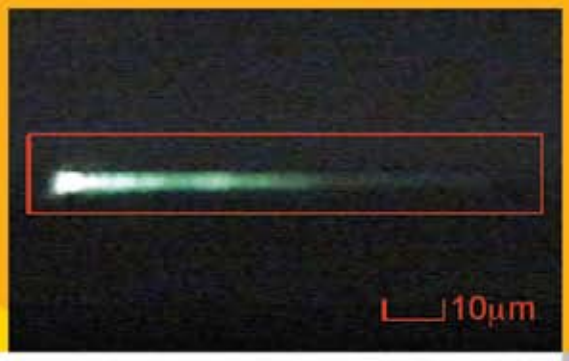
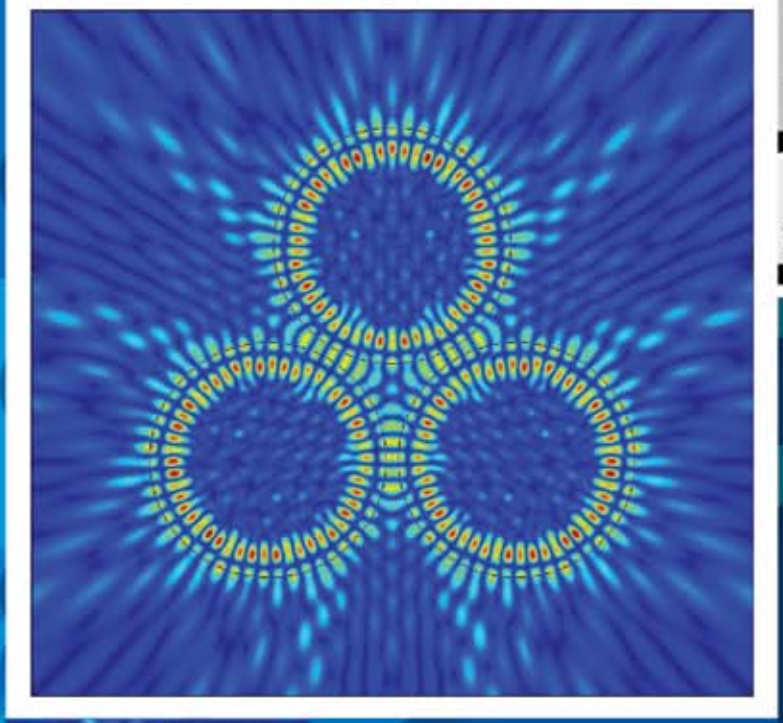
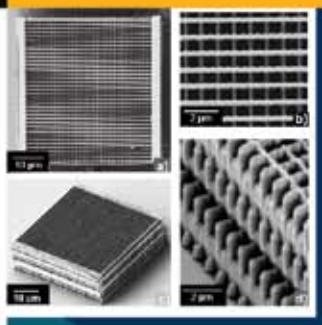
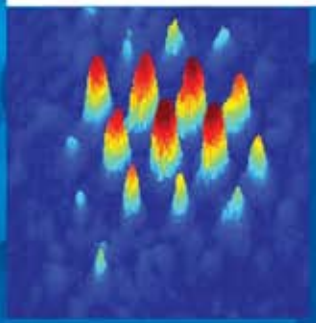
CUDOS

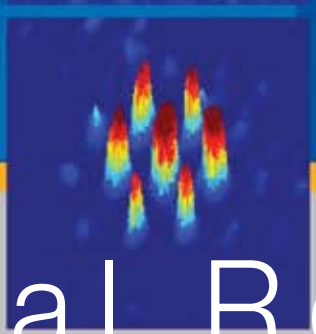
The Centre for Ultrahigh bandwidth Devices for Optical Systems (CUDOS)

