**Sol-Gel Based Fabrication Methods for Photonic Crystal**

**ABSTRCT**

Photonic crystals (PhC) composed of periodic change of dielectric materials are capable of manipulating the interaction between photon and materials and thus controlling the flow of light. Undergone a rapid theoretical and technical exploration during the past three decades, PhC structures have been implemented in numerous photonic devices and have been found useful for widespread applications, such as communication, optical sensor, energy harvest, and display. As PhC-based devices operating in the visible or near Infrared (NIR) wavelength regimes, the period of the dielectric constant modulation is sub-wavelength and below one micrometer. At such a length scale, the fabrication of PhC structure with a sufficient precision and size is challenging,

In this thesis, a sol-gel based imprint lithography is demonstrated to fabricate PhC slabs on a glass substrate and three dimensional (3D) PhCs inside a capillary tube. The one-dimensional (1D) and two-dimensional (2D) photonic crystal slabs, which are also known as guided mode resonant (GMR) filters, have been studied for their capabilities of generating narrowband reflections in visible and NIR portions of the spectrum. The sol-gel based imprint method uses titanium alkoxides sol-gel solution to transfer desired patterns from a master mold to the glass substrate within 5 minutes. This one-step fabrication process warrants a simple, rapid, and low-cost formation of GMR structures over a surface area as large as 1 cm2m, which is currently limited by size of available imprint mold. Also, our sol-gel imprint approach enabled the tuning of GMR modes by pre- and post-imprint processes. The fabricated PhC slabs were characterized and their applications in refractometry-based biosensing were explored. A dielectric thin film with a high refractive index (n = 1.78), functions as the light confinement layer. Meanwhile, the imprinted grating structure on hybrid inorganic-organic sol-gel thin film couples the light excitation into GMR mode. The 1D GMR filter exhibited a Q factor of 70 at resonant wavelength while 2D GMR filter has Q factor of 158 at resonant wavelength. As for refractometric biosensor, a bulk sensitivity of 50 nm per refractive index unit and the detection of monolayer of polyamino acid have been measured.

 In addition, efforts has been devoted to investigate the fabrication of 3D PhC inside a capillary tube, where the self-assembled polystyrene (PS) sphere was exploited as the template. Within a few simple steps, inverse opal PhC structures was generated inside glass tubes and can perfectly work as nanoscale optofluidics. With volume ratios of polystyrene and sol-gel solution from 5:1 to 7:1, the fabricated inverse opal PhC structures were discovered to be more compact and ordered. By trying different PS sphere diameter of 185nm, 236 nm, 269nm, and 307nm, the resonant wavelength of inverse opal PhC has been found a redshift with an increase of PS sphere diameter.