DAMAGE OF SOLIDS EXPOSED TO INTENSE XUV FREE ELECTRON LASER SINGLE SHOTS. *POST-SITU* CHARACTERIZATION BY X-RAY MICRODIFFRACTION, OPTICAL MICROSCOPY AND *AFM*

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The irradiation of solids with short-wavelength femtosecond pulses delivered by the XUV free electron laser creates states of strong electronic excitation with a highly reduced influence of optical nonlinearities at frequencies in between the plasma frequency and the frequency of the inner shell absorption edge. The absorption depth for most of materials can be therefore much longer, as compared to femtosecond optical pulses, boosting creation of well-defined excitation conditions in relatively large sample volumes [1, 2].

In the present work, we report on results obtained on three materials: the insulating α-SiO_2, the semiconducting monocrystalline silicon and the metallic films of gold deposited on sapphire substrate. The samples were irradiated by single pulses, of 25 fs FWHM, at the FLASH facility in HASYLAB (Hamburg), operating at a wavelength of 32.5 nm. The applied fluency has been kept in the range of 100-2000 mJ/cm^2.

After irradiation, the samples were examined by several techniques, including optical microscopy with Nomarski contrast and AFM, as well as by X-ray diffraction and reflectometry at W-1 beamline of DORIS storage ring (Hamburg). Finally, the microstructure was probed at ID-13 beamline in ESRF, Grenoble, with the X-ray submicrometer beam of size of 250 nm. 2D diffraction patterns were recorded in transmission mode while the samples were step-scanned along chosen paths throughout places irradiated with laser pulses of various fluencies.

Ablation craters of well defined edges with smooth interiors were found in the materials for virtually all applied fluencies. Pronounced embankments and columnar structures around ablation craters, induced at intermediate fluencies, were revealed in silicon. In α-SiO_2 a typical diffraction pattern of an amorphous material was observed without any traces of irradiation-initiated crystallization. A step-like, complete removal of the gold film was evidenced inside of damaged areas, with only small gold residues in central part of craters exposed to higher fluencies. Polycrystalline phase of gold was found in thin leafs 200-300 nm thick, set upright as walls up to few micrometers high and outlining the crater boundaries.

The observed features are compared with results of a damage induced at other wavelength between 13.4 nm and 98 nm and related to models of ablation [2, 3].

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