Highly efficient THz generation by mid-IR pump pulses

Strong-field THz transients allow on-demand control of the properties of matter and to engineer new dynamic states in a wide range of materials. Nonetheless, current table-top THz sources remain rather weak, with the most promising being optical rectification in nonlinear crystals and two-color plasma filaments pumped by near-infrared sources. While the former is mainly restricted by multi-photon absorption of the short wavelength driving pulse, causing crystal damage, the latter suffers from pump pulse scattering in dense plasma and limited laser field-asymmetry. These limitations can be overcome with intense long wavelength driving pulses. However, until recently, such high-power mid-infrared sources were simply not available. In this work, we exploit the recently developed mid-IR optical parametric chirped pulse amplifier (OPCPA) system to drive efficient THz generation in the organic crystal DAST (4-N,N-dimethylamino-4’-N’-methylstilbazolium tosylate) by optical rectification and in two-color plasma filaments, wherein we report on a record electric field strength of 100 MV/cm and an optical- to THz conversion efficiency which is more than an order of magnitude higher compared to previous works with near-IR drivers. In order to confirm the extreme THz field, the intense THz pulse is focused onto bulk semiconductors, wherein we observe THz-induced photoluminescence and a spectral shift of a co-propagating probe pulse, mediated by THz-induced cross phase modulation. The strong-field THz source is further applied to heterostructure quantum dots without any field enhancing structures to investigate the pure quantum confined Stark effect. The possibility to manipulate optical properties of nano-scale semiconductors by direct THz radiation demonstrates the feasibility for an all-optical electro-absorption modulator with data rates in the range of Tbit/s.