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Barry Luther-Davies

Barry Luther-Davies is Professor of Laser Physics at the Australian National University with experience in lasers, laser-matter interaction physics, photonics, optical materials and nonlinear optics. He completed a BSc and PhD at the University of Southampton, UK before joining ANU in 1974. At ANU he led a team working on the physics of laser-produced plasmas, until the early 1990s when the research evolved into studies of laser-materials processing and pulsed laser deposition of thin films. More recently he specialised in nonlinear optical materials and devices and photonics as part of the Australian Research Council's Centre of Excellence for Ultrahigh bandwidth Devices for Optical Systems (CUDOS). He is a Fellow of the Optical Society of America and the Australian Academy for Technological Sciences and Engineering. He was awarded the Pawsey Medal of the Australian Academy of Science in 1986 for his contribution to laser-plasma interaction physics and was an ARC Federation Fellow from 2003-2008. Professor Luther-Davies has published more than 340 papers in scientific journals, contributed several book chapters and several hundred conference papers. In 2011 he served as a Topical Editor for the Journal of the Optical Society of America-B and an Advisory Editor for Optics Communications.

Key Areas of Research Contribution

The team within the Laser Physics Centre at ANU focuses on the Hybrid Integrated Circuits flagship project which supplies advanced waveguide devices to three other flagship projects: Terabit per second Optical Communications, Mid-infrared Photonics and Quantum Integrated Photonics.

Hybrid integration involves vertical integration of different waveguide platforms to create high performance circuits which utilise the best properties of the different layers. In 2011 the team focused on reducing insertion losses in our nonlinear waveguides used for all-optical processing by fabricating vertical taper couplers to mode match between UHNA-3 optical fibers and dispersion engineered chalcogenide rib waveguides or nanowires. In addition they made their first rare earth doped chalcogenide films with ≈0.2-1at% Er and luminescence lifetimes in the ms range. Laser gain in rare earth doped chalcogenide nonlinear waveguides can compensate pump propagation losses which limit the conversion efficiency of four wave mixing in nonlinear waveguides. In a complementary approach the group fabricated their first hybrid $Er:TeO_2/As_2S_3$ waveguides using gain in the TeO_2 layer to compensate the propagation losses in the composite waveguide.

For Quantum Integrated Photonics, the team at the Laser Physics Centre aimed to fabricate zero dispersion nanowires to generate correlated photons pairs via spontaneous four wave mixing at frequencies separated by >30THz allowing noise from spontaneous Raman scattering to be avoided. To fabricate these low dispersion structures, waveguide dimensions must be controlled to an accuracy of <5-10nm. They compensated dimensional errors identified during waveguide fabrication by adding a depressed or raised index intermediate coating between core and cladding to tune the dispersion to the required range. The group will fabricate devices in the first half of 2012.

Nanowires offer extreme nonlinearity at high efficiency. The group fabricated symmetrical nanowires this year with polarisation independent dispersion and a nonlinear parameter of $150W^{-1}m^{-1}$.

Photonic crystals (PhC) nanocavities integrated into our hybrid waveguides are embedded in a cladding which results in a low index contrast of only ≈1.2. The researchers at the Laser Physics Centre demonstrated that by careful waveguide design a low index contrast does not prevent high-Qin the cavity. They confirmed this experimentally by fabricating a side-coupled heterostructure based on a

W0.54 PhC waveguide in a $Ge_{11.5}As_{24}Se_{64.5}$ 2D photonic crystal. The devices had a loaded Q of ≈120,000 and intrinsic-Q of >650,000 when embedded in a cladding index with index of ≈1.45. These structures are more compatible with integration into a hybrid waveguide and benefit from better thermal stability than air-clad PhCs. With a relatively photostable chalcogenide glass, the cavities also demonstrated exceptional frequency stability and bistability when probed with mW laser powers.

