# Raman scattering studies of structural modifications of semiconductor surfaces induced by intense femtosecond X-ray free-electron laser pulses

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The recent development of short wavelength (XUV and X-ray) free-electron lasers (FELs), enables the study of interaction of ultrashort, femtosecond, intense pulses with matter. With the advent of the sources, a unique combination of radiation properties creates new research possibilities. In particular, radiation intensity produced in FELs by many orders of magnitude exceeds intensities available from other monochromatic XUV and x-ray sources, making thus it possible to excite a solid material through phase transition points. As typical pulse duration, on the order of femtoseconds, is shorter than most of the time constants related to structural transformations and to the energy transfer, it is possible to separate the processes from influence of radiation absorption during the pulse duration. Moreover, the photon energies, larger than value of energy gap in any material make it possible to avoid nonlinearities in absorption.

We report on the results of Raman scattering (RS) studies of semiconductor surfaces irradiated by ultrashort, high intensity $10^{12}$ - $10^{14}$ W/cm$^2$ XUV ($\lambda$ = 51 nm) pulses. The samples surfaces were irradiated at the normal incidence angle by series of single shots using SCSS free-electron laser facility. GaAs bulk crystal and (111)-oriented ZnO layer deposited onto GaN (001) substrate were selected for these studies as all mentioned semiconductor compounds are very important today, widely investigated materials applied in various devices. An analysis of possible mechanisms of different, intensity dependent stages of the surface damage requires a detailed knowledge about the spatial distribution of new crystal phases (e.g. an amorphous or a recrystalized compound) introduced by the irradiation. It is demonstrated that Raman scattering technique is an efficient, non-destructive method to investigate possible surface modifications and to look for an evolution of these modifications with an increasing distance from the irradiated area center.

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