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THz Near-field Nanoscopy at 25 Nanometer Spatial Resolution

Terahertz (THz) imaging and spectroscopy has emerged as a powerful tool for analysis of biological specimens or for studying and controlling low-energy excitations in solid-state systems [1]. One major limitation of THz spectroscopy is, however, the spatial resolution that is limited by diffraction to about 100-1000µm, making it impossible to extract intrinsic, local material characteristics of nanoscale Graphene or other 2D-material structures or devices.
Scattering-type scanning near-field optical microscopy (s-SNOM) bypasses the diffraction limit, enabling optical measurements with extreme subwavelength spatial resolution of below 20nm [2]. THz time-domain s-SNOM spectroscopy of a semiconductor SRAM sample enables quantitative analysis of free carrier concentration and scattering rates of nanoscale device structures at unprecedented surface sensitivity (Fig. below). Similarly, THz s-SNOM measurements at single frequencies enabled highlighting highly conductive nanostructures in transistor devices [3]. Using a similar experimental concept to generate a local photo-current by THz radiation allows for studying nanoscale conductivity in a biased Graphene device [4] or to characterize carrier scattering in a graphene sheet that has been encapsulated in h-BN and placed on a split metallic film [5].
Extending the already established concepts of mid-IR s-SNOM imaging and spectroscopy of 2D materials [6] to the THz frequency range a plethora of fundamental and applied new insights into Graphene and other 2D device structures can be expected from THz near-field nanoscopy measurements.

References

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Figure

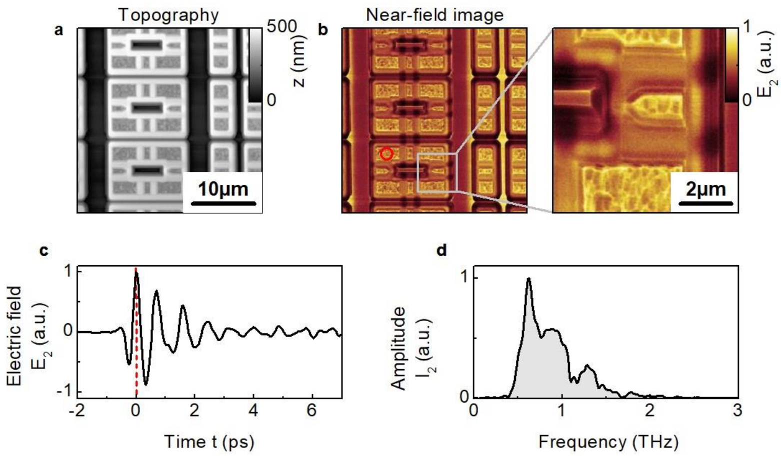

Figure 1: a Topography image of the SRAM. **b** Spectrally integrated near-field image measured at THz-TDS delay-time t=0ps (see red-dashed line in c) featuring a spatial resolution <20nm. Variations in the scattered electric field intensity indicate changes in the local carrier density of the different doping regions. **c** THz-TDS waveform measured on the n+ -doped region (see red cross in b) with <20nm spatial resolution. **d** Near-field spectrum of the waveform shown in c.