A guided mode view on Near-field Scanning Optical Microscopy measurements of optical magnetic fields with slit probes

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Recent Near-field Scanning Optical Microscopy (NSOM) experiments with slit metal coated probes claim to measure the out-of-plane optical magnetic field around a dielectric sample waveguide [1]. The observations can also be explained by mode overlap calculations.

Summary

Measurements [1] of electromagnetic fields around an optical waveguide, by means of Near-field Scanning Optical Microscopy (NSOM) with a metal-coated tapered fiber tip with a slit in the coating, seem to indicate that the in-plane electric and out-of-plane magnetic components of the optical field can be determined independently. We consider the structure shown in Figure 1(a) as a simplification of the configuration of [1]. The probe is assumed to be purely cylindrical; any effects related to the tapering to the much wider, non-slit probe fiber are thus not taken into account. Interest is in the polarized optical signal that is detected at the upper end of the probe, if the lower end scans through the evanescent optical field over the surface of the sample waveguide. The tip supports two guided, though lossy, modes, one with a major x-oriented electric field component that is localized in the glass core (b), and another with a dominant y-oriented electric field that is located mainly in the probe slit (c). We create a standing wave pattern in the sample waveguide by interfering counter-propagating versions of its fundamental TE (x-polarized) mode. Under the assumption that the probe does not significantly perturb the sample field, the optical signals associated with the two modes propagating upward in the probe are given by inner products with the sample field at the end facet of the tip, 20 nm above the surface. These overlap integrals involve only the x and y components of the fields. Figures 1(d) and (e) show that, just as in the experiments [1], the maxima of the power picked up by the two probe modes are shifted by half a period.

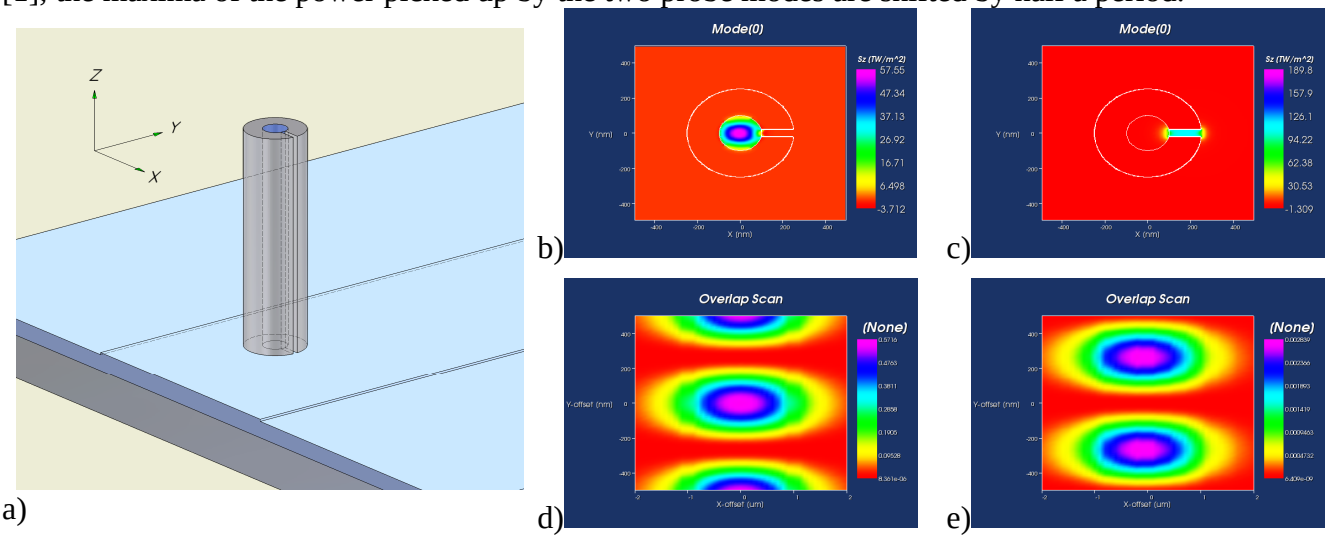

Figure 1:, a): Coated probe (150 nm Al on a 100 nm radius glass core, with a 40 nm slit) above a silicon nitride waveguide [1]. b),c): Intensities of the two modes supported by the slit probe. d), e): Signal power associated with the x- and y-polarized probe modes vs the position (x,y) of the tip.

[1] M. Burresi et al., *Science* **326**, 550-553 (2009)