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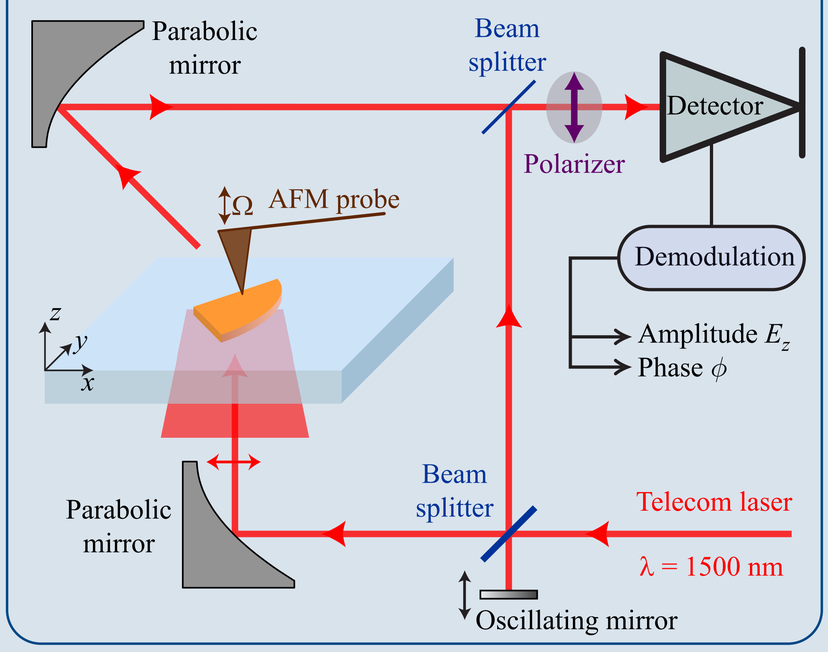
Nanofocusing in circular sector-like nanoantennas

1. Introduction

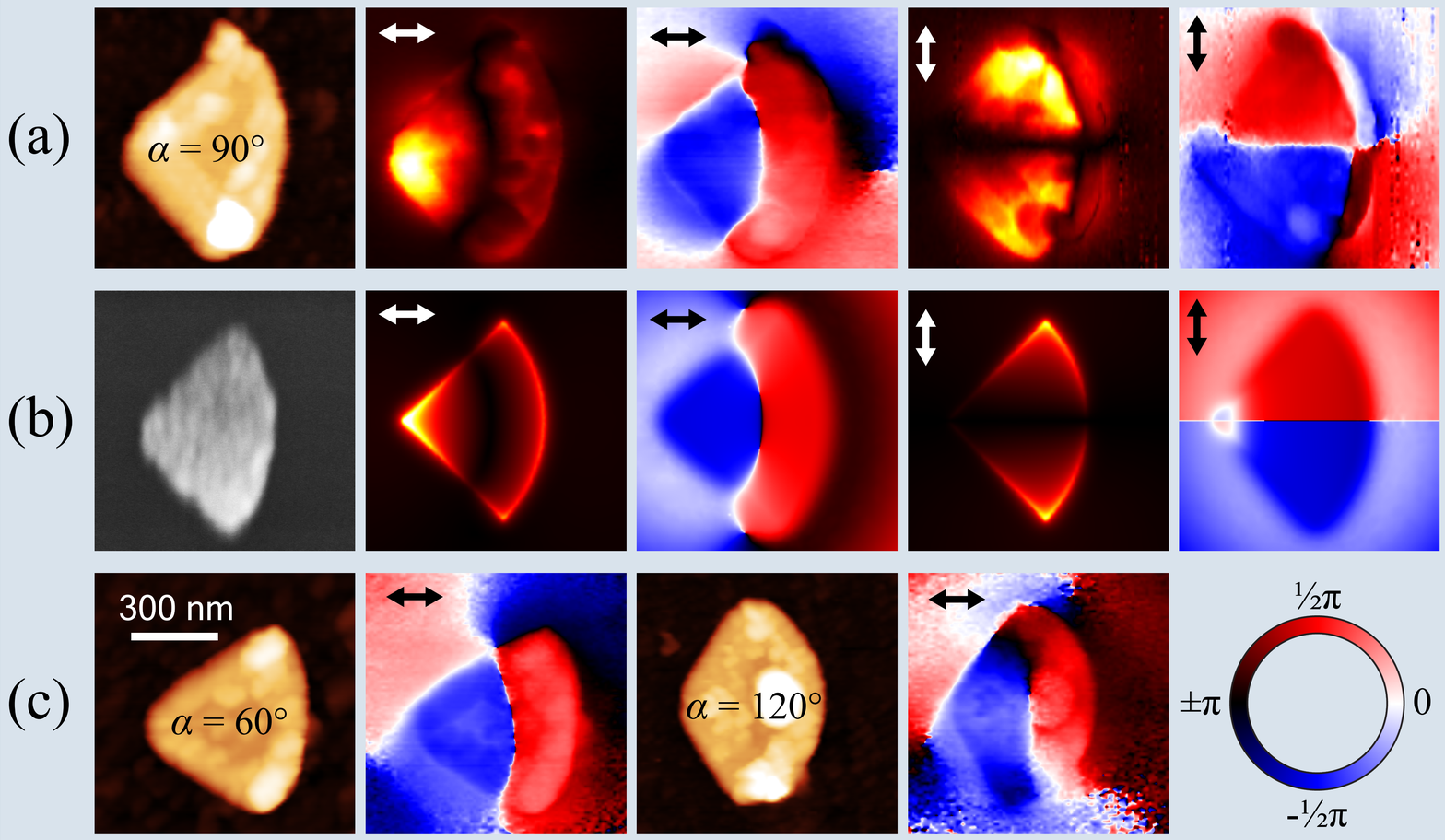
Gold circular sector-like nanoantennas (with a radius of 500 nm and a taper angle of 60°, 90°, and 120°) on glass are investigated in a near-infrared wavelength range (900 - 2100 nm). Amplitude- and phase- resolved near-field images of circular sector-like antenna modes at telecom wavelength feature a concentric circular line of phase contrast, demonstrating resonant excitation of a standing wave of counter-propagating surface plasmons, travelling between a tip and opposite circular edge of the antenna. Transmission spectra obtained in the range 900 - 2100 nm are in good agreement with numerical simulations, revealing the main feature of this antenna configuration, viz., the resonance wavelength does not depend on the taper angle and is determined only by the sector radius. Simulations indicate a 1.8 times larger field enhancement at the antenna tip compared with the widely used triangular nanoantenna. This feature together with a better defined frequency response makes circular sector-like nanoantennas very promising for implementing bow-tie antennas and attractive for many applications.

