Ultrafast Phase Transitions Triggered by Femtosecond Laser Pulses

Eckhart Förster
Institute for Optics and Quantum Electronics, Friedrich Schiller University
1, Max Wien Platz, D-07743 Jena, Germany

Non-thermal melting of semiconductor crystals, phase transitions on a sub-picosecond scale can be studied by optical pump x-ray probe experiments. Powerful femtosecond lasers deliver brilliant ultra-short K alpha pulses on a time scale from 100 fs to1 ps that can be optimized for these pump probe experiments. These experiments consist of (i) high luminosity point-to-point imaging in narrow spectral line channels and (ii) x-ray diffraction of ultra-short pulses by the sample crystal.

In order to fulfil all the demands, theoretical codes have been developed to optimize design of the instruments. X-ray topographic cameras and diffractometers were modified for fabrication and characterization of 2-D bent crystals. Best results were obtained when structurally perfect wafers of Si, Ge, and quartz crystals were prepared whilst monitored by x-ray topography and diffractometry. After final check of x-ray imaging and reflection properties of the toroidal crystals, monochromatic x-ray focus and laser pump beam are adjusted spatially to coincide on the sample crystal.

Ultrafast processes are studied in Langmuir Blodgett films containing Cd, in bulk semiconductors, such as InSb, and in Ge or CdTe semiconductor films. As penetration depths of optical pump beam are usually much shorter as x-ray extinction depths, best sensitivity to ultra-fast structural changes is obtained for minimum x-ray extinction depths. This can be achieved by selecting samples containing heavy elements, thin crystalline film samples and by using asymmetric Bragg reflections, respectively.