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<th>ROBL-CRG</th>
<th>Experiment title: Structure modifications in materials irradiated by ultra-short pulses of VUV free electron laser</th>
<th>Experiment number: 20_02_064 20_02_605 EU #30</th>
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<td>BM 20</td>
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**Report:**

The objective of the project was to characterize structural changes induced in samples by irradiation with free electron laser (FEL) working in the VUV region. The samples – Si(001) wafers and deposited on the wafers films composed of Au, Al or graphite 50-200 nm thick – were irradiated at VUV TESLA Test Facility FEL at DESY, Hamburg, with the quantum energy centered around 14 eV, in short pulses of only 50 fs and of peak power up to 1 GW. The FEL beam was focused on the sample surfaces to microspots of size 10-100 μm. The energy density in the spots varied from below the ablation threshold (“annealing mode”) up to far above this threshold (“damage mode”).

The x-ray measurements were recorded at λ = 1.23984 Å by mapping the samples with the diffractometer fixed at a particular angular position deflected from exact Bragg reflection of the order of 10^-3o. The incident x-ray beam was confined by external slits to the dimensions of about 40 x 30 μm².
In Fig. 1 examples of the x-ray diffracted intensity distribution maps recorded on samples with a mesh grid of 20 µm around chosen spots irradiated by FEL are shown. The maps determine the damage distribution range and intensity around the spots. It was found that, even in the case of the most intense FEL irradiation, the detectable damaged area surrounding the center of irradiation is localized within the radius of 120-170 µm. The intensities observed in the spots are commensurate with the FEL irradiation fluencies applied. In the centers of strongly damaged spots a split in the maximal intensity occurs with a well pronounced minimum, of the intensity 15-30% lower, indicating places with extremely strong damage of the sample material, its amorphization or ablation (see Figs 1c, 1d). The obtained results allowed also for identification of relatively weakly damaged spot areas, which are hardly observable by conventional optical microscopy.

For chosen spots, the mappings were completed at the exact Bragg reflection and at few positions declined from the reflection toward the higher and the lower angles. Comparing maps obtained at both sides of exact Bragg reflections, we found a shift in intensity maxima positions around some damaged centers reaching as much as 100 µm (compare Figs 1c and 1d). The reason of this shift is not clear, though it seems to be connected with oblique beam incidence on the sample surface during FEL irradiation.