attribute to the generated sound wave but does not fit to the laser-assisted switching signal that we were looking for.

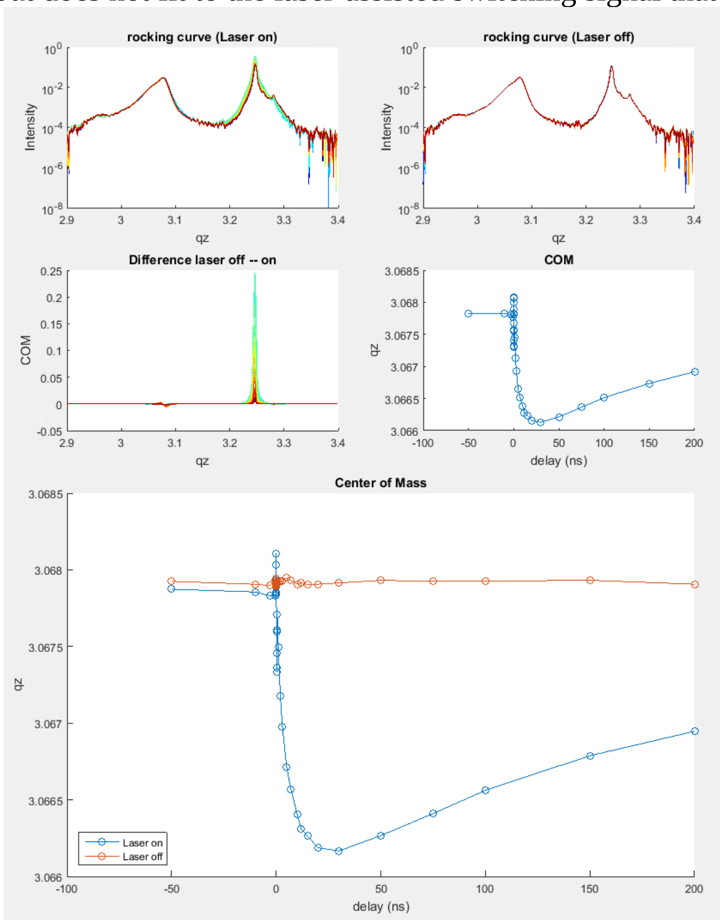

Figure 2: Top: Extracted ω/2θ curves with and without laser with applied electric field (U = 3 V, repetition rate 2 kHz, excitation fluence 10 mJ/cm2, room temperature). Middle: Difference plot and center of mass for the $BaTiO_3$ reflection. Bottom: Comparison measurement with and withou laser illumination.