# MIR and THz Spectroscopy with 10 nm spatial resolution

Philip Schaefer*, Artem Danilov, Andreas Huber
*neaspec GmbH, Munich, Germany*
**Corresponding author: philip.schaefer@neaspec.com*

Scattering-type scanning near-field optical microscopy (s-SNOM) is a method that circumvents the diffraction limit of light by creating an optical nano-focus at the apex of a metallic AFM tip, confining the light–matter interaction to the tip-sized optical near-field [1]. This principle works for light from the visible and IR up to the THz spectral range. An asymmetric interferometric detection scheme allows background-free monochromatic optical mapping of amplitude and phase (reflection and absorption) [2] as well as nano-FTIR spectroscopy using a broadband MIR laser source [3], both at 10 nm spatial resolution. THz amplitude and phase spectra are acquired through a coupled THz-time-domain spectrometer.

In this talk, we will show how this AFM-based method can be used for correlative nanoscopy combining optical imaging and spectroscopy with standard scanning probe modes to extensively characterize matter. The broadband optics make it possible to perform optical correlation at the MIR and the THz spectral range and the AFM platform enables the correlation with mechanical data channels, such as AFM topography, as well as electronic AFM modes, such as Kelvin probe force microscopy (KPFM). An example of such correlation can be seen in Fig 1. The left image shows the SRAM structure in topography. High doping concentrations ($10^{18} – 10^{20}$ cm$^{-3}$) are highlighted through the IR image and low concentrations ($10^{15} – 10^{17}$ cm$^{-3}$) are highlighted through the THz image. Applying the Drude model, charge carrier concentrations and charge mobilities can be determined respectively. Additionally, the Kelvin probe force image (KPFM) maps the surface work function correlatively. With the unique ability to quantify the charge carrier concentration in a contact-free manner from s-SNOM images [4] these correlative measurements can be used for a comprehensive characterization of the surface and nanostructure electronic properties.

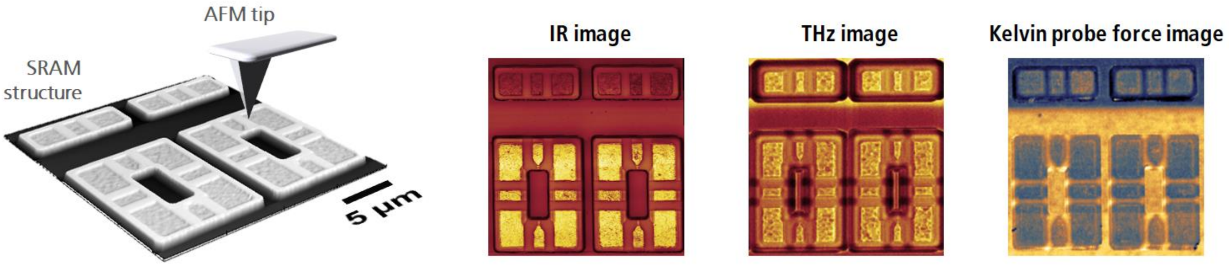

*Fig. 1: AFM topography, IR reflection, THz reflection and KPFM nanoscale images of an SRAM structure*

**References:**
[1] F. Keilmann, R. Hillenbrand, *Phil. Trans. R. Soc. A* 362, 787 (2004).
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[3] I. Amenabar *et al.*, *Nat. Commun.* 8, 14402 (2017)
[4] C. Liewald, *et al.*, *Optica* 5, 159 (2018)