# Plasmonic superlens based on doped GaAs

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Infrared and THz free-electron lasers are interesting sources for near-field investigations as they are tunable in a range where suitable tabletop sources exist only at particular frequencies. The free-electron laser FELBE at Dresden covers the frequency range from 1.3–75 THz with narrowband (~ 1 % spectral width) radiation. We show for the low-frequency region of FELBE (1.3–8.5 THz) that scattering near-field microspectroscopy can be performed with a constant spatial resolution of 50 nm, as limited by the diameter of the scattering tip. For the lowest frequency (1.3 THz), this corresponds to l/4600 [1]. I will discuss a 3-layer superlens based on doped GaAs that is sandwiched by two intrinsic GaAs layers [2]. Superlensing is expected whenever the condition $\mathrm{Re}(\varepsilon_{GaAs}^{doped}) = -\mathrm{Re}(\varepsilon_{GaAs}^{intrinsic})$ is met, which is the case close to the plasma resonance frequency of the doped layer. Here, the Drude response in the doped layer induces resonant enhancement of evanescent waves accompanied by a significantly improved spatial resolution at radiation wavelengths around 15 THz (see Fig. 1) [2]. The resonance frequency is adjustable by changing the doping concentration. Compared to superlenses based on phononic resonances the plasmonic superlens features a broader range of the resonant response. Such a tunable superlens consisting of a single semiconductor material is a versatile device to enhance signal and spatial resolution in near-field imaging of buried structures.

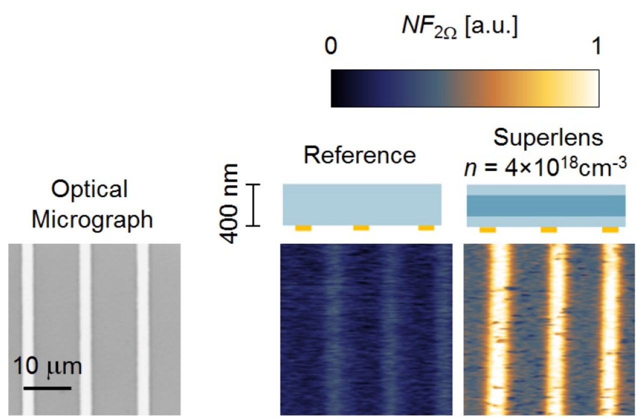


Fig. 1: Near-field image (second harmonic demodulation) of 2 $\mu$m thick gold stripes using a superlens and a reference sample (400 nm thick intrinsic GaAs). Both images were obtained at 15 THz, the resonance frequency of the superlens. On the left, an optical image of the gold stripes is depicted.

## References

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[2] M. Fehrenbacher, S. Winnerl, H. Schneider, J. Döring, S. C. Kehr, L. M. Eng, Y. Huo, O. G. Schmidt, K. Yao, Y. Liu, and M. Helm, Nano Lett. **15**, 1057 (2015).