Polarization-Resolved Near-Field Mapping of Nanoscale (λ_0/310) IR Transmission Line Modes

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Abstract

Metal antennas and transmission lines (TL) are common devices for receiving and transporting signals in the radiofrequency regime. It has been demonstrated that by reducing the size down to the micrometer range, these devices can be operated at infrared frequencies (~30 THz) [1-3].

Here we demonstrate that functional infrared TLs with gap widths down to 25 nm can be fabricated by Gallium Focused Ion Beam (FIB) milling of gold films on CaF2 substrates [1]. Interferometric and polarization-resolved near-field microscopy [4] is applied to map in real space the propagation of the TL modes. For the first time, we measured the strongly confined fields of a propagating TL mode by mapping the s-polarized scattered field. Imaging TLs with 25 nm gap width we experimentally demonstrate an infrared mode with diameter of D_m = 42 nm (λ_0/220), which intriguingly, shows a propagation length of about L_m = 8 µm. Interestingly, this is more than two orders of magnitude larger than the mode diameter, L_m/D_m = 190.

Applying combined Gallium and Helium FIB milling, we fabricated infrared TLs with single-digit nanoscale gap widths. Imaging a TL with 5 nm gap width we experimentally demonstrate an infrared mode with a diameter of only D_m = 30 nm (λ_0/310) and a propagation length of about L_m = 2 µm (Fig. 1). Numerical calculations predict significant propagation distances (> 1µm) for even smaller gaps down to 1 nm width. TLs comprising such nanoscale wire-separation could become highly valuable building blocks for ultra-sensitive mid-infrared sensing, spectroscopy and nanoimaging applications.

References

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[3] P. Sarriugarte et al., *Opt. Comm.* **285**, 3378-3382 (2012).
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Figures

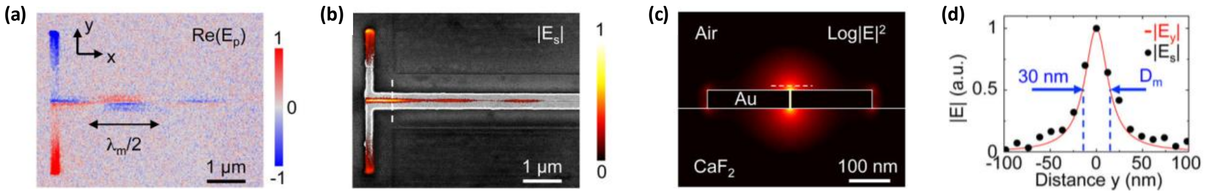

Fig. 1: Near-field imaging of a transmission line (TL) with a 5 nm gap. **(a)** Experimental near-field image showing the real part, Re(E_p). **(b)** Experimental near-field amplitude image |E_s| superposed on the SEM image (grey color). **(c)** Numerically calculated mode profile. **(d)** Near-field amplitude |E_s| perpendicular to the TL extracted along the dashed lines in (b,c) (dots: experimental data, line: calculation), revealing an infrared mode diameter of only 30 nm. Imaging wavelength was λ_0 = 9.3 µm.