Optical nanofibers with gold nano-aperture antenna for sensing

Yun Wang[1*], *Michalis N. Zervas*[1], *Gilberto Brambilla*[1]

[1]Optoelectronics Research Centre, university of Southampton, Southampton SO17 1BJ, UK

[*]*Email address: yw11e13@soton.ac.uk*

The plasmonic resonance of single metallic nano-aperture, which acts as an optical antenna, can improve the signal intensity as well as reduce the effective area and favour the sub-wavelength resolution for sensing, by overcoming the diffraction limit and confining the field in a nanometer-size area [1-2].

To further confine the field, based on [3], the tip-enhanced bow-tie shaped aperture (Fig.1) was designed with a flare angle of 45º to minimise electrons accumulating at the waists. The aperture was created at the end-face of a tip in a radius of 5nm to let the back reflected signal propagate in the fundamental mode, and was coated with a 60nm-thick gold layer to eliminate any backscattered light. A perfect electric conductor boundary was applied to exploit the sample geometry and thus improve the computing efficiency. Multi-pairs of additional I/O ports were applied to get rid of multi-reflection of high order modes inside the 2-μm high model. These modes excited by the scattering at the nano-structure suffer high loss, thus are negligible in the experiment. The sensitivity of the nano-aperture when used as a refractometric sensor was simulated by changing the outside refractive index and resulted to be 650nm/RIU (Fig. 2).

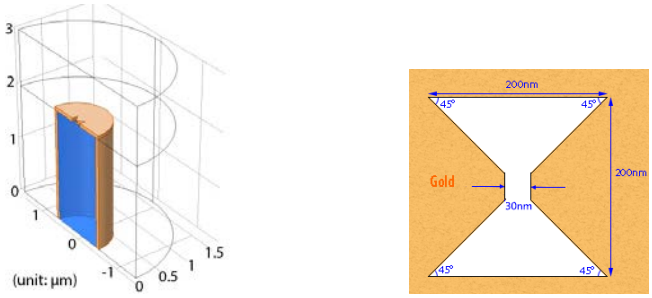

Figure 1: 3d (left) and 2D (right) schematic of the bowtie aperture in COMSOL. The orange and blue parts are the gold and silica fibre respectively, and they are surrounded by air.

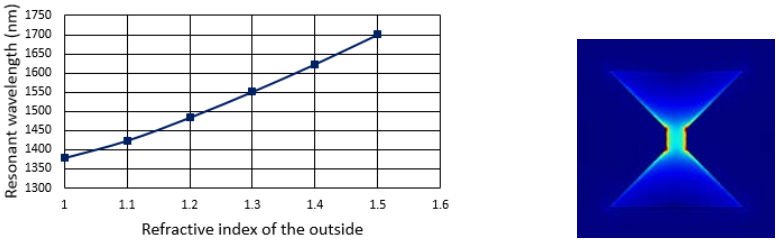

Figure 2: Resonant wavelength as a function of the outside environmental refractive index (left), suggesting a sensitivity of 650nm/RIU; the electric field distribution at the aperture at the resonant wavelength (right).

References:

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