This year the group improved their understanding of the structure/property relations of glasses in the GeAsSe system from EXAFS and Raman spectroscopy and through analysis of the thermal properties of glasses over a wide range of compositions. In collaboration with Ningbo University the team characterised glasses in the GeSbSe system, which are free from toxic Arsenic, to see if particular compositions of these glasses have high thermal and optical stability like the GeAsSe system. However substitution of Sb for As introduces a higher level of ionic bonding and initial results therefore show a strong influence of the Sb content on the physical properties.

For Mid-infrared Photonics, chalcogenide glasses with low levels of impurities are essential. Through collaboration with the University of Arizona Luther-Davies' team obtained purified samples of $Ge_{11.5}As_{24}Se_{64.5}$ with reduced levels of O and H impurities for device fabrication in 2012. During 2011 they improved our facilities for Mid IR science combining our 3.4µm 7ps OPA source with a new InSb camera to visualise coupling at wavelengths out to ≈5.5µm. Initial trials of an As_2S_3 on TeO_2 composite proved unsuccessful due to OH contamination in the TeO_2.

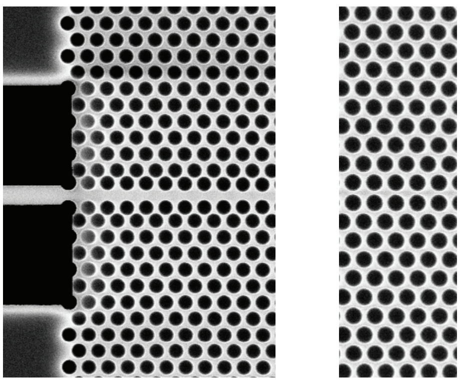

Fig 1: SEM image of $Ge_{11.5}As_{24}Se_{64.5}$ 2-D photonic crystal: LHS input nanowire coupled to W1 waveguide which creates a taper to the W0.54 waveguide in the region of the heterostructure (RHS).

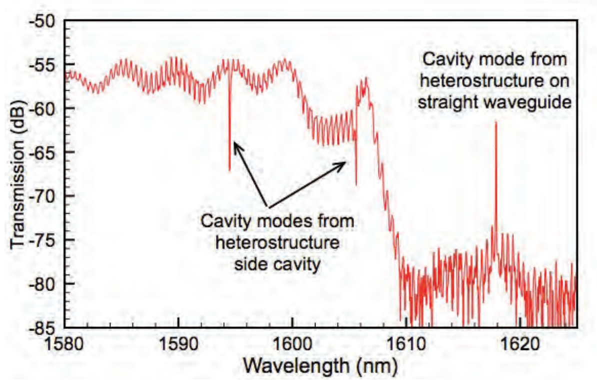

Fig. 2. Measured optical transmission of the PhC embedded in an index matching fluid with index-1.45. The high transmission region contains two resonances which represent coupling to the side cavity; the low transmission region shows a single resonance corresponding to coupling through the in-line heterostructure cavity of the main waveguide.

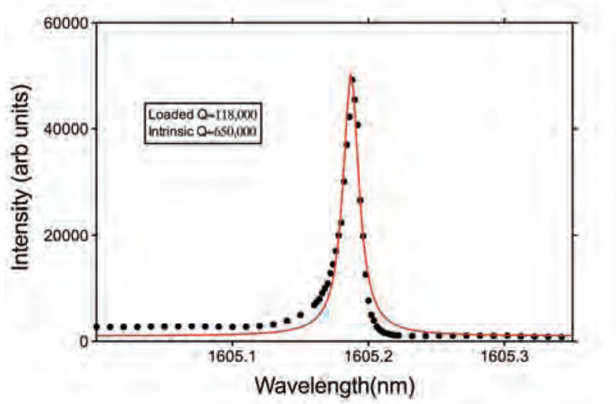

Fig. 3. A high resolution scan of the strongest resonance to the side cavity shows an intrinsic Q of >650000 was achieved.

Recognition

Prof Luther-Davies presented an Invited talk at the OSA Topical Meeting on Nonlinear Optics in Hawaii and was Chair, Program Committee Integrated and Guided-Wave Optics and Thin Film Optics Cleo Pac Rim 2011.

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