Terahertz nanoscopy: a non-destructive dielectric characterization tool for nanomaterials and nanostructures

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Terahertz (THz) radiation usually refers to electromagnetic waves around 0.1 to 10 THz, residing between the millimetre and the mid-infrared regions. Temporally, THz waves oscillate in the order of picoseconds and thus match various elementary excitations and low-energy modes of materials. Typically, conventional THz material characterization is restricted by the diffraction limit (λ/2) and the resolvable spatial features are limited to around hundreds of micrometers. Such a scale is far larger than the elementary unit of material structures. The low spatial resolution of THz responses hampers the understanding of mechanisms governing phenomena at nanoscale and the observation of interactions occurring at the spatial dimension far below the probing wavelengths [1]. Here, we demonstrate the utility of employing THz scattering-type scanning near-field optical microscopy (s-SNOM) to quantitatively investigate the near-field properties of nanostructures, including inorganic semiconductors and dielectrics, contemporary devices, and biological structures [2-4].

[1] X. Chen, D. Hu, R. Mescall, G. You, DN. Basov, Q. Dai, M. Liu, *Adv. Mater.*, **31**, 1804774 (2019).

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[3] X. Guo, X. He, Z. Degnan, BC. Donose, K. Bertling, A. Fedorov, AD. Rakić, P. Jacobson, *Appl. Phys. Lett.*, **119**, 091101 (2021).

[4] A. Solemanifar, X. Guo, BC. Donose, K. Bertling, B. Laycock, AD. Rakić, *Nanotechnology*, **33**, 065503 (2022).

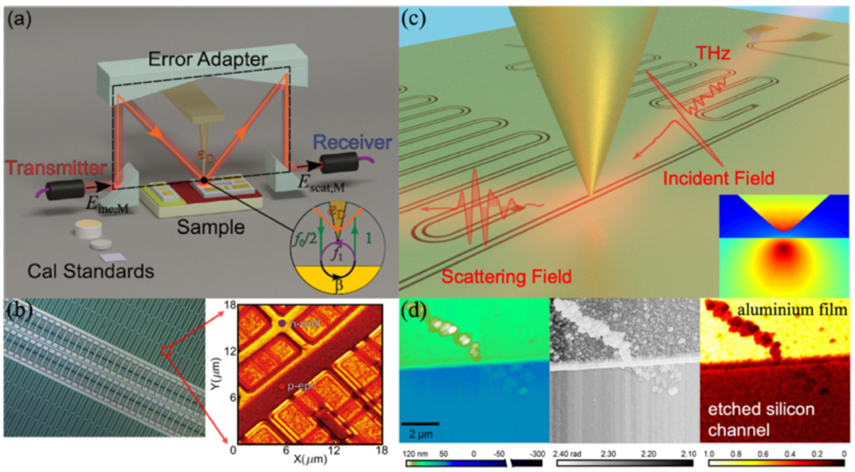

Figure 1: (a) a schematic illustration of s-SNOM with THz time-domain spectroscopy, (b) a silicon static random access memory sample and its spatially varying THz near-field responses, (c) a schematic illustration of the near-field probing of a coplanar microwave resonator chip, and (d) the corresponding near-field responses from THz s-SNOM.