Nanoscale 3D Imaging Using High Harmonics

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I will discuss cross-sectional nanoscale imaging in the extreme ultraviolet (XUV) spectral region using high-harmonics produced by femtosecond laser radiation. The imaging technique is particularly easy to understand in time-domain: An attosecond pulse incident on a sample is reflected at the internal structures of the sample. As a consequence, a series of attosecond pulse replicas is generated. The delay between these pulse replicas is on the order of 100 to a few 100 attoseconds, corresponding to structures on the order of 10s to 100s nanometer.

Naturally, the pulse replicas differ in spectral amplitude and phase, depending through which and how much material they have propagated. In any case, their spectral interference can be measured by an XUV spectrometer and used to reconstruct the internal structure of the sample. In fact, it is possible to retrieve the phase of the XUV radiation reflected by the sample. Accordingly, the field of the train of pulse replicas is known.

A particularly relevant application of XCT for the spectral range up to 100 eV are silicon-based samples. We have demonstrated depth resolutions of 20 nm and very high sensitivities. Buried oxide layers of a thickness of a few nanometers could be detected as well as buried monolayers of graphene. Thanks to the ability to reconstruct the field, it is even possible to identify the material encapsulated in silicon and to determine also properties like layer roughness without destroying the sample. A unique perspective is ultrafast imaging.