Hyperspectral NanoPhoto Luminescence Spectroscopy on Indium Phosphite Nanowires by Means of "Campanile" Tips

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The concept of optical antennae to focus light well below the diffraction limit, while enhancing the optical near field several orders of magnitude has only been feasible due to the advancements in nano fabrication over the past few years. A lot of work has been done on various nano fabrication approaches of optical antennae and the determination of their resonance behavior, leading to novel mode-coupling schemes, antenna-coupled plasmonic waveguides, and resonators that separate near fields energetically as well as spatially on length scales well below the diffraction limit.

Though many possible optical antenna designs exist, by far the most promising for near-field imaging purposes are plasmonically-coupled structures. We developed a novel geometry which are bell tower like "campanile" tips at the end of an optical fiber that works like an optical transformer (Figure 1A). The important advancement of this structure is the capability of exciting and collecting through the optical fiber with high efficiency, precluding the need for a transparent substrate in addition to having a resonance ranging from the visible into the near IR.

Through focused ion beam (FIB) milling, a "campanile" tip is fabricated at the end of a previously etched glass optical fiber. The optical fibers are tapered using a HF etching and coated with a 100nm gold layer to ease the following milling process which defines the shape of the campanile tip. Then a gold layer is deposited on two opposite sides of the campanile structure via shadow evaporation and a 15nm gap at the tip apex is opened by means of high resolution FIB milling. The final step is to fill the gap with a thin film dielectric deposition via an atomic layer deposition (ALD) system. Due to the intrinsic properties of metal-insulator-metal waveguides, the optical focus size is determined by the dimensions of the gap, making it possible to achieve sub-10-nm spatial resolution optically.

We demonstrated the functionality of these tips by mapping the photoluminescence of the Indium Phosphite nano wires with nanometric resolution (Figure 1B-F). The luminescence signal for the InP wires was very bright such that each spectra was integrated for just 10ms with a 633 nm laser power of 100uW.

Using these campanile tips we are coming close to the holy grail of near field optics, where we excite through an optical fiber reproducibly an optical antenna, which creates a highly enhanced, spatially super-confined near field spot over a large spectral range, while enabling to collect the signal through the reversed pathway

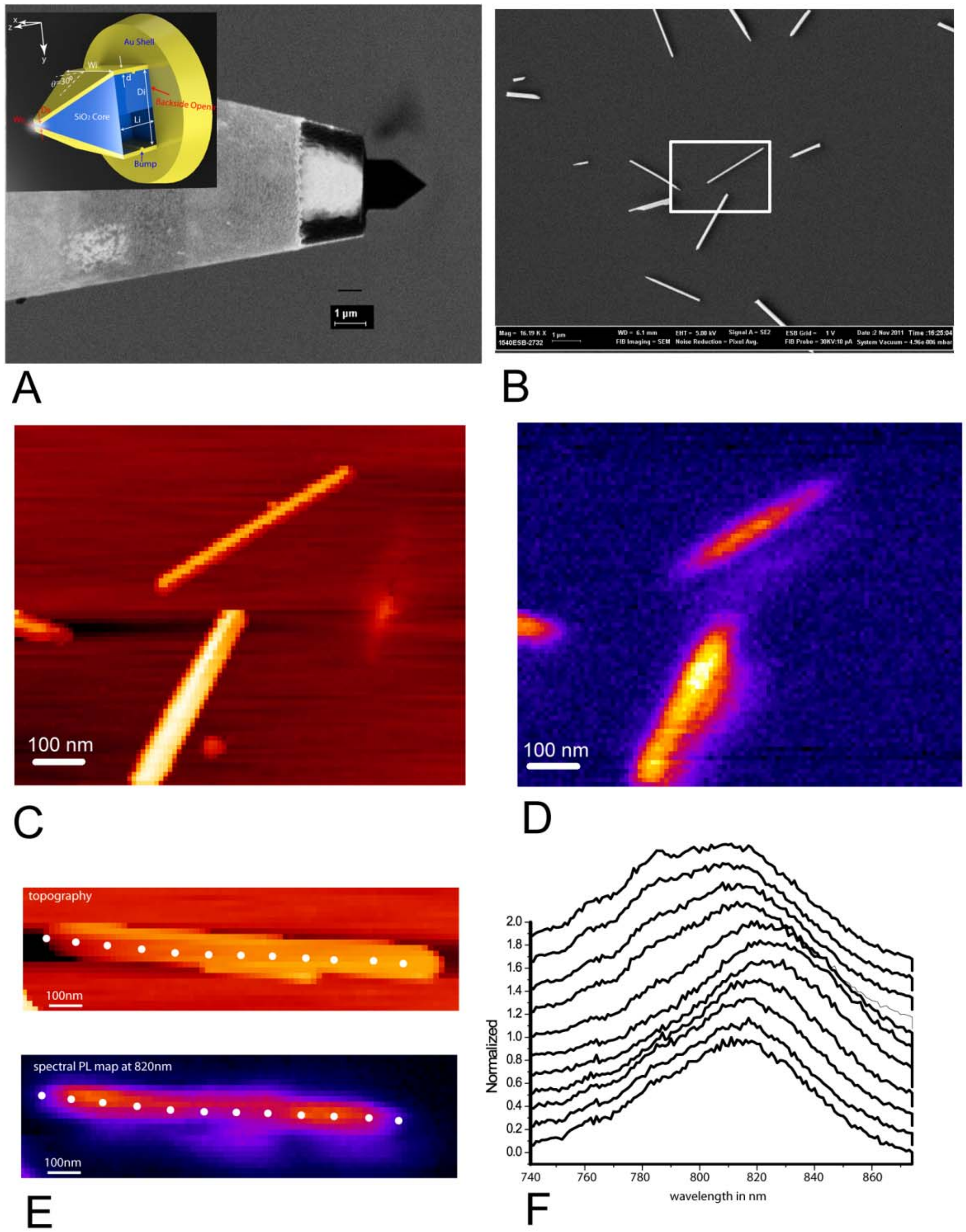

Figure1. A) The optical transformer optimized for an optical fiber resembles strongly a church tower hence campanile tip. B) SEM image of the InP sample. C) Topological map. D) Photoluminescence map. The spectral peak varied from wire to wire, however, a correlation between length/diameter and spectral peak was not found. E) The spectrum varied along almost all InP nano wires. F) Water fall of spectra shown above, which are the spectra taken along the indicated positions, a strong position dependent variation can be observed. Not only does the peak shift but various modes contribute to each spectrum which gains in intensity dependent on the position.