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Microstructured optical fibres as micro/nano materials templates, for optoelectronic and surface enhanced Raman scattering applications

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Abstract

Optical fibres are the Internet and telephone communications backbone, interconnecting buildings, cities and nations. Optical fibre technology led directly to the data communications revolution of the late 20th century and is now impacting many other fields from remote sensing to biomedicine. Currently, telecommunications fibre systems require external solid state circuits to generate, amplify, receive, and manipulate the light. However, the process of converting the data between optical fibers and chip-based optoelectronic devices consumes enormous amounts of power, requires costly technology and reduces overall bandwidth. Therefore, it is preferable to avoid having to transform in-fibre photonic signals to chip-based electronic signals. Indeed, the ultimate vision would be a purely fibre based system.

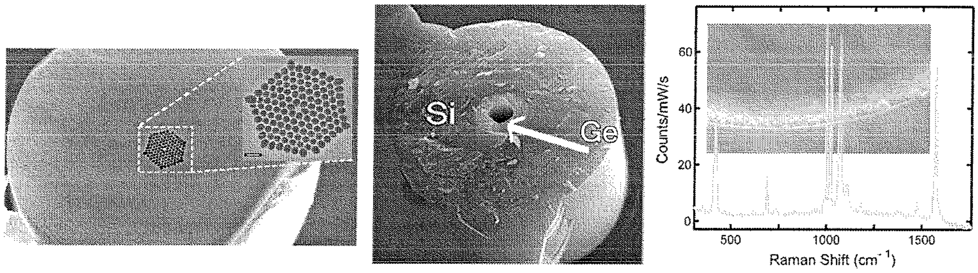

Figure 1. (Left) We have used Silica MOFs as micro/nano material template. (Centre) By depositing semiconductor materials we have fabricated silicon/germanium hetero-junction inside MOFs. (Right) By depositing silver nanoparticles inside MOFs, we have fabricated SERS fibre sensors.

We have recently reported [1] an innovative technique that takes a significant step towards this goal, as it allows us to fabricate crystalline semiconductor micro/nano structures directly inside the MOF capillaries. This technique utilises a high pressure deposition process similar to that used for modern planar electronic devices and so opens up the possibility for directly combining the light guiding properties of optical fibres with the exceptional capabilities of semiconductors for manipulating light and electrons (Fig. 1). As a proof of principle, we fabricated a transistor composed of crystalline germanium within a MOF. Moreover, we have grown silver nanoparticles inside the microstructured optical fibre's (MOFs) holes [2]. The resulting metal-dielectric MOFs serve as excellent substrates for surface enhance Raman spectroscopy (SERS) allowing for long interaction lengths between the fibre's optical guided modes and plasmonic resonances of the silver nanoparticles with thiol molecules used as analyte (Fig. 1).

These results suggest that the synthesis of metamaterials using MOFs scaffolds as templates is a powerful means to create 3D structures with appropiate micro/nanometric architecture. By combining solid state materials and MOF many of the functions currently performed by planar optoelectronics might now be integrated directly inside the fibre itself, and new semiconductor devices that cannot be realised in a conventional planar geometry may now become possible. As well, it will be possible to fabricate a new generation of in-fibre biosensors with outstanding sensitivity.

References

1) P.J.A. Sazio *et al. Science* 311, 1583 (2006)
2) A. Amezcua-Correa *et al. ECOC* Tu-4.3.4, Cannes (2006)