Bioresorbable Optical-Fiber Sensing Probes

RESEARCHERS

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In recent decades, continually increasing health care requirements have sharpened the need for advanced tools for early disease diagnosis, patient monitoring and treatment.[1] Medical practitioners have welcomed the development of unconventional biomedical instrumentation and sensors, including optical-fiber sensors. In the past year, we have reported work with bioresorbable fiber sensors that could increase the range of applications for fiber sensors in biomedicine.

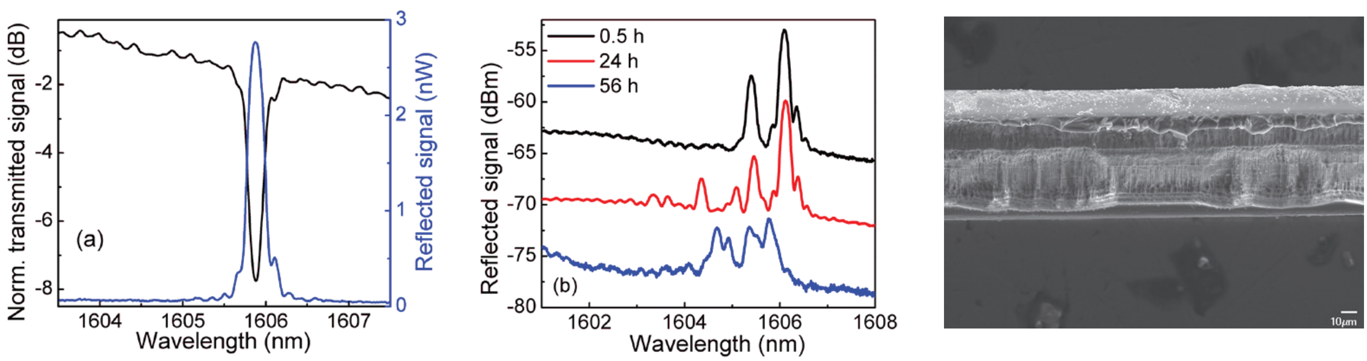
One of the most promising technologies suggested for fiber-based biomedical sensing involves fiber Bragg gratings (FBGs)—a mature photonic technology with established applications in several fields including biosensing, safety/security and structural-health monitoring. The intrinsic characteristics of FBG sensors make them also suitable for medical applications, such as controlled laser delivery systems, miniature intra-aortic probes and disposable body sensors for biochemical analysis.

An additional, highly favorable feature of an invasive optical-fiber sensor is controlled solubility in physiological environment. A sensor made of a bioresorbable material that can be safely assimilated by the human body at a specific time interval eliminates the need for extraction surgery, allowing safer exploration of sensitive human organs.

Recently, we reported the inscription and dissolution behavior of Bragg gratings in a bioresorbable calcium phosphate glass optical fiber.[2] The optical fiber used exhibits good mechanical durability, high optical transmission and a stoichiometrically tunable dissolution rate.[3] Using 193-nm excimer laser radiation[4] and the phase mask technique, we inscribed FBGs with average refractive-index changes of 5.8×10^{-4}.

To study the fiber dissolution, we fabricated tilted Bragg gratings with 1-degree tilt angle and immersed them in phosphate buffered saline (PBS) solution, with pH and temperature conditions resembling those of the human body. The spectral study of the dissolution process, supported by SEM images and micro-Raman spectroscopy of the exposed and dissolved optical fiber, revealed selective chemical-etching effects due to accelerated hydroxyl incorporation into the phosphate glass, by as much as an order of magnitude, after UV irradiation.

The experimental investigations carried out indicate that bioresorbable glass FBGs with tailored dissolution behavior can potentially be used for the development of soluble, miniaturized photonic sensing probes. We believe these probes can find use in efficient *in vivo* monitoring of vital mechanical or chemical parameters with a specific time span, and also in controlled in-body drug delivery. OPN



Left: Transmission and reflection signal of a phosphate glass fiber Bragg grating (FBG). Center: Reflected-signal evolution of a tilted FBG immersed in phosphate buffered saline (PBS) solution for up to 56 h. Right: Scanning electron microscope side view of the cladding region of an FBG after dissolution in PBS for 5 h.