Planar fabrication assisted fiber nanowire manufacturing

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Current fabrication of low-dimension functional materials (semiconductors or metallic nanowires and nanotubes) requires either resource-intensive top-down processing or hardly scalable bottom-up synthesis, which so far have hindered industrial applications and wide accessibility to such materials. Recently iterative fiber drawing techniques have been proposed as a method to fabricate arrays of nanowires [1-3]. This requires multiple fiber draws to be able to realise nanoscale features. Furthermore, this method does not allow the realisation of complex multilayer structures which are not necessarily nanowires or nanotubes and inherent constraints in the traditional fiber drawing process, mainly starting from bulk materials, means that one can only utilise low melting point metals and mostly polymer clads.

Here we demonstrate a novel high-throughput method for the large-volume production of embedded nanocomposites by taking advantage of thin film properties and patterning techniques commonly used in planar fabrication and combining these with fiber drawing used in mass manufacturing of optical fibers. This hybrid process enables the fabrication of single and one dimensional (1D) arrays of nanowires encased in a chosen preform material with a single fiber draw, removing the need for costly and time consuming iterative fiber drawing to achieve nanoscale features. Furthermore, this method allows an unprecedented ability to combine materials with vastly different thermal properties. As a proof of principle of the remarkable potential of this method, nanowires of Germanium Antimony Telluride (GST), which thus far have not been realized in fiber form, as well as ultra-long gold nanowires embedded in silicate glass fibers were drawn with a single fiber draw (Fig. 1).

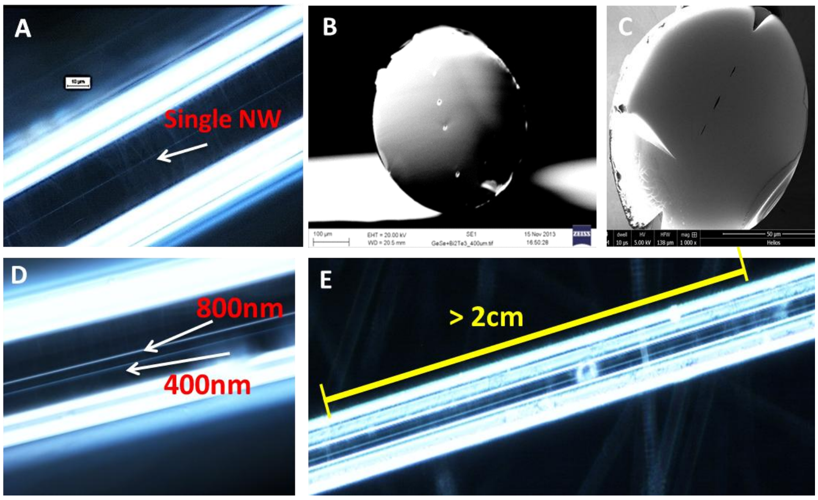

Fig. 1 Single, double and 1-dimensional nanowire array enclosed in glass fiber. A) Optical dark field microscopy of single nanowire of 500nm diameter enclosed in a silicate glass fiber. B) Scanning electron microscopy of the tip of one-dimensional array nanowires in glass fiber. C) Scanning electron microscopy of the tip of the nanoribbon fiber. D) Dark field microscopy of a double nanowire fiber with two different nanowire diameters. E) Ultra-long nanowires enclosed in a glass matrix.

This fabrication technique enables mass-production and ultra-long multimaterial nanocomposites embedded in fiber form, which paves the way for a range of applications in photodetectors, lasing, sensing and nanophotonics, to name a few.

References

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