OPTICAL FIBRE NANOWIRE SENSORS AND APPLICATIONS

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Optical fibre nanowires (OFN) have recently attracted increased attention because of their numerous applications in sensing and particle manipulation [1] and their extraordinary optical and mechanical properties, which include, amongst others:

- biocompatibility: OFNs show good compatibility with cells/ biological matter as they are made from silica.
- configurability/flexibility: OFN are manufactured stretching optical fibres, thus they mantain their original size at the exstremities (fig. 1), allowing for prompt connection to any fiberised source/detector.
- robustness: OFNs are extremely strong and have a conventional fibre pigtail at their extremity, thus can be handled with tools typical of the macroscopic world.
- large evanescent fields: a considerable fraction of the transmitted power can propagate outside the OFN physical boundary when the OFN size is small, allowing for enhanced sensing and optical manipulation.
- strong confinement: when OFNs are nanostructured and metal coated, light can be confined to 50-100 nm spot sizes, allowing for nanosensing and single nanoparticle trapping/manipulation.

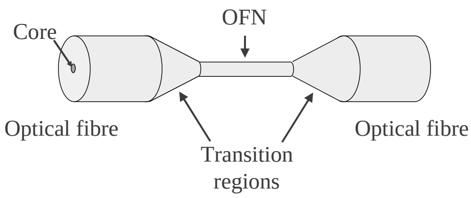

Fig.1 Schematic of an OFN.

This talk will review the applications of OFN to particle manipulation/trapping and to bio-sensing, with a special stress on efficient light confinement to small areas. Confinement to small areas has been studied in the past for applications in scanning near field optical microscopy (SNOM), but efficiencies of the order of 10^{-5}-10^{-6} are common when the aperture size is of the order of 50 nm [2]. Indeed, optical transmission optimization is the major issue, as 1) the minimum measurable analyte quantity in an optical nanosensor is related to the minimum detectable light signal and 2) the optical trapping force is proportional to the light intensity at the aperture output. OFN nanosensors have already been used to sense different analytes inside a single cell but their sensing head has been limited by the OFN light collection efficiency [3]. In fact, since the collected signal is proportional to the sensing area, a decrease of one order of magnitude in the diameter of the analyzed area implies a reduction of 2 orders of magnitude in the collected light. While normal microsensors extract a signal over an area with several microns in diameter, OFN nanosensors can have a size of few hundred nanometers, implying a considerable smaller signal. Moreover, propagation along metal coated OFN with conical shape occurs via a longitudinal evanescent wave, implying a further decrease in the collection efficiency which is related to the OFN cone slope and to the minimum size. By optimising the OFN shape, transmission efficiencies as high as 10^{-2} have been recorded for OFN tips with apertures of the order of 50 nm.

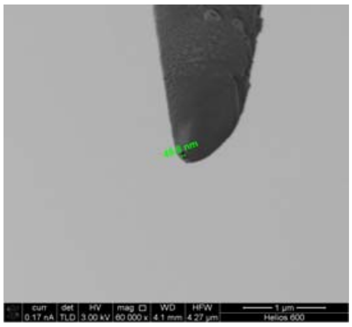

Fig.2 Nanostructured OFN tip with an aperture size of ~50

Reference

[1] G. Brambilla, “Optical fibre nanowires and microwires: a review,” J. Opt., vol. 12(4), 043001, 2010.
[2] B. Hecht, B. Sick, U. P. Wild, V. Deckert, R. Zenobi, O. J. F. Martin, and D. W. Pohl, “Scanning near-field optical microscopy with aperture probes: fundamentals and applications,” J. Chem. Phys. 112(18), 7761–7774 (2000).
[3] T. Vo-Dinh, “Nanosensing at the single cell level” Spectrochim. Acta B 63, 95-103 (2008).