Supporting Information for

Mapping Magnetic Near-Field Distributions of

Plasmonic Nanoantennas

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Experimental setup.

A description of the scanning near-field optical microscope (SNOM),¹ the hollow-pyramid probe and the sample geometry are presented in this section and illustrated in Figure S1 a, b and c, respectively. A supercontinuum white light (SCWL) laser (NKT Photonics, Koheras SuperK Extreme Standard) with spectral range 400 nm - 2000 nm is used as the light source. It delivers up to 5 W of power at 80 MHz repetition rate. From the broad spectrum, single wavelengths with

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a linewidth of ~ 5 nm to ~ 20 nm and power of a few mW, depending on the wavelength, are selected with an acousto-optic tunable filter (AOTF) (NKT Photonics, SpectraK Dual). Simultaneous selection of up to eight different wavelengths is possible. Since the system is fully fiber coupled, minimal alignment adjustments are required when changing between different AOTF filters and detectors for measurements in different spectral regions. The selected illumination is coupled into the microscope, where it passes through a polarizer and is then focused on the apex of the SNOM probe by a 20x objective with numerical aperture $NA = 0.4$. The probe consists of a hollow SiO_2 pyramid, covered with an Al layer with thickness of about 100 nm, which is etched through at the apex. This opens up an aperture with a sub-wavelength diameter of nominally 100 nm, which provides optical resolution below the diffraction limit. Scanning electron micrographs (SEM) of such a probe, showing the pyramidal shape, cantilever, and aperture, are shown in Figure S1 b. Next, the light transmitted through the sample is collected in the far-field by a 60 $\times$ achromat microscope objective ($NA = 0.8$), directed through an analyzer, and confocally picked up by the pinhole of an optical fiber. The collected light in the fiber can be coupled to different detectors. For the measurements presented in this paper, two spectrometers, equipped with a front-illuminated Si CCD camera for the visible, and an InGaAs detector array for the near-infrared spectral range, were used. While the sample is scanned, the spectrometer collects a full spectrum at each scan pixel. Near-field images are then constructed by plotting the transmitted light intensity at each pixel for a selected wavelength range only. Typically areas of 10 μm by 10 μm were measured with a 50 nm pixel size. One scan takes roughly 25 minutes and typically four to six different excitation wavelengths are measured simultaneously, although even eight is feasible. The sample can be scanned in atomic force microscopy (AFM) contact or tapping mode with an XYZ piezostage, and beam-deflection laser feedback. A dichroic mirror in this stable feedback system makes a narrow spectral window around 1000 nm experimentally not accessible.

Figure S1. (a) Schematics of the transmission SNOM setup. OF: optical fiber, L: lens, P: polarizer, O: objective, A: analyser, S&S: sample and scan stage. (b), SEM image of the cantilevered aperture probe - side view (left) and front view (right). (c) Sketch of the sample structure and SEM image of a single nanobar of length $L = 1120$ nm and width $W = 70$ nm.

Electric and magnetic field profiles at the apex of the probe.

The structure of the probe was modeled following the information provided by the manufacturer (materials used, layer thicknesses, cone angle, and aperture size). Schematics of the simulated probe together with the dimensions is shown in Figure S2 a. Surface roughness, possible layer thickness variations, and rounding of the edges were not taken into account. Finite-difference time-domain (FDTD) simulations of the probe show that an incident x-polarized plane wave induces a dipolar charge polarization at its apex (Figure S2 b), indicated with "+" and "-" signs. The corresponding current profile (Figure S2 c), shows that the current flows in two curved halves of a circle, following the red arrows. As a result, the H_y field is adding up just beneath the probe as is evident from the field profiles shown in Figure S2 d. The H_x and H_z fields produced by these currents are zero at a vertical plane through the middle of the probe, along the direction of incident light polarization. The electric and the magnetic field plots have a common color scale. The profiles are obtained at $\lambda = 1\mu\text{m}$ and remain almost unchanged throughout the experimental spectral range. For the field profiles, the x-z cross-sections are taken through the probe center and the x-y cross-sections 30 nm below the aperture. For the charge and current profiles, the x-y cross section is taken 30 nm above the aperture.

Figure S2. Probe characterization. (a) Schematics of the simulated probe - side view (top) and bottom view (bottom). (b) Charge distribution inside the probe 30 nm above the aperture shows dipolar charge separation. (c) Current distribution inside the probe 30 nm above the probe aperture shows that the currents flow in two curved halves of a circle. (d) Electric (left) and magnetic (right) field distributions at the probe aperture for an x-polarized incident plane wave at $\lambda = 1 \mu\text{m}$. x-z cross-sections taken through the probe center, x-y cross-sections 30 nm below the aperture. Dashed white lines indicate probe's boundaries.

References

1. WITec Wissenschaftliche Instrumente und Technologie GmbH, <http://www.WITec.de>.