Spectral Gapless Intense Terahertz Pulse Generation in Strained Diamond

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High-intensity THz pulse generation is critical for spectroscopy, particularly in the 5–15 THz range, where key lattice vibrations and quasi-particle excitations reside. However, stable, tunable, and energetic THz sources in this spectral window remain a challenge. Our previous work (Light Sci Appl. 2023, 12:34) demonstrated Raman-resonance-enhanced four-wave mixing (R-FWM) as a viable approach to bridge this gap, yet non-collinear phase matching limited interaction length and energy scalability, and required complex optical adjustments for frequency tuning.

In this study, we overcome these limitations by realizing collinear phase matching via strain-induced birefringence in diamond. This enables longer interaction lengths, significantly increasing THz output energy while ensuring diffraction-limited beam quality and ease of tunability. We develop a theoretical framework describing the interplay between pump pulses and transient Raman phonon, establishing the fundamental limit of THz output. Experimentally, we demonstrate coherence lengths exceeding 10 mm and generate stable 60-fs THz pulses with 30 nJ energy from a 2-mm-thick strained diamond. These pulses can be tightly focused to achieve peak field strengths of ~2.3 MV/cm. More importantly, our results show that the energy conversion efficiency of R-FWM can rival or surpass that of difference frequency generation, broadening its applications in high-energy THz-IR pulse generation.

Short Bio:

Chuanshan Tian received his PhD degree in Condensed Matter Physics from Fudan University. He is a professor of Fudan University, China.