AUSTRALIAN NATIONAL UNIVERSITY
Phone: +61 2 6125 3792
Email: Dragomir.Neshev@anu.edu.au

Dragomir N. Neshev

Dragomir Neshev received the PhD degree in physics from Sofia University, Bulgaria in 1999. Since then he has worked in the field of nonlinear optics at several research centres around the world. Since 2002, he has been with the Australian National University, where he is currently Associate Professor and leads the Experimental Photonics group at the Nonlinear Physics Centre. He is the recipient of a number of awards, including a Queen Elizabeth II Fellowship (ARC, 2010) an Australian Research Fellowship (ARC, 2004), a Marie-Curie Individual Fellowship (European Commission, 2001), and the Academic award for best young scientist (Sofia University, 1999). His activities span over several branches of optics, including nonlinear periodic structures, singular optics, plasmonics, and photonic metamaterials.

Key Areas of Research Contribution

A/Prof Neshev is the project leader of the Functional Metamaterials flagship project of CUDOS. In this role he is responsible for setting the research goals and milestones of the project, as well as for its yearly management and collaborative links. During 2011 A/Prof Neshev was also involved in the research activities of two other flagship projects, namely Nanoplasmonics and Quantum Integrated Photonics.

2011 Achievements

Tuneable and nonlinear metamaterials

In 2011, A/Prof Neshev's team developed tuneable and nonlinear metamaterials as one of the major milestones of the Functional Metamaterials project. The approach included the fabrication of fishnet left-handed metamaterials structures operating at telecommunications wavelengths [Fig. 1(a,b)]. They achieved tunability through infiltration of the structures with nematic liquid crystals [Fig. 1(b,c)]. Due to the strong nonlinearity of the liquid crystal as a result of molecular re-orientation with respect to external electric fields the fabricated structures became highly sensitive to light illumination. The group showed experimentally that due to the nonlinear response of the liquid crystal the fishnet structure exhibits change in transmission at moderate power levels. The overall nonlinear response was tuneable by applying a biasing voltage across the metamaterial, demonstrating for the first time electrically tuneable nonlinear response of metamaterials.

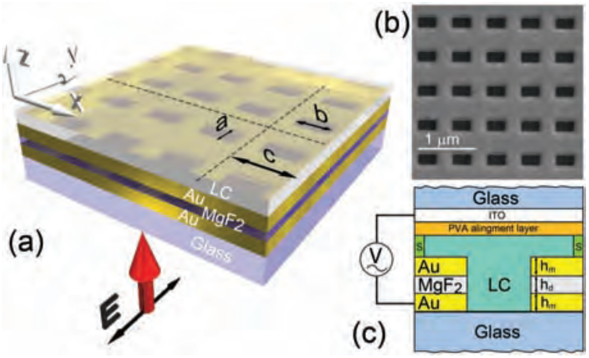

Figure 1: (a) Schematic of the fabricated LC infiltrated fishnet metamaterial. (b) Scanning electron microscope image (top view) of the fabricated structure. (c) Side view of the LC cell: DL is a dielectric layer, S - 100 µm thick plastic spacers. Parameters for the fabricated Au-MgF$_2$-Au fishnet are $h_d = h_m$ = 50 nm, a = 190 nm, b = 350 nm, and c=600 nm.

Plasmon beam manipulation

Within the Nanoplasmonics project, A/Prof Neshev contributed actively in the development of novels schemes for plasmon beam manipulation. A highlight of this research was the experimental demonstration of plasmon Airy beams, as a means to achieving non-diffracting and self-healing surface plasmons. These results were published in Physical Review Letters and were highlighted among the top 30 works in Optics of 2011 by the Optical Society of America as well as by Viewpoint in Physics by the American Physical Society. Following these observations the Nanoplasmonics team developed and is currently experimentally testing new schemes to manipulate Airy plasmons by linear plasmonic potentials. Such potentials can be formed in metal-dielectric structures as the one shown in Fig. 2(left). These structures can bend the Airy plasmon to the left or to the right by simply varying the wavelength, as shown by the finite difference time domain simulations in Fig. 2(right).

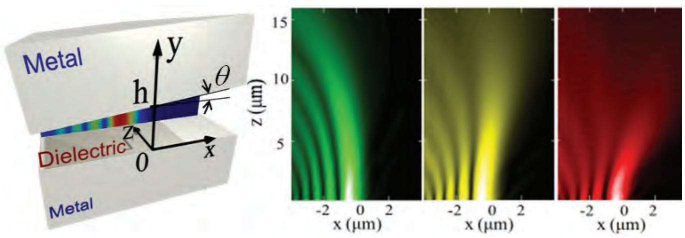

Figure 2: (left) Wedged metal-dielectric-metal structure for manipulating Airy plasmon with one metal plate tilted by an angle θ. (right) Numerically calculated field distributions of three plasmonic Airy beams at wavelengths of 0.6, 1 and 1.4 µm (in false colours) and $\theta = 0.458°$.

Quantum Integrated Photonics

One of the main aims of the Quantum Integrated Photonics flagship project is the integration of single photon sources and quantum circuitry. There has been extensive research in passive quantum circuitry involving waveguides and waveguide components, but in all experiments the non-classical light has been generated external to the circuit. The possibility of integrating the quantum sources and the passive components on a single chip however provides the team with a new opportunity to design the quantum statistics of the generated photons by simple classical means. In 2011 the research group predicted that the combination of photon pair generation and quantum walks in an array of coupled optical waveguides represents a flexible platform for engineering the spatial quantum correlations. Their theoretical predictions have been published in the prestigious journal Physical Review Letters and have created significant interest for the experimental realisation of such integrated quantum sources. Experiments are underway through collaboration within the CUDOS flagship projects.

Recognition:

2011 has been a dynamic year in terms of international collaborations and activities to promote the next stage of the CUDOS research centre. A particular focus in these activities was the establishment and the promotion of the Functional Metamaterials project. As such A/Prof Neshev has given several invited talks, visited international collaborators and has participated in organising and technical committees, details of which are contained later in this report.

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