Compression of high power NIR pulses for ultra-fast high power THz spectroscopy

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Heading towards high power high repetition rate THz spectroscopy is vital for studying undiscovered material properties is thin films like graphene, MoS_2 and many others. To power this, we make use of a MHz repetition rate, 1030 nm, 220 fs pulse width laser source available from NKT photonics.

Compressing the pulses to 22 fs and with only 10% of the full laser power, we have already shown a world record-breaking THz signal from organic HMQ-TMS crystals [1]. Using the full power has the potential of a 10 times stronger THz signal. Hollow core fibers (HCFs) provide the environment needed for high power pulse propagation and self-phase modulation, generating the bandwidth needed to obtain 20 fs pulses.

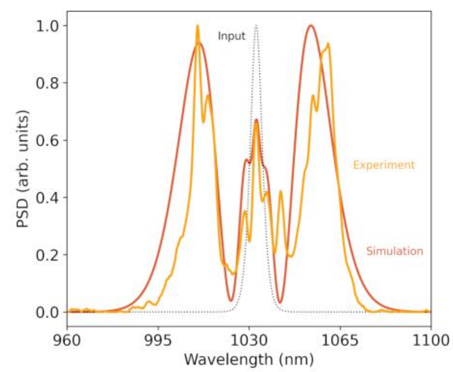

Fig 1. Spectral broadening with 26 bar Argon. Input: 1030 nm, 31 W, 10 MHz repetition rate.

Obtaining a 20 fs short pulse is vital for broadband THz generation. Previous we have used spectral broadening in a solid core photonic crystal fiber, which limits the power.

HCFs guide the full power of our laser source, allowing high power compressed pulses. This relies on self-phase modulation and post compression. With the ability to tune the pressure and the repetition rate of our laser source, it is possible to match the parameters for the desired spectral broadening at the highest possible repetition rate, is a unique feature. We are therefore able to maximize the peak power while maintaining a clean pulse.

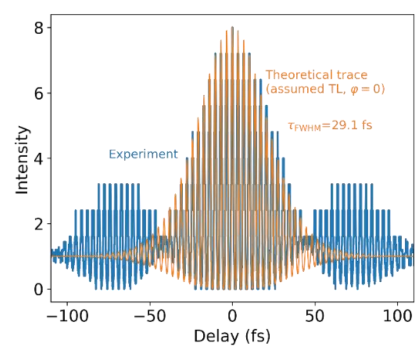

Fig 2. Interferometric autocorrelation trace of compressed pulse with SF11 prism compression.

With a coupling efficiency at 80 % yielding a maximum output of 31 W, we are able to compress 210 fs pulses down to 30 fs at 10 MHz repetition rate. This requires a pressure of 26 bar Argon in the 1.5 m HCF, and post compression with SF11 prisms spaced at 480 mm. See Fig 1.and 2. The compressed pulsed is measured with an interferometric auto correlator based on two photon absorption in GaAsP.

[1] Tobias Olaf Buchmann et. al, "High-power few-cycle THz generation at MHz repetition rates in an organic crystal", APL Photonics 5, 106103 (2020)