Dual-SNOM investigations of multimode interference in plasmonic strip waveguides

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Supporting information

Description of the movie: As the movie plays, the excitation tip (whose position is indicated by an orange triangle in panel (g)) moves from the left edge of the waveguide to the right edge. Panel (a) shows the trigonometric profiles of the three waveguide modes ($u_i(x)$, formulas (1)-(2)) and, in orange color, the excitation Gaussian (tip) profile ($g(x)$, formula (4)). In (b), the

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absolute values of the excitation coefficients c_i are shown (formula (3)). Panels (c)-(e) show the contributions of the individual modes ($|c_i(x_{\mathrm{exc}})\,u_i(x)\exp{(\mathrm{i}\,n_{\mathrm{eff},i}\,k_0\,y)}|$) to the interference pattern at two positions: at the excitation tip's location ($y=0$, continuous lines) and at the detection tip's location ($y=6.5\,\mu\mathrm{m}$, dashed lines). Panel (f) shows the absolute values of the total field at the same locations, i.e., at $y=0$ (continuous line) and at $y=6.5\,\mu\mathrm{m}$ (dashed lines). Panel (g) shows the beating pattern (intensity) along the waveguide (formula (5)). The white dashed line marks the position $y=6.5\,\mu\mathrm{m}$, where the field profiles, shown as dashed lines in (c)-(f), were detected. By combining the total field profiles at the detection location (dashed curves in panel (g)), the image in (h) is obtained, which corresponds to Fig. 6(b) of the paper.

Table 1: The effective indices and propagation lengths of the waveguide modes as calculated by Comsol.

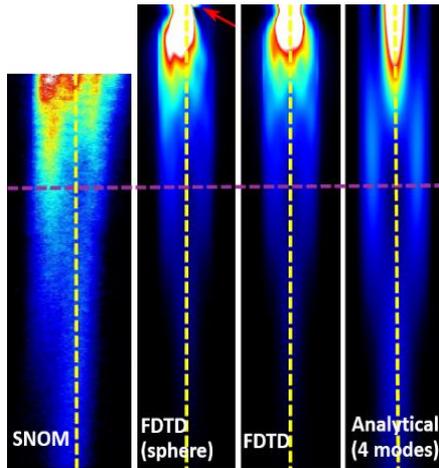| mode	n_{eff}	propagation length
t1	1.031+0.0073i	14.4 μm
t2	1.015+0.013i	8.4 μm
t3	0.982+0.017i	6.2 μm
t4	0.956+0.030i	3.4 μm
b1	1.586+0.0139i	7.6 μm
b2	1.565+0.0146i	7.2 μm
b3	1.532+0.0152i	6.9 μm
b4	1.486+0.0156i	6.8 μm
b5	1.427+0.0150i	7.0 μm
b6	1.357+0.0231i	4.6 μm
b7	1.268+0.0312i	3.4 μm
b8	1.159+0.0434i	2.4 μm
b9	1.036+0.0622i	1.7 μm

Comparison of intensity distributions

Figure S1: The images obtained by SNOM measurements, FDTD calculations with gold sphere, without gold sphere, and analytical calculation for four modes on exactly the same spatial domain. The magenta dashed line across the waveguides is plotted at a distance of 6.5μm away from the excitation location. The results presented in Figs. 5 and 6 in the manuscript are extracted at this distance. The yellow lines coincide with the waveguides' symmetry axis. The width of the waveguides is 2.5 μm. These dashed lines indicate the lines along which the intensity profiles are compared and presented in Fig. S2.
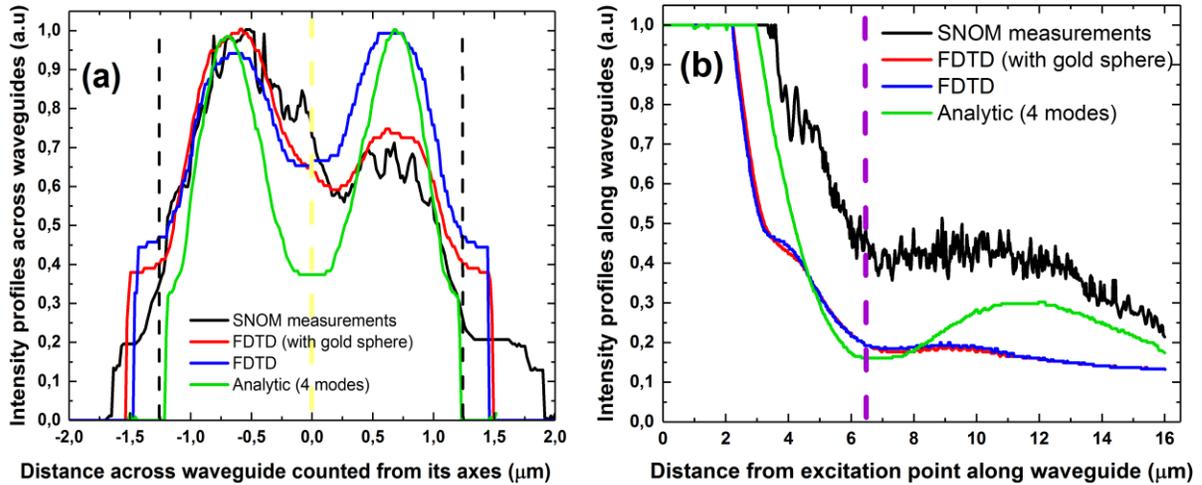

Figure S2. Comparison of the intensity profiles **(a)** across and **(b)** along the waveguides.

(a) Intensity profiles across the waveguides, i.e. along the dashed magenta lines in Fig. S1. The dashed black lines at +/- 1.25 μm positions indicate the edges of the waveguides with a width of 2.5 μm. As can be seen, the lateral positions of the intensity maxima across the waveguide match pretty well and the intensities drop at the edges of waveguides is clearly seen. By comparing red and blue curves, one can clearly notice the influence of the gold sphere: the right maxima value is smaller than the left one. The FDTD calculation with gold sphere close to the excitation location corresponds well with the SNOM measurements. Yellow dashed line indicated the waveguides' symmetry axis as in Fig.S1.

(b) Intensity profiles along the waveguides' symmetry axis (along the dashed yellow lines in Fig. S1). As can be seen, the intensity minima match pretty well but the maxima are slightly shifted. Magenta dashed line at a position of 6.5 μm indicates the line along which the intensity profiles across the waveguides are plotted in (a).