Fakultät für Elektrotechnik und Informationstechnik

Terahertz radiation from a large-area photoconductive emitter via high average power Yb-oscillator

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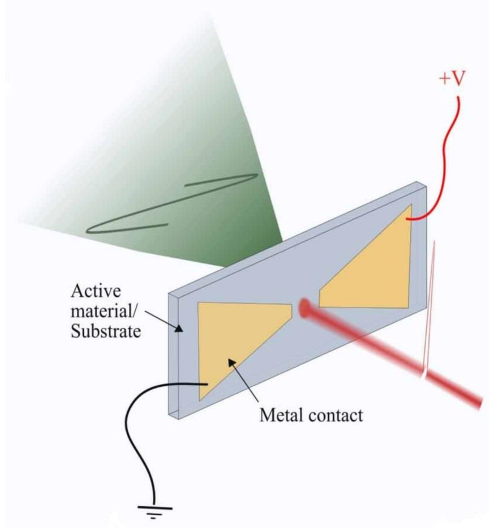
Motivation

High efficiency, high dynamic range (DR), broadband and high power THz source based on photoconductive emitter:

Photoconductive antenna (PCA)



- Advantages: no need of high pulse energy, no critical alignment required, makes PCA popular for industry application
- Disadvantages: their small excitation area ($\sim 5\ \mu m$) limits optical excitation power

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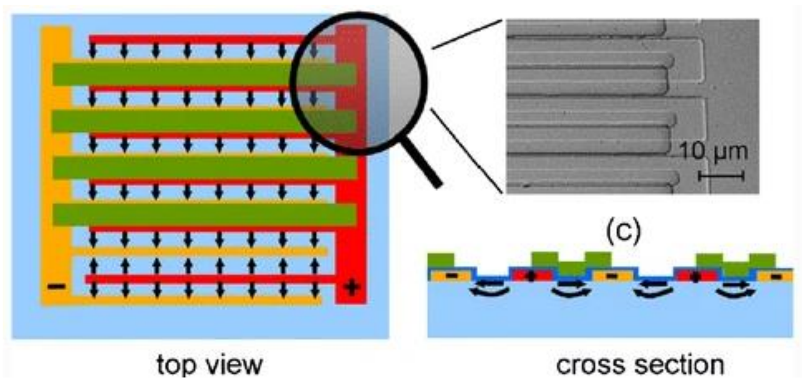
Utilize a microstructured large area emitter (LAE) as an excellent alternative:



- Large active area (1 cm^2) enables full power utilization of ultrafast laser
- Their electrode structure provides high bias fields when moderate voltages are applied