2. Measurement setup

Phase- and amplitude-resolved near-field investigation of nanoantennas was done using a scattering-type scanning near-field optical microscope (s-SNOM), based on an atomic force microscope, that uses cantilevered tips as near-field probes. The sample was scanned in a tapping mode, with the tip oscillating at the mechanical resonance frequency $\Omega \approx 250$ kHz with an amplitude ~ 50 nm. The structures were illuminated from the bottom with focused light at λ = 1500 nm. The light, scattered by the tip, was collected by a parabolic mirror and directed towards the detector, where it was overlapped with an interfering reference beam, yielding both the amplitude and the phase of the scattered light using pseudoheterodyne detection

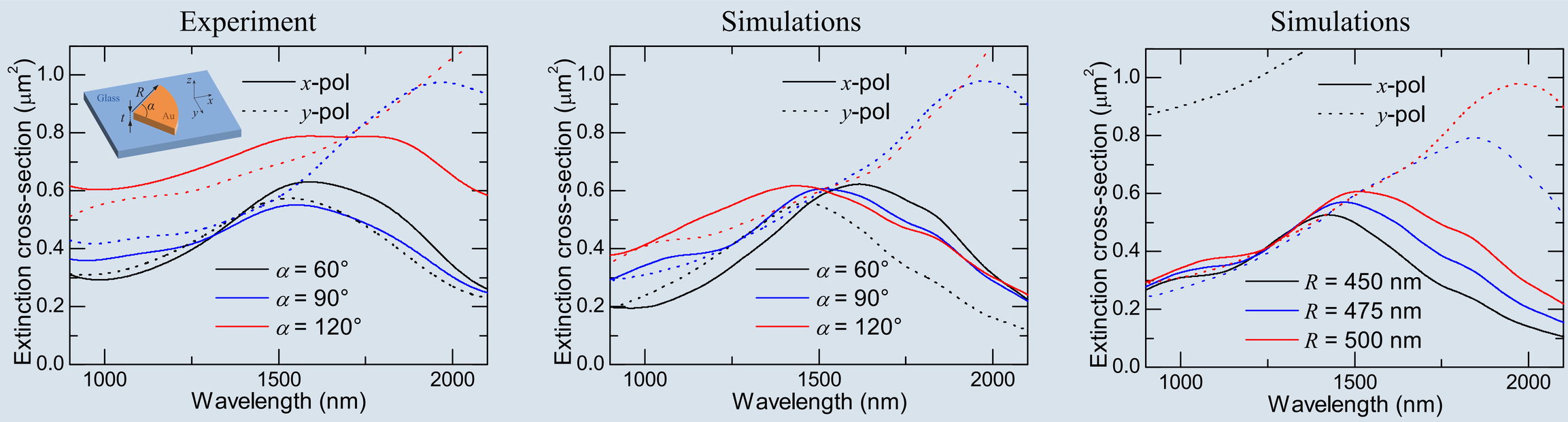


3. Near-field investigations



(a) Pseudocolor s-SNOM images for the circular sector-like antenna with R = 500 nm and α = 90° at λ = 1500 nm, showing (from left to right) topography, optical amplitude and phase for x- and y-polarized incident light. (b) Scanning electron microscope (SEM) image of the same structure as in (a), and numerically calculated distributions of E_z amplitude and phase for x- and y-polarized incident light for the same structure. (c) Pseudocolor s-SNOM images of topography and optical phase for the antennas with R = 500 nm and α = 60° and 120° at λ = 1500 nm. Right bottom: periodic color bar for the phase images. All images have a lateral size of 900 × 900 nm^2, and the polarization is shown with arrows.

4. Extinction cross section



Results: almost no change in the extinction cross section and resonance wavelength with a change of the taper angle from α = 60° to α = 120° for x-polarization – compared to a substantial variations for y-polarization.

5. References

[1] D.K. Gramotnev, A. Pors, M. Willatzen, and S.I. Bozhevolnyi, "Gap-plasmon nanoantennas and bowtie resonators," Phys. Rev. B **85**, 045434 (2012).
[2] V.A. Zenin, A. Pors, Z. Han, R.L. Eriksen, V.S. Volkov, and S.I. Bozhevolnyi, submitted to Optics Express (2014).

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