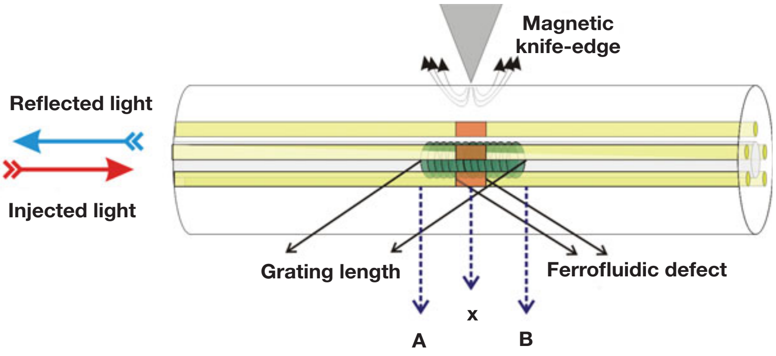
Magnetofluidics used for tuning optical fibers

Microstructured optical fibers make for a versatile photonic platform which combines tailored optical mode propagation properties with microfluidic functionality. For instance, microfluidic channels running through a fiber can permit the movement of small plugs of liquid whose own optical properties alter the passage of light in a controllable way. A report published in the July 1 issue of *Optics Letters* (DOI:10.1364/OL.36.002548, p. 2548) demonstrates how this emerging technology can employ magnetosensitive liquids to create optical fiber devices whose spectral transmission is tunable with a magnetic field.

S. Pissadakis and his team from the Foundation for Research and Technology, Institute of Electronic Structure and Laser, in Greece, developed these magnetofluidic devices in collaboration with the group of W. Margulis from Acreo AB in Sweden, which fabricated silicate optical fibers incorporating five axial microfluidic channels. Using deep ultraviolet laser radiation, they inscribed a 2.4 cm length of the fiber with a region of alternating refractive index known as a Bragg grating, which reflects and transmits specific wavelengths of light.



A schematic of the microfluidic optical fiber in which an infiltrated ferrofluid (orange) alters the spectrum reflected from a Bragg grating (green). Reproduced with permission from *Opt. Lett.* **36**(13)(2011), DOI:10.1364/OL.36.002548, p. 2548. © 2011 Optical Society of America.

A “ferrofluid” dispersion of magnetite (Fe_3O_4) nanoparticles in an isoparrafinic solvent was infiltrated into the microfluidic channels as a 2 mm long plug which acts as a phase defect when overlapping with the grating. This shows up as a dip in the reflected bandwidth whose position and magnitude can be altered by using an external magnetic field to displace the fluid.

A more powerful effect was seen when applying the same principle to a “chirped” Bragg grating, which includes a linear variation in the period of the alternating refractive index. In this case, the ferrofluid plug causes an asymmetrical chopping of the Bragg grating reflected spectrum, narrowing the bandwidth and shifting it to higher wavelengths. In this instance, the sections of grating on either side of the plug are no longer in resonance, and therefore only the illuminated side interacts with the reflected spectrum.

“Such magnetofluidic optical fiber components could be the precursors to developing ultracompact and high-performance photonic devices, serving diverse sensing applications in medicine and electrical power delivery,” Pissadakis said.

Tobias Lockwood

Energy Focus

Lithiation highway in Si nanopillars contributes to anisotropic shape changes

Because of its high theoretical specific capacity, silicon is a promising candidate material to use as anodes in lithium-ion batteries. One major challenge for silicon in this context is its large volume expansion upon lithium insertion, up to 400%, which leads to anode pulverization and decreased performance. The use of various Si nanoarchitectures has been instrumental in improving performance due to increased ability to accommodate large volume changes. Though Si nanomaterial electrochemical performance has been studied extensively, mechanistic understanding of volume change upon lithium insertion in these materials is limited. S.W. Lee and colleagues at Stanford University report on anisotropic shape changes of silicon nanopillars induced by electrochemical lithiation as published in the June 9 online edition of *Nano Letters* (DOI: 10.1021/nl201787r).

The researchers used scanning electron microscopy (SEM) to study silicon nanopillars in varying states of lithiation. The nanopillars of distinct axial orientations are fabricated using deep reactive-ion etching on Si wafers with SiO_2 nanospheres as an etch mask. This study includes nanopillars with axial orientations of <100>, <110>, and <111>. Lithiation is accomplished by using the nanopillars as the working electrode in electrochemical half cells with Li metal foil as the counter electrode.

Upon lithiation, surprising cross-sectional shape differences are observed between the different types of nanopillars. The circular cross sections of the pillars develop into “plus” sign shapes in the <100> pillars, ellipses in the <110> pillars, and rough hexagons in the <111> pillars. In the most extreme case, the <110> pillars expanded 245% along the long axis of the final ellipse and only 49% along the short axis.

These directions of increased expan-