

# Silicon-based mesoporous photonic crystals: towards smart biomaterials that can sense and deliver therapeutics

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Porous silicon (PSi) photonic crystals have aroused research interest as label-free chemical and biological sensing transducers owing to the ease of fabrication, high quality optics and a sensitive optical response to changes in refractive index. Furthermore, as their optical properties can be tuned to the tissue window and the material itself degrades to benign products in the body, it may be an ideal *in vivo* sensing material. A major impediment to using PSi materials as sensors however is this degradation of the material via oxidation in ambient air and aqueous environments which influences the optical properties. Herein, we describe progress our group has made in derivatising PSi towards 1-D silicon-based photonic materials for applications in biology and medicine and applying these materials for monitoring the activity proteases released by macrophage cells.

Narrow-linewidth rugate filters [1], a class of photonic crystal, are fabricated on silicon to display a high reflectivity resonant line in the reflectance spectrum. The position of the resonance is sensitive to changes in refractive index, thus allowing quantification of infiltrating biological species. The efficacy of rugate filters as biosensing transducers requires 1) protection from aqueous degradation, 2) resistance to non-specific adsorption and 3) distal reactivity for coupling of biorecognition molecules. Chemical strategies based on hydrosilylation of functional alkenes protect the PSi against oxidation, resist non-specific adsorption of biomolecules and allow biorecognition molecule immobilization [2].

As an example of PSi biosensing utility, immobilisation of peptides on the pore walls is used to demonstrate the optical detection of protease enzyme activity [3]. Introduction of protease results in cleavage of the immobilised peptides within the rugate filters, detected by an optical blue-shift to shorter wavelengths. We also demonstrate the application of these photonic crystals for monitoring protease activity using porous silicon-biopolymer hybrid photonic crystals where optical responses from of attomole of protease enzymes was detected [4]. Tailored surface chemistry allows the capture of human monocyte derived macrophages (HMDMs) on the PSi surface. Upon stimulation an optical response from just 1500 HMDMs was detected. The number of cells from which the optical response was observed was determined by the size of the illumination spot rather than an intrinsic limitation of the optical devices. As a consequence we are now reducing the size of the photonic crystals to microparticles which have the potential to bind to individual cells and monitor protease activity from these individual cells.

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**Biography:**

Professor Justin Gooding graduated with a B.Sc. (Hons) from Melbourne University before spending two years working for ICI Research. He then returned to University obtaining a D.Phil. from the University of Oxford in electrochemistry. A post-doctoral appointment at the Institute of Biotechnology in Cambridge University introduced him to biosensor research. He returned to Australia in 1997 as a Vice-Chancellor's Post-Doctoral Research Fellow at UNSW before commencing a lectureship at Flinders University in 1998 and then UNSW in 1999. He was one of the recipients of a 1988 RACI Masson Medal, 2004 NSW Young Tall Poppy award, a 2005 Alexander von Humboldt Fellowship, 2007 Erskine Fellow and the 2007 RACI Lloyd Smythe Medal for Analytical Chemistry and the 2009 Eureka Prize for Scientific Research. He is currently and ARC Professorial Fellow in the School of Chemistry at UNSW where he leads a research teams of 20 people.