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Synchrotron topographic evaluation of strain around craters generated by irradiation with x-ray pulses from free electron laser with different intensities

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The important question associated with the use of new 4th generation of radiation sources, the free electron lasers (FELs), refers to the interaction of the extremely intense beam with solids.

In our previous experiments exploring X-ray topography it was possible to reveal many important features of the strain fields connected with the craters generated by the FUV pulses from FLASH at HASYLAB. It also was possible to evaluate the depth extension of the damaged area by means of the synchrotron transmission section white beam topography [1]. The completion of the section topographs was the simulation of contrast obtained using the approximation of damaged area connected with the craters by "droplet-like" inclusion.

In the present case we studied the silicon sample irradiated at the Linac Coherent Light Source (LCLS) with X-ray pulses of three different wavelength corresponding respectively to 830 eV, 1855 eV and 2000 eV and different impact energy of pulses differing from 1 to 17 μJ. It was established that the pulses were non Gaussian fluency distribution [2], and much of them caused melting of the irradiated silicon. The important goal of the experiment was evaluation and comparison of the strain field connected with generated craters.

The topographic investigation has been performed at DORIS III at HASYLAB. The most important experiments were realized using monochromatic beam topography but they were also completed with both projection and section white beam reflection topography. The topographs revealed many characteristic features of the damages related with the craters, which usually significantly exceeded the beam size, and the real diameter increased with the energy of the pulse. It was in particular indicated that the relative lattice parameter change in the inner, most probably melted region of the craters was on the level up to 5×10^{-5}. The interference fringes connected with the craters were also observed in the white beam section topography.

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