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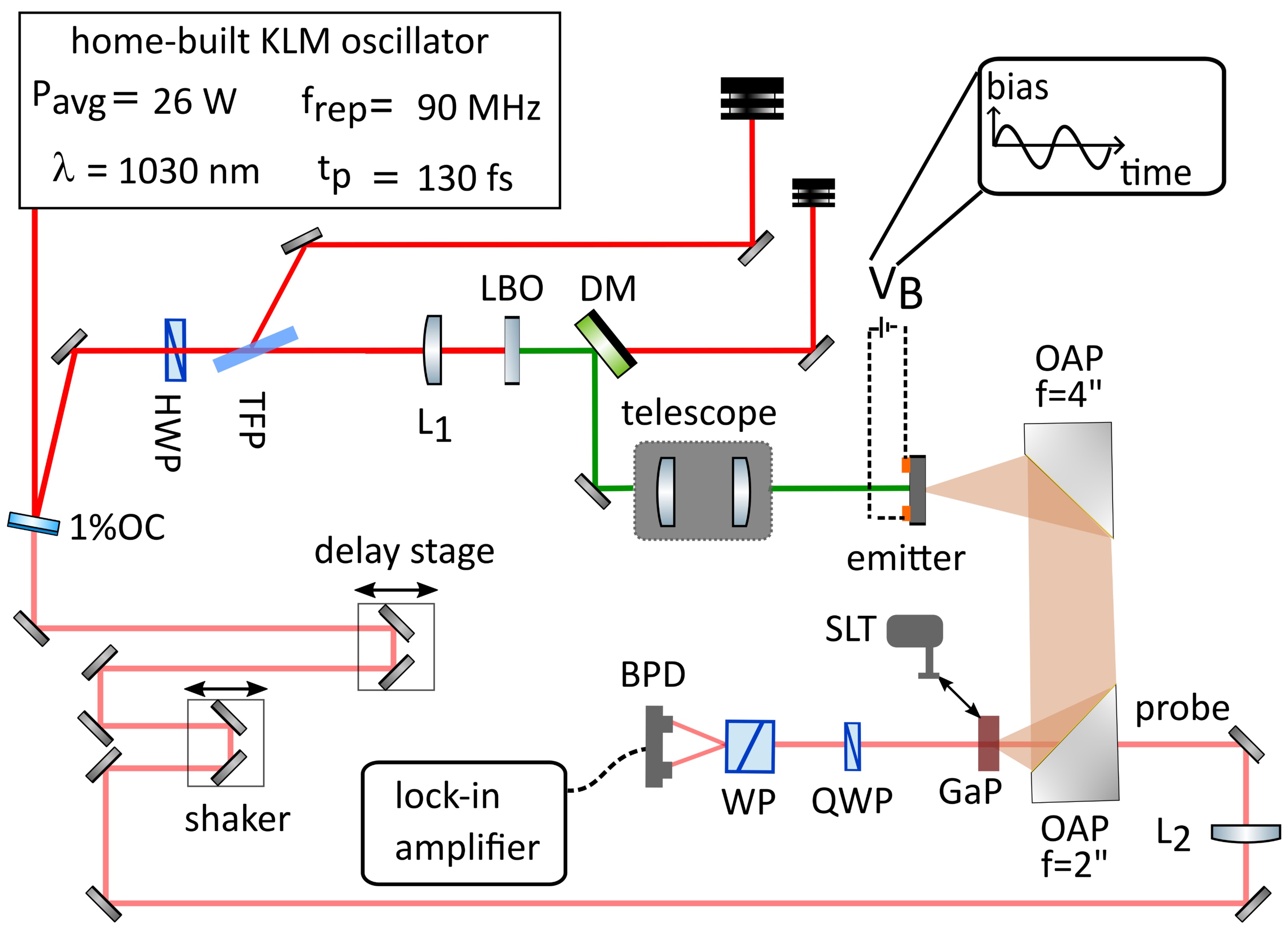
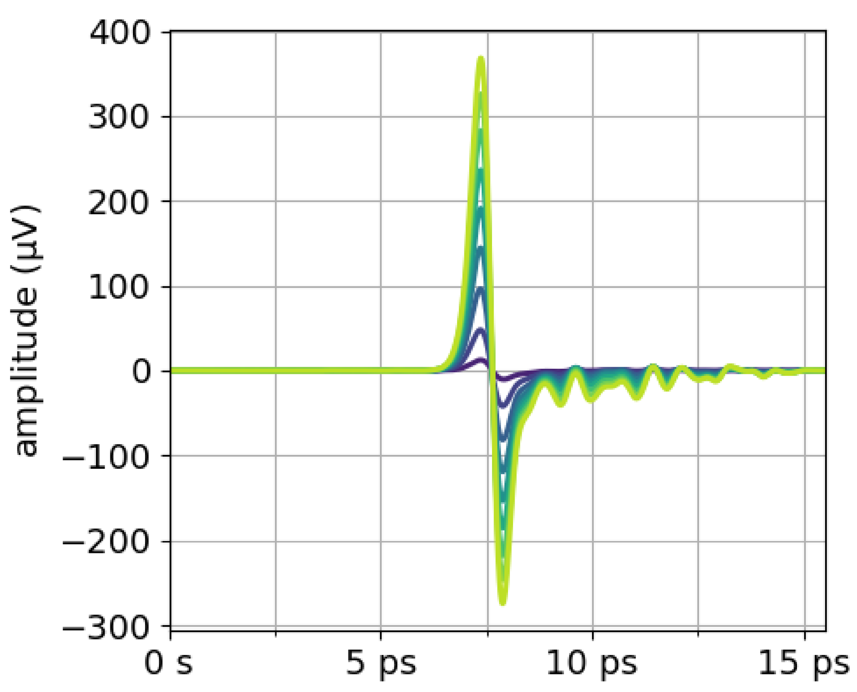
Setup