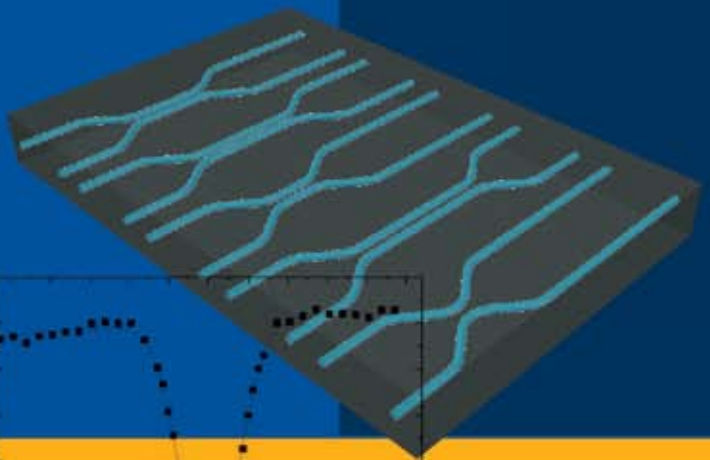


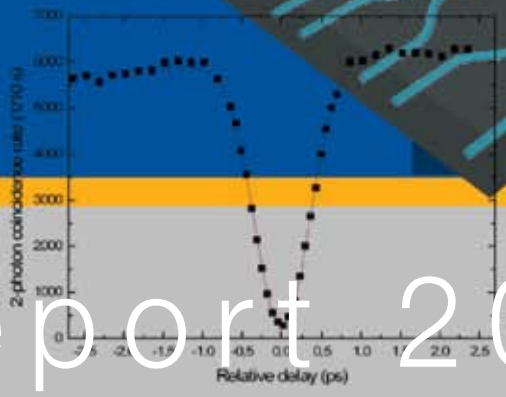






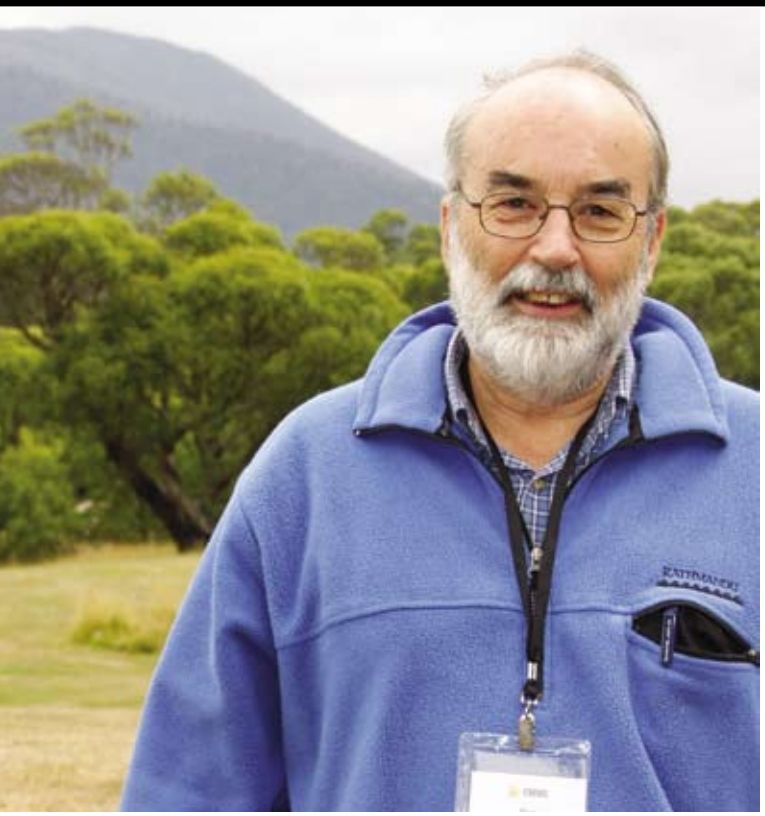






Annual Report 2008

Chief Investigator: Ross C McPhedran



CI short biography

Ross McPhedran completed his undergraduate studies and PhD at the University of Tasmania, before moving to Sydney in 1975 as a Queen Elizabeth II Fellow. He was appointed a Senior Lecturer in the School of Physics in 1984, and was promoted to a Personal Chair in 1994. His interests range over many aspects of wave theory, photonics, microstructured fibres, elastodynamics, composite science, mathematical methods and numerical algorithms.

Awards, honours, major international visits

In 2008, Professor McPhedran gave invited talks on the topic of electromagnetic cloaking at the NATO Advanced Research Workshop Metamaterials for Secure Information and Communication Technologies, Marrakesh, Morocco and the international conference Metamaterials 2008, Pamplona, Spain. He also gave an invited talk on reactive cloaking at the Australia- Japan Nanophotonics Workshop, Australian National University, Canberra.

He was a Visiting Professor at the Institut Fresnel, Marseille, where he worked on electromagnetic cloaking and the total absorption of light by optimized diffraction gratings. He also visited the University of Liverpool under a grant from the EPSRC U.K., where he worked on the properties of elastic waves in platonic crystals. He finished a term on the Board of Journal of Optics A and continues on the Board of Waves in Random and Complex Media.

