MHz repetition-rate, few-cycle, multi-octave THz generation in HMQ-TMS

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Optical rectification of near-infrared (NIR) pulses at 1035 nm in HMQ-TMS has previously been shown to generate THz fields larger than 200 kV/cm, with conversion efficiencies exceeding 0.26% [1]. Compared to inorganic crystals, *e.g.* GaP, it has consistently shown superior conversion efficiency for a variety of pump wavelengths [2-4]. These studies, however, were performed at sub- or few-kHz repetition rates; scaling the repetition rate to enable high average power THz wave generation remains a major challenge. Femtosecond fibre and thin-disk lasers have been proposed as a route to THz wave generation at MHz repetition rates, allowing faster data acquisition and consequently improved signal-to-noise ratios, and hence enabling sensitive spectroscopic measurements. Inorganic crystals such as GaP have been tested with NIR MHz pump sources, resulting in high average power THz wave generation up to 7 THz [5,6]. Here, we demonstrate that HMQ-TMS offers a tenfold increase in conversion efficiency over GaP and determine the thermal damage threshold in the MHz regime.

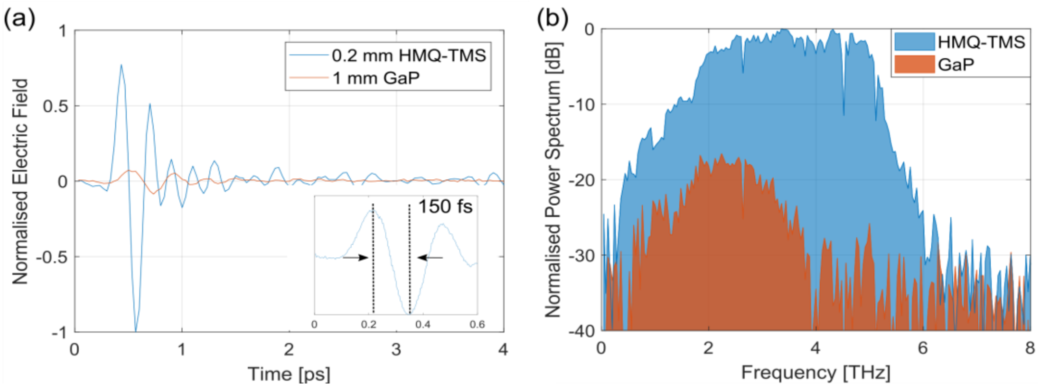

Figure 1. THz waveforms in the time domain (a) and their corresponding spectra (b).

The output of a 10 MHz, 250 fs Yb:fibre laser is spectrally broadened in a large mode area fibre and compressed to 30 fs, providing 700 mW (61 nJ) of pump power that is focused to a spot size of 50 µm in a 200 µm thick HMQ-TMS crystal. The residual NIR pump is removed with a Teflon filter, while the THz emission is collimated and refocused with off-axis parapoloidal mirrors onto a 300 µm thick GaP detection crystal, where a small fraction of the laser beam is used for EO sampling. Figure 1(a) shows the generated time domain THz waveform compared with a 1 mm GaP crystal for identical experimental conditions. The THz field generated in the HMQ-TMS is stronger by an order of magnitude and has a transient duration (leading maxima to minima) of 150 fs [Fig 1(a) inset]. The corresponding spectrum [Fig. 1(b)] extends to 6 THz at the −30 dB level, almost twice the bandwidth achieved with the 1 mm GaP crystal. Damage of the HMQ-TMS crystal occurred after 2 hours of prolonged irradiation at a fluence of 1 mJ/cm^2, indicating a significant reduction in the threshold compared to previous reports due to the elevated repetition rate [4]. A large-area crystal and a looser focus could allow further scaling of the THz wave power.

References

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