Efficient Light Confinement in optical fibre tapers using plasmonics

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Light confinement is limited by diffraction and the ultimate spot size is related to the light wavelength λ and to the refractive index n of the medium where light is being focused. Because of its evanescent wave nature, plasmonics gain a fundamental role in sub-wavelength confinement. In fact plasmons are relatively unaffected by diffraction, can propagate for moderately long distances and can be confined well below the so-called "diffraction limit".

In this work nanostructured optical fibre tapers are used to excite plasmons and *efficiently* confine light to sub-wavelength dimensions. Tapers seem particularly attractive because they confine adiabatically light to the diffraction limit and provide an extremely regular field distribution within a relatively small area.

Figure 1a shows a schematic of a taper device. The taper tip is cut at an angle α suitable to excite plasmons. For the fundamental mode (HE_{11}) in a taper with diameter d~1.5μm, α changes by less than 1^o within the wavelength range 700-950 nm, thus a focused ion beam (FIB) system has been used to cleave the tip with better accuracy than 0.1^o. The sample is then covered with ~50 nm of Au and an aperture is made.

SEM images of the fabricated tips are shown in Figs.1b-d. The gold surface smoothness is fundamental for the plasmon propagation and a very slow deposition rate has been used to ensure a uniform and even gold coating at the cleaved tip end.

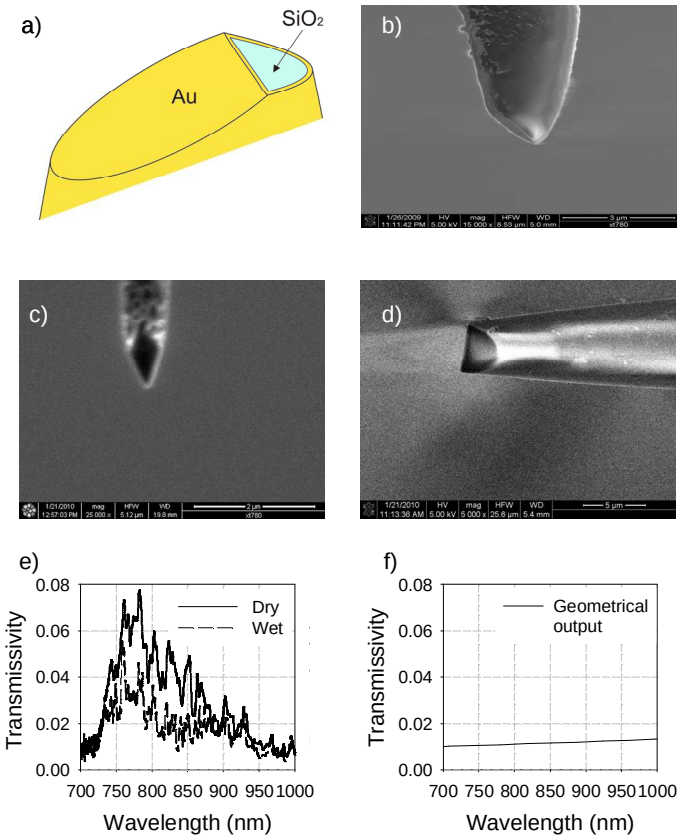

Fig. 1 Schematic (a) and SEM pictures (b-d) of sub-wavelength light sources. (e) Transmissivity spectra of sample b in dry and humid environments and (f) expected output because of geometrical constrains.

Transmissivity (*T*) was measured in the 650-1750nm range with a supercontinuum source and an OSA. Normalised spectra are shown in Fig. 1e. At λ=780nm in a dry environment *T*~7%, nearly one order of magnitude higher than that outside the peak (λ~700nm and λ~950nm).

Fig. 1f shows the result of simulations evaluating the transmission without the Plasmon contribution: at λ=780nm *T*~1%, nearly one order of magnitude smaller than the measured value of *T*~7%. This enhancement has been ascribed to plasmons.