Key areas of research contribution within the Centre

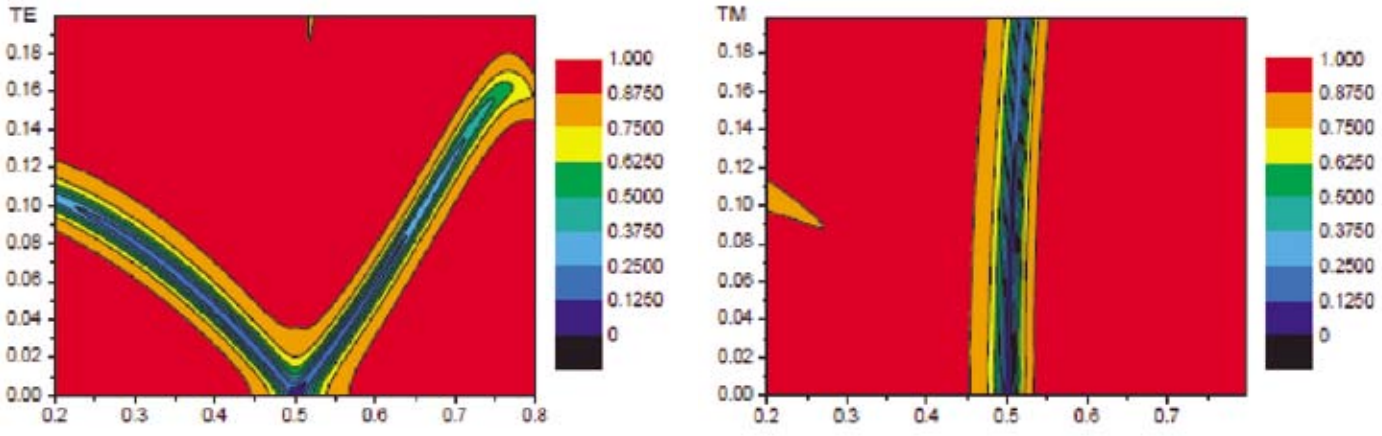
Professor McPhedran is engaged in the theory underlying the electromagnetic properties of photonic crystals, and currently is particularly involved in the development of theories for the properties of defects in PC's. He is also involved in the development of methods for density of states calculations in photonic crystals and their applications in radiation dynamics effects, and the modelling and applications of microstructured fibres. He works on the theory and applications of surface plasmons in structured materials, and is active in the study of the use of plasmonic resonances in optical cloaking.

Researchers and students

Dr. Christian Karnutsch works on microfluidics and plasmonics, in collaborations with Professors Eggleton and McPhedran. Sam Campbell has successfully completed his PhD project, working with Professors McPhedran, de Sterke and Botten on lamellar diffraction gratings and their applications, while Sahand Mahmoodian is working with the same trio, together with Kokou Dossou and Chris Poulton, on analytic methods for accurate evaluation of the properties of defects in photonic crystals. Parry Chen has commenced a PhD working with Professors McPhedran, de Sterke and Botten, Michael Steel, Chris Poulton and Ara Asatryan on the theory of photonic crystals incorporating both negative index materials and normal materials.

Research achievements during 2008

In conjunction with researchers from the Institut Fresnel, it was shown [1] that a doubly-periodic grating with a sinusoidal profile can be optimized to absorb 100% of light of a specific wavelength and



Absorption by optimised grating: left, TE; middle, TM; right, unpolarised.

arbitrary polarization falling on it at the chosen angle of incidence (30°). This complements previous theoretical and experimental work from the same team showing that total absorption of light could be achieved for normally incident light. It is an important achievement since it shows that it is possible to design gratings which can convert plane waves into plasmons with perfect efficiency, with the appropriate grating being able to be determined for a wide class of plane wave directions. The optimized gratings may then be able to function as plasmon amplifiers.

The figures shows absorption of light by an optimized grating as a function of direction cosines of an incident plane wave for TE polarization (left), TM polarization (middle) and unpolarised light (right). The grating has been optimized for an angle of incidence of 30°, which corresponds to 0.5 on the horizontal axis.

A study [2] of surface plasmon detectors for bio-molecules has shown that the use of diffraction gratings having two Fourier components in the profile rather than one can result in significant enhancements in sensitivity. The optimized system in fact has sensitivity corresponding to a change of reflectance between 2% and 10% for a change in refractive index of 0.001 in the analyte.

Work has continued on cloaking, or the hiding of objects from detection by electromagnetic wave probes, using a mechanism based on resonant interaction between the probe and a cloaking system. The interaction cancels out the probe wave in a region surrounding the cloaking system, rendering particles in that region undetectable. Current work has concentrated on the extension of previous work from the static domain to finite wavelengths, and the consequent refinements necessary in the design of the cloaking system.

Studies have commenced on the properties of photonic crystals incorporating both negative-index and positive-index materials, the PhD subject of Parry Chen. Such crystals raise fundamental issues, as their bands are quite unlike those of conventional photonic crystals. It is evident both from our work, and from the controversy surrounding papers in the literature, that it is important to incorporate both dispersion and material absorption into the negative-index materials. Neglect of these effects may result in numerical results on band structure which are physically unachievable.

[1] Popov, E., Maystre, D., McPhedran, R.C., Neviere, M. Hutley. M.C. and Derrick, G.H. :Total absorption of unpolarized light by crossed gratings, Optics Express, 16, 6146-6155 (2008).

[2] Bonod, N., Popov, E. and McPhedran, R.C.: Nicorovici, N.A., Milton, G.W. and McPhedran, R.C.: Increased surface plasmon resonant sensitivity with the use of double Fourier harmonic gratings, Optics Express, 16, 11691-11702 (2008).

[3] Nicorovici, N.A.P., McPhedran, R.C., Enoch, S., and Tayeb, G.: Finite-wavelength cloaking by plasmonic resonance, New Journal of Physics, 10, 115020 (2008) (16 pp.).