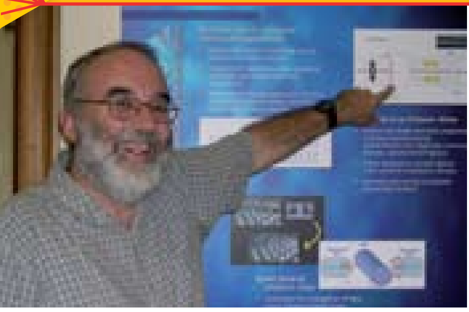
CUDOS

The Centre for Ultrahigh bandwidth Devices for Optical Systems (CUDOS)

ANNUAL REPORT

2006



Ross McPhedran

Ross McPhedran received his undergraduate training and pursued his PhD studies at the University of Tasmania. After a year in Marseille France as a CSIRO Postdoctoral Fellow, he came to the University of Sydney as a Queen Elizabeth II Fellow, and is now a Professor in Physics working in the areas of computational electromagnetism, photonics and mathematical physics. He is currently on the Editorial Boards of Proceedings of the Royal Society A, Journal of Optics A and Waves in Random and Complex Media.

Key areas of research contribution within the Centre

Wave propagation in periodic media, microstructured fibres, numerical methods.

Roles and responsibilities within Centre

Chief Investigator.

Awards, honours, major international visits

Ross McPhedran attended a Board Meeting of Proceedings of the Royal Society A in London in April and then carried out research at the University of Liverpool. He attended the inaugural OSA Topical Meeting on Photonic Metamaterials, Grand Bahamas, June 2006 and the LEOS Conference in Montreal, Canada, October 2006, as part of a trip in which research visits were made to Liverpool, Erlangen and Marseille. Ross was also Chair of ETOPIM7, the Seventh International Conference on the Electrical Transport and Optical Properties of Inhomogeneous Media, which took place at Cockle Bay Wharf, Darling Harbour from July 9-13 2006.

Describe key areas of research activity

Density of state functions in photonic crystals, which contributes to the Radiation Dynamics project. Light propagation in photonic crystal fibres, and development of coated photonic crystal fibres for sensor and signal processing applications.

Research achievements during 2006

We have investigated emission by sources in structured photonic crystal environments. This emission is controlled in part by the electromagnetic properties of the environment created by the structure, and is modelled by calculating the local density of states (LDOS), a function of both position and frequency. Our previous studies of LDOS have used highly accurate multipole methods to calculate this function, but have been restricted to photonic crystals composed of cylinders. In order to lift this restriction, and make the LDOS more widely available as a tool for designing photonic structures with specific emission properties, we are developing the Finite Difference Time Domain Method in the commercial software package RSOFT to enable LDOS calculations. We also reported on a simple way of calculating the LDOS for structures with two microcavities, viewing the LDOS of the full structure as resulting from the interaction between resonant modes of the individual microcavities. This interaction can be viewed as a quantum interference effect, and can lead to emission suppression if the resonant modes interfere destructively. This work is being carried out through collaboration with Professor Mark Dignam of Queen's University, Kingston, Ontario.

[1] Dignam MM, Fussell DP, Steel MJ, de Sterke CM, McPhedran RC, Spontaneous emission suppression via quantum path interference in coupled microcavities, PHYSICAL REVIEW LETTERS 96, 103902 (2006)

[2] Fussell DP, Dignam MM, Steel MJ, de Sterke CM, McPhedran RC, Spontaneous emission and photon dynamics in dielectric microcavities, PHYSICAL REVIEW A 74, 043806 (2006)

The field of silica-based microstructured fibres has matured rapidly, going from concept demonstration to commercial availability in a decade. The most recent area to emerge is the development of techniques to coat the holes in fibres with a material different from that of the matrix material, and in particular to coat them with metals. We recently extended the CUDOS MOF software to deal with coated holes, and showed how their guidance mechanism may be a strong function of frequency. This occurs with metal coatings, as a result of resonant plasmonic interactions. In particular, we demonstrated coupling of the fundamental mode in a metal coated microstructured optical fibre to plasmonic resonances, paving the way for in-fibre ultra sensitive sensors (Figure 1). We have also shown that in the case of silicon carbide coatings, the resonant features evident near its reststrahlen wavelength are accompanied by a similarity between the coated MOF and one with uncoated but larger holes. This latter feature may well be of use in the design of enhanced sensitivity sensors.

[1] Kuhlmey BT, Pathmanandavel K, McPhedran RC, Multipole analysis of photonic crystal fibres with coated inclusions, OPTICS EXPRESS 14, 10851 (2006)

[2] Kuhlmey BT, McPhedran RC, Photonic Crystal Fibres with Resonant Coatings, PHYSICA B (in press)

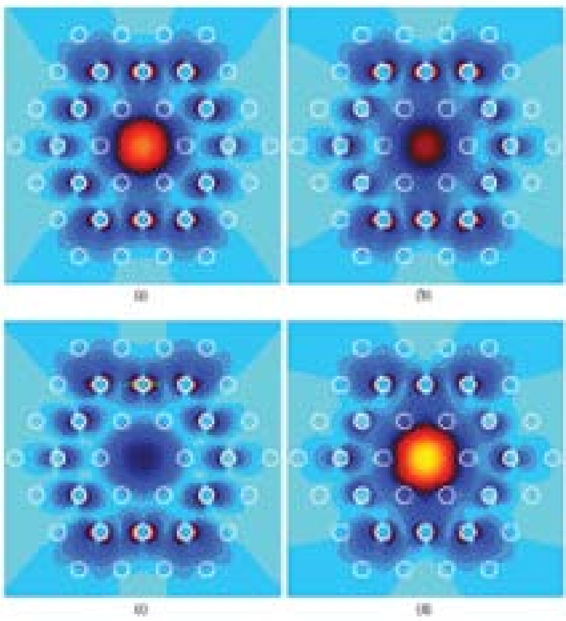


Figure 1. Norm of the electric field of the fundamental mode interacting with a plasmonic resonance in a partially metal coated microstructured optical fibre. The second ring of holes from the center is coated with 20 nm of metal. Frame (a) shows the field at wavelengths slightly shorter than that of the plasmonic resonance, Frame (b) and (c) at the resonance (note the field concentration at the silver interface characteristic of surface plasmons), and (d) for wavelengths above resonance. A loss peak in the transmission spectrum of the fibre occurs when the surface plasmon is excited. The frequency at which this plasmon resonance occurs is strongly sensitive to the optical properties in the immediate vicinity of the metal coating so that by introducing a sample fluid in the coated holes, its refractive index can be measured to extremely high accuracy.