Infrared Resonant Antenna Tips for Enhanced Near-Field Mapping of Molecular Absorption

Florian Huth[1,2], Andrey Chuvilin[1,3], Martin Schnell[1], Iban Amenabar[1], Roman Krutokhvostov[1],
***Stefan Mastel**[1] and Rainer Hillenbrand[1,3]*

[1] *CIC nanoGUNE Consolider, 20018 Donostia-San Sebastian, Spain*
[2] *Neaspec GmbH, 82152 Martinsried, Germany*
[3] *IKERBASQUE, Basque Foundation for Science, 48011 Bilbao, Spain*
s.mastel@nanogune.eu

We report the development of infrared-resonant antenna probes for tip-enhanced optical microscopy [1]. We employ focused-ion-beam (FIB) machining to fabricate high aspect ratio gold cones, which replace the standard tip of a commercial Si based AFM cantilever (Fig. 1a). Calculations show large field enhancements at the tip apex due to geometrical antenna resonances in the cones, which can be precisely tuned throughout a broad spectral range from visible to THz frequencies by adjusting the cone length. Spectroscopic analysis of these probes by FTIR and nano-FTIR [2] corroborates their functionality as resonant antennas and verifies the broad tunability (Fig. 1b). By employing the novel probes in a scattering-type near-field microscope and imaging a single tobacco mosaic virus (TMV), we experimentally demonstrate high performance mid-infrared nano-imaging of molecular absorption (Fig. 1c). Our probes offer excellent perspectives for unprecedented optical nano-imaging and nano-spectroscopy, pushing the detection and resolution limits in many applications, including nanoscale infrared mapping of organic, molecular, and biological materials, nano-composites, or nano-devices [3-4]. Furthermore, due to their well-defined geometry the antenna probes will significantly ease the qualitative description of the tip-sample near-field interaction, which will be essential for quantitative measurements of the local sample properties such as dielectric function and molecular absorption.

References

[1] F. Huth et al., *Nano Lett.* **13**, 1065 (2013)
[2] F. Huth et al., *Nature Materials* **10**, 352 (2011)
[3] J. Stiegler et al., *Nature Comm.* **3**, 1131 (2012)
[4] A. Huber et al., *Nature Nanotech.* **4**, 153 (2009)

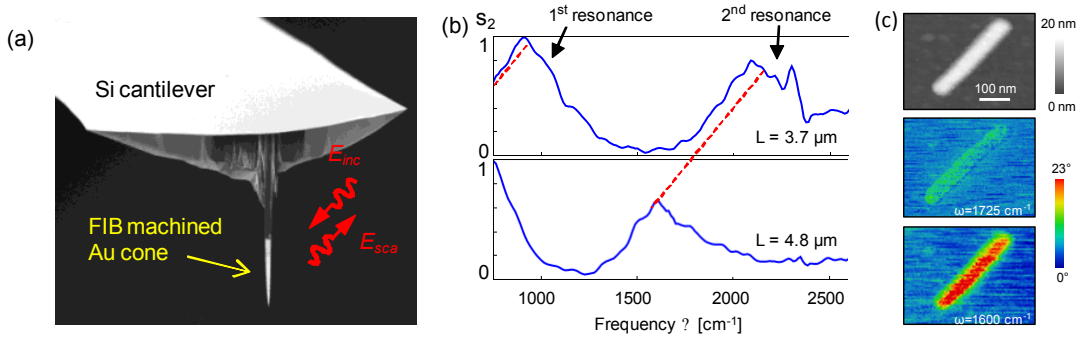

Fig. 1: (a) SEM image of an IR-resonant antenna probe, where a high-aspect ratio Au cone is attached to a Si cantilever. (b) nano-FTIR spectra of antenna probes of different lengths L, showing the 1st and 2nd antenna resonance. (c) Topography and infrared near-field phase images of a TMV virus.