Resolving 20ps coherent acoustic lattice vibrations with shortened synchrotron pulses

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We report a benchmark experiment to demonstrate photoacoustic pulse shortening in a synchrotron-based optical pump - x-ray probe experiment [1,2]. The ESRF x-ray probe pulse with an original duration of 120 ps was shortened to 8 ps by introducing the PicoSwitch into the beam. We employ the shortened x-ray pulse to monitor propagating sound waves in a thin film sample [3,4]. The sample consists of the thin 90nm dieelectric layer ($LaAlO_3$) deposited on a 57nm thin metallic layer ($LaSrMnO_3$) supported by single crystal substrate. The high angular and temporal resolution is a direct prove for sufficient switching contrast. The device was installed at the ID09 beamline at ESRF. The PicoSwitch reduces the totals photon flux by 10^{-3} photons/pulse. By increasing the repetition frequency and bandwidth we estimate a flux of 10^{10} photons/sec with the shortened pulse in our setup.

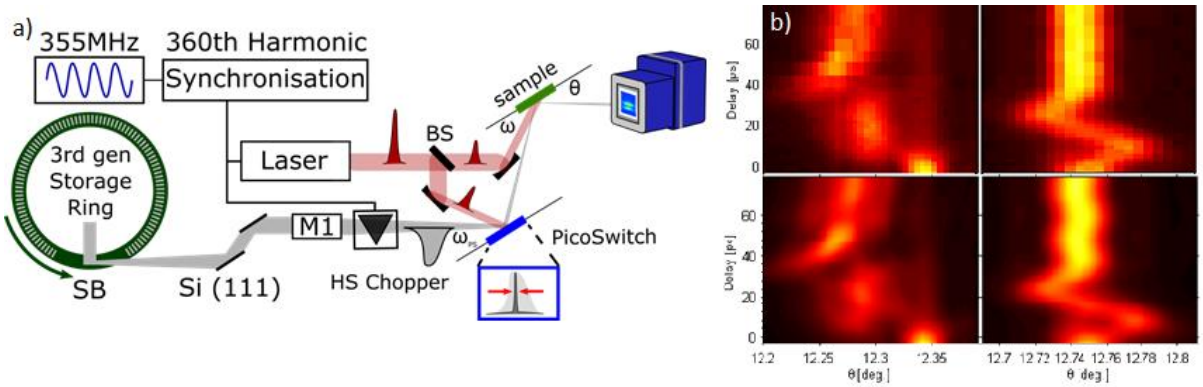

Figure 1: a) ID9 Layout of the benchmark experiment for x-ray pulses shortening. The repetition rate of the synchrotron single bunch is reduced by a heatload- and high speed chopper to 1kHz. An ultrafast laser system is synchronized to the repetition rate of the synchrotron. The laser pulses are split into two beams to trigger the ultrafast Bragg switch, so called PicoSwitch, and to excite the coherent acoustic phonon dynamics in the sample. b) Benchmark Experiment: The two upper panels show a measurement of the coherent acoustic phonon dynamics in the thin film double layer structure consisting of 104nm $LaAlO_3$ and $LaSrMnO_3$. For both cases rocking curves with the shortend x-ray pulses from the PicoSwitch are demonstrated. The two lower panels show dynamics diffraction simulation from the expected coherent acoustic phonon dynamics trigger by ultrafast optical excitation.

References

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