



Focal Points

Welcome back and happy New Year. I trust you are all well rested and looking forward to a productive and fulfilling year.

I would like to thank MQ Photonics for your support and well wishes late last year while I was dealing with a medical emergency involving my youngest daughter. I pleased to report she has fully recovered and she is as cheeky as ever. Thanks particularly to Brian and Mike for holding down the fort during my absence.

On to business! It is perhaps common knowledge that Graham Marshall departs the Centre in April to pursue a great opportunity at the University of Bristol, working closely with Prof. John Rarity and his group. However, it is probably less well known that Graham has also been awarded a prestigious Marie Curie Fellowship associated with his relocation to Bristol. We anticipate Graham will be a regular visitor back to Macquarie. Join me in wishing him all the best for the future.

I'm most grateful to David Inglis for stepping up as MQ Photonics Seminar Coordinator while Alex Fuerbach is on OSP. I have challenged David to bring a different flavour to this series, perhaps more bio-photonics talks!

Congratulations to PhD student Nick Cvetojevic. Nick shared the top spot for Best Student Poster at the recent CUDOS Annual Workshop.

Mick Withford

Media: discussed in editorial and top-downloaded articles

BioOptics
WORLD.

Advances in lasers, optics,
and imaging for the life sciences

<http://www.bioopticsworld.com/articles/2011/12/nonlinear-optical-microscopy.html>

Biomedical Optics EXPRESS

OSA
The Optical Society

Top-Downloaded Articles for December 2011

<http://www.opticsinfobase.org/boe/abstract.cfm?uri=boe-2-12-3321>

Z Song, T A Kelf, W H Sanchez, M S Roberts, J Rička, M Frenz, A V Zvyagin, “Characterization of optical properties of ZnO nanoparticles for quantitative imaging of transdermal transport”, *Biomedical Optics Express* 2 (12), 3321-3333 (2011)

Abstract: Widespread applications of ZnO nanoparticles (NP) in sun-blocking cosmetic products have raised safety concerns related to their potential transdermal penetration and resultant cytotoxicity. Nonlinear optical microscopy provides means for high-contrast imaging of ZnO NPs lending in vitro and in vivo assessment of the nanoparticle uptake in skin, provided their nonlinear optical properties are characterized. We report on this characterization using ZnO NP commercial product, Zinclair, mean-sized 21 nm. Two-photon action cross-section of this bandgap material ($E_{bg} = 3.37$ eV, $\lambda_{bg} = 370$ nm) measured by two techniques yielded consistent results of $\eta_{ZnO}\sigma_{ZnO}(2ph) = 6.2 \pm 0.8$ μGM at 795 nm, and 32 ± 6 μGM at 770 nm per unit ZnO crystal cell, with the quantum efficiency of $\eta_{ZnO} = (0.9 \pm 0.2)$ %. In order to demonstrate the quantitative imaging, nonlinear optical microscopy images of the excised human skin topically treated with Zinclair were acquired and processed using $\sigma_{ZnO}(2ph)$ and η_{ZnO} values yielding nanoparticle concentration map in skin. Accumulations of Zinclair ZnO nanoparticles were detected only on the skin surface and in skin folds reaching concentrations of 800 NPs per μm^3 .

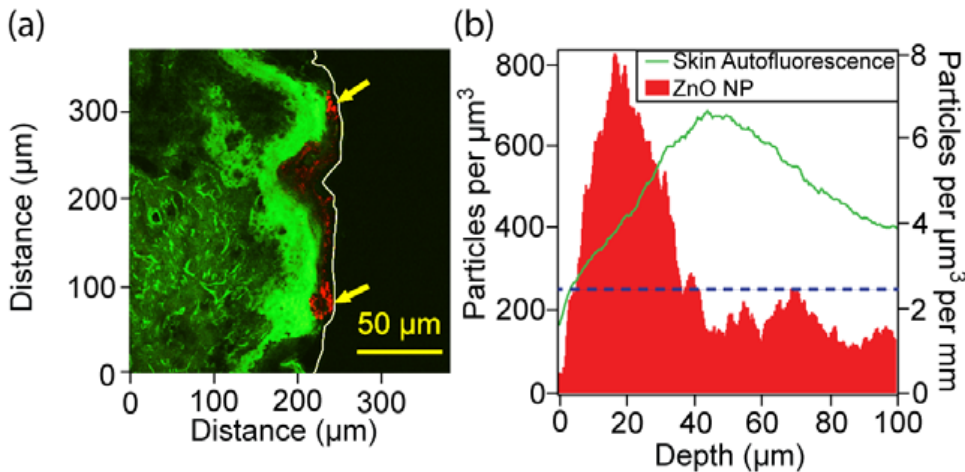


Fig. 7. (a) An overlay of the confocal/multiphoton image of the excised human skin, and (b) plot of the ZnO NP distribution versus the skin depth processed from the image data. Left panel: green color, skin autofluorescence excited by 405 nm; red color, ZnO NP distribution in skin (*stratum corneum*) excited by 770 nm, with collagen-induced faint SHG signals in the dermal layer. Yellow arrows point to ZnO NP clusters. Right panel: ZnO NP concentration in the epidermis. A threshold line (dashed, blue) delineates spurious signals due to the image processing artifacts (below the line) from the ZnO NP signals. The right-hand-side axis, ZnO NP concentration per unit length averaged across the entire imaged skin surface.

Updates on AstroPhotonics

1) Discovery of an Exoplanet in the process of Formation.

