Ultrafast laser induced anisotropic carrier transport dynamics in smooth and surface pre-structured crystal semiconductors, detected by terahertz pulses

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Charge transport anisotropic dynamics within two-photon absorption (TPA) induced by ultrashort laser pulses in a Zinc Telluide (ZnTe) semiconductor crystal is detected and analyzed by using terahertz (THz) pulses. The anisotropy consists in an oscillation of the induced carrier density with crystal orientation. Electron densities as low as $10^{13} cm^{-3}$ are detected, due to the high coupling of THz electric field with free carriers. The anisotropy of TPA and its dynamics are analyzed in samples with smooth surfaces first and then with surfaces pre-structured with LIPSS (Laser Induced Periodic Surface Structures).

We can distinguish an intrinsic anisotropy induced by TPA, and an extrinsic one generated by the permanent pre-structuration of the crystal surface. The intrinsic anisotropy is attributed to a dependence of the TPA cross-section on the crystal orientation (Fig. 1 (c)) as described in [1]. The extrinsic anisotropy is due to polarization coupling and surface birefringence effects introduced by LIPSS. We show that pre-structuring the crystal surfaces clearly influences the intrinsic TPA-induced anisotropy by shifting the charge density oscillation (Fig. 1 (d) right) and, more surprisingly, also by changing the carrier relaxation dynamics (Fig. 1 (d) left) [2].

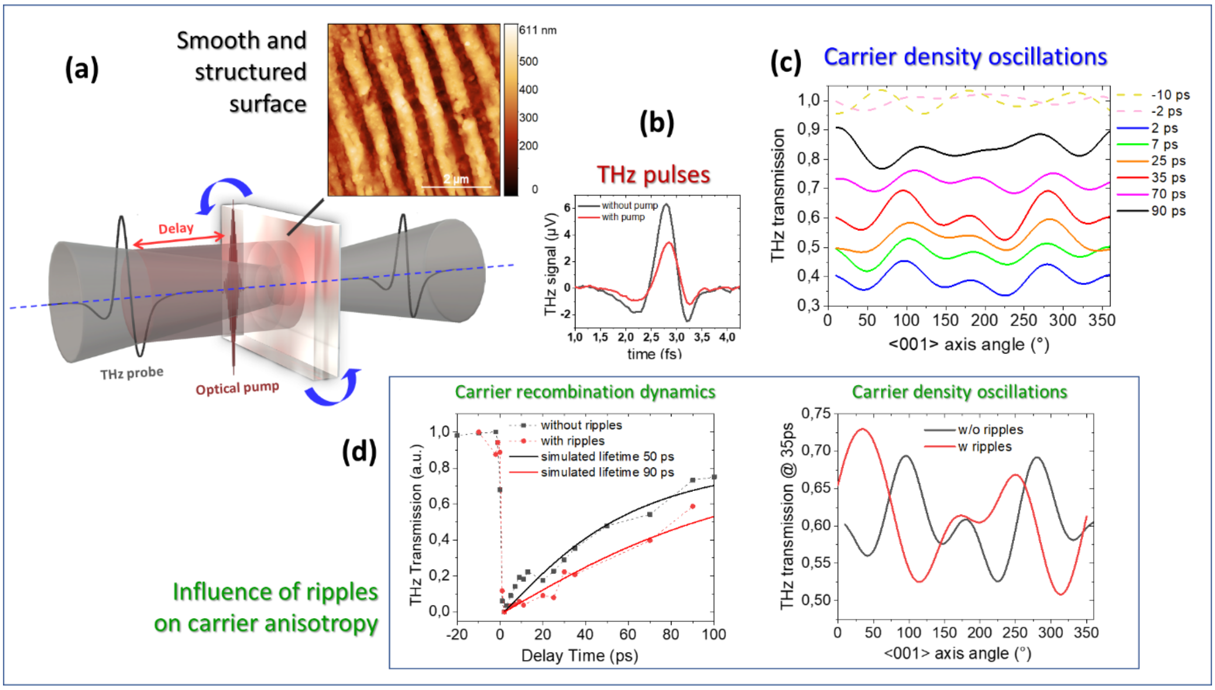

Figure 1: (a) Schematic of the measurement concept. (b) THz pulses used for probing the charge carrier dynamics. (c) Charge carrier density (THz transmission) oscillation with crystal orientation as a function of time. (d) Comparison of carrier density dynamics (left) and oscillation with crystal orientation (right), without (dark lines and dots) and in presence (red lines and dots) of LIPSS.

References: [1] M. D. Dvorak et *al*., IEEE journal of quantum electronics **30**, 256 (1994); [2] D. Zhang et *al*., Opt. Express **31**, 24054 (2023)