Nonlinear phenomena on semiconductors by THz-FEL irradiation

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THz wave or FIR light has both characteristics of the high-frequency radio wave and the low-energy light. THz-FEL (free electron laser) is expected to exhibit unique responses with various materials from solid to gas due to its high luminance, monocromaticity, and the time and spatial coherency. The

ISIR THz-FEL generates aroud 100 μm wavelength THz pulses corresponding to 12 meV phton

energy. The peak power is up to 2 MW. The electric field at a focal point using short focus lens can be estimated 3 MV/cm which enables nonlinear phenomena on materials. The monocromatic, fuge peak power, pulse light is unique in the THz/FIR region.
The nonlinearity of solids by THz-FEL was explored using semiconductors. The samples were widely used from normal semiconductors to wide gap semiconductors. As a result, a nonlinear absorption as high as 90% was observed in Si having 1.1 eV band gap [1]. Also, when irradiated beyond a certain illumination threshold, periodic structures of less than wavelength were found on the surface of Si [2]. Such structures have been known for NIR fs-laser as LIPSS (laser induced periodic surface structure), but it was discovered for the first time in THz/FIR region by using FEL. And, the periodic structure by THz-FEL is parallel to the FEL polarization direction and its periodic interval extends to 1/25 of the wavelength that are different from the LIPSS by NIR fs-laser. The mechanism of LIPSS generation has not yet been elucidated, but the rationale of LIPSS as a self-organized dissipative structure on the material surface in a non-equilibrium open system [3] is shown by the pulse number dependence of LIPSS interval from this study.

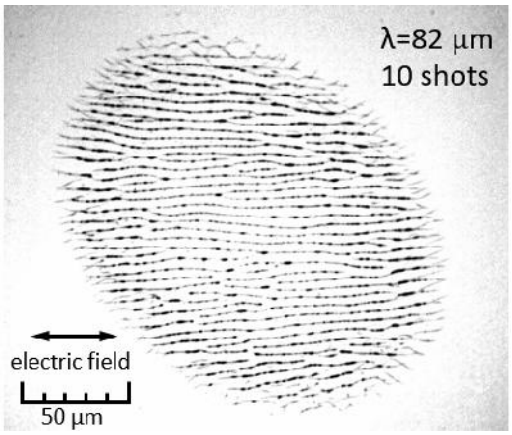

Figure. LIPSS on Si induced by THz-FEL irradiation [2].

References

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