Access to Ultrafast Dynamics of Functional Materials with Soft X-Rays

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Tracing the ultrafast dynamics of functional materials plays a key role in the further development of various technological fields. When light elements (carbon, nitrogen, oxygen) or transition metals are a fundamental part of these materials, the study of element sensitive absorption in the soft X-ray region ($>$ 100 eV photon energy) on the femtosecond time scale provides access to the dynamic behavior. In addition to radiation production in large scale facilities, the required ultrashort soft X-ray pulses can be produced via high harmonics (HHG) of infrared laser pulses. Due to the extremely low efficiency of this process, powerful infrared laser pulses with few cycles are required. These systems are based on a new generation of laser sources using optical parametric processes and amplification (OPA). The realization of this concept is linked to the technological advancement of Yb-doped laser technology, which allows powerful driver pulses with picosecond pulse duration and multiple kHz pulse repetition rate.

The NanoMovie project framework at the Max-Born-Institute in Berlin includes two powerful infrared OPCPA systems at 2 [1,2] and 3 [3] micrometers center wavelength together with experimental areas. Both systems are based on the same concept: The signals at the desired broadband wavelength are derived from white light sources, amplified and finally compressed (OPCPA). For more than 3 years, the 2-micron system has been the workhorse for various studies, **e.g.** ultrafast switching of magnetization [4], surface analysis [5] and modification on the nanometer scale, and structural dynamics of surface layers [6]. The realization of these pump-probe experiments was made possible by a reasonably high and stable soft X-ray photon flux over the entire spectral range between 100 and 550 eV. Recent advances in the development of the 3-micrometer system can extend the soft X-ray spectral range up to about 900 eV photon energy.

OPCPA-system architecture and parameter, HHG characterization, showcases of soft X-ray absorption and scattering experiments featuring different application are presented.

References

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