- We utilized a large area photoconductive emitter (LAE) based on semi-insulating GaAs with an active area of $1 \times 1\ cm^2$
- To achieve absorption in GaAs, the laser pulse was frequency doubled using a 2 mm thick LBO crystal
- For THz trace detection, a conventional electro-optic sampling (EOS) setup was employed, utilizing a 3 mm thick gallium phosphide (GaP) crystal
- The bias voltage for the emitter was generated by a waveform generator, supplying a sinusoidal wave
- A fast scan delay in combination with a lock-in amplifier was used for low noise detection
- A lambda half wave plate (HWP) and a thin film polarizer (TFP) were utilized to adjust the laser power, with a telescope for beam size control on the LAE



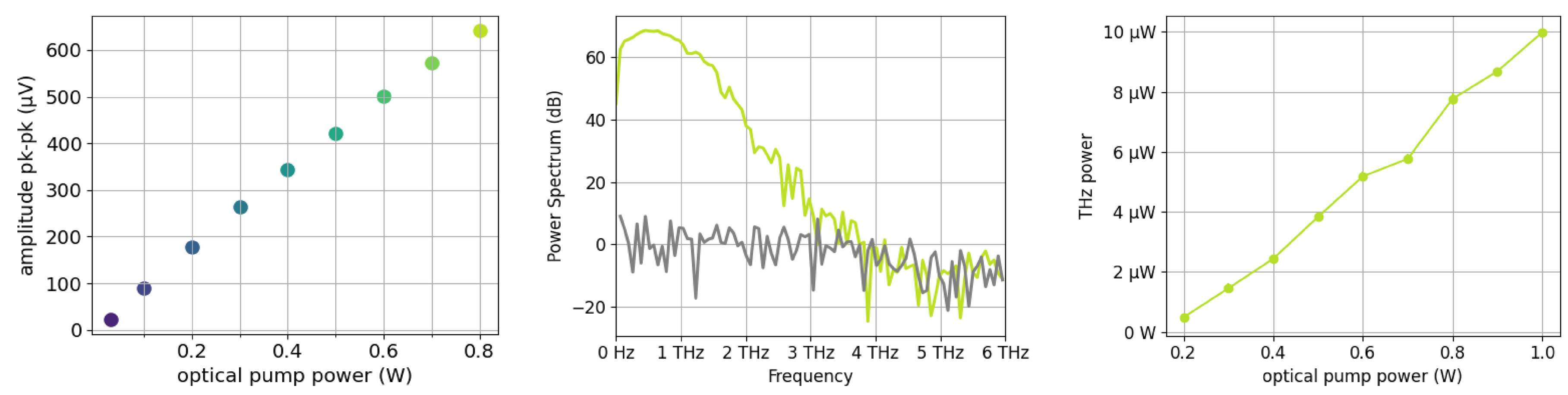
Investigation

A set of EOS traces was acquired using a beam diameter of 1.4 mm and an average power range spanning from 30 mW up to 800 mW on LAE.



- The probe is delayed periodically relative to pump (THz) by a shaker at 1 Hz frequency and 15 ps of scan range
- A bias voltage with sinusoidal wave shape and 10 V of peak-to-peak value is applied to the emitter
- Chopping of the THz signal at 20 kHz is done electronically by modulating the emitter bias voltage (10 V pk-pk) for low noise lock-in detection

Results



- Peak-to-peak value of EOS signal increases monolithically with increasing of optical power
- Power spectrum at maximum power shows 70 dB of dynamic range (DR) in frequency domain, which is achieved with 70 s of measurement time
- THz power of 10 µW, measured by a calibrated THz power meter (SLT THz20), when the LAE is excited with 1 W of 515 nm pulses and 10 V DC bias voltage

Conclusions

- Our preliminary results demonstrate exciting the LAE with 1 W from our laser system, which, to the best of our knowledge, exhibits the highest average power applied to this type of emitter without any apparent signs of thermal saturation
- Initial tests on the water-cooled LAE indicate its safe operation at an average power of up to 10 W, showing the potential to increase the THz power further
- Enhancing the sensitivity of detection and achieving higher dynamic range (DR) can be accomplished by increasing the averaged number of traces through adjustments in scan delay frequency or exploring alternative photoconductive detectors