Dr Mike Ireland has recently been in the news with his discovery of a planet around the star LkCa 15 in the process of formation. In addition to the print and online media, he has been interviewed seven times for radio and once for television. The planet was seen as an object 500 times fainter than the star at a 2.2 micron wavelength and an angular separation of only 0.3 micro-radians. This high dynamic range detection was based on closure-phase relations in the technique of aperture-mask interferometry, the same technique that underpins the Dragonfly photonic chip developed by Nemanja Jovanovic and collaborators. The next step in high-contrast imaging will require a new generation of hyperspectral near- and mid-infrared imaging instruments and refined algorithms. Some of this future work will be made possible with the mid-infrared RIBG camera grant funded in the last round. For more details, please seek out Mike and also his collaborator Frantz Martinache from the Subaru telescope who will be visiting from time to time over the next 2 months.

2) New ARC Discovery grant for Astrophotonics

Dr Mike Ireland, together with Prof Tim Bedding (USyd) and Prof Quentin Parker have had success in the recent ARC Discovery Grant round with the project "Sound and Fury: Finding planets amidst the noise of their dying stars". This project will involve developing compact, precise visible light spectrographs for small telescopes to search for planets around pulsating giant stars. It ties in closely with Izabela Spaleniak's PhD project, which aims to provide a 10 fold increase in the sensitivity of this class of instrument through the use of a photonic lantern on a chip.

Mike Ireland

Seminars

MQ Photonics Seminars / Visitors

Time / Date: 11am / Fri 10th Feb

Room: E7B T2

Speaker: **Prof Hui Cao**, Department of Applied Physics, Yale University, USA

Topic: Bio-Inspired Photonic Nanostructures and Lasers

Abstract: Nature has used ordered structures to create vivid colors that are strongly iridescent, e.g., natural opals. These are a well known biomimetic model for photonic nanostructures, such as photonic crystals. It is less well known that nature has also used quasi-ordered structures extensively to create vivid colors that are weakly iridescent, e.g., the spongy nanostructures in the feather barbs of numerous birds. We mimic nature to fabricate photonic nanostructures with only short-range order. Despite the lack of long range order, light is effectively confined in such structures and it is the basis of efficient lasing in appropriately engineered devices. The laser wavelength is tuned via a structural parameter. Our recent research on lasing in biomimetic structures with short-range order will be discussed.

Time / Date: 11am / Fri 17th Feb

Room: C5C 498

Speakers: **Luke Helt** (visiting PhD student from the University of Toronto), and **Robert Williams**

Topic: Advanced point-by-point fibre Bragg gratings and applications in fibre lasers / Quantum and Classical Wave Mixing in Integrated Devices

Time / Date: 11am / Fri 24th Feb

Room: C5C 498

Speaker: **Ondrej Ketzler** and **Dr Sebastian Stark**

Topic: High average power diamond Raman beam conversion / Dynamics of ultrashort pulses in tapered photonic crystal fibers

Time / Date: 11am / Fri 2nd Mar

Room: TBA

Speaker: **Dr Will Hughes**, Garvin Institute

Topic: The challenges of trying to image events inside single cells and their disruption due to disease

QSciTech and MQPhotonics, Seminars by Dr Jim Butler

Time / Date: 2pm / Thur 9th Feb

Room: C5C 498

Speaker: **Dr Jim Butler**

Time / Date: 3pm / Fri 10th Feb

Time / Date: 3pm / Fri 17th Feb

Time / Date: 3pm / Fri 24th Feb

Topic: A Modern Alchemy: Chemical Vapor Deposition of Diamond

Dr Jim Butler is visiting Macquarie until the end of this month, under the QSciTech "Distinguished Visitor Program" and he is helping us out with the set up of our new CVD reactors for the ANFF nanodiamond facility. Jim previously worked at the US Navy Research Laboratory and is known as "Diamond Jim", due to his extensive research in the field of CVD diamond growth (over 6350 citations and a h-index of 45) and his frequent role in acting as a voice for the worldwide diamond scientific community in popular media.

During his stay he will be giving a number of talks which will consist of one introductory seminar and three masterclasses, which should be well worth attending. I would particularly recommend members of QSciTech and MQPhotonics making sure that they come along, since the talks should give you a good idea of what we should be capable of synthesizing at Macquarie soon.

Publications

Recently published articles

N Cvetojevic, N Jovanovic, J Lawrence, M Withford, J Bland-Hawthorn, "Developing arrayed waveguide grating spectrographs for multi-object astronomical spectroscopy", *Opt. Express* 20, 2062-2072 (2012)

Abstract: With the aim of utilizing arrayed waveguide gratings for multi-object spectroscopy in the field of astronomy, we outline several ways in which standard telecommunications grade chips should be modified. In particular, by removing the parabolic-horn taper or multimode interference coupler, and injecting with an optical fiber directly, the resolving power was increased threefold from 2400 μm 200 (spectral resolution of 0.63 μm 0.2 nm) to 7000 μm 700 (0.22 μm 0.02 nm) while attaining a throughput of 77 μm 5%. More importantly, the removal of the taper enabled simultaneous off-axis injection from multiple fibers, significantly increasing the number of spectra that can be obtained at once (i.e. the observing efficiency). Here we report that ~ 12 fibers can be injected simultaneously within the free spectral range of our device, with a 20% reduction in resolving power for fibers placed at 0.8 mm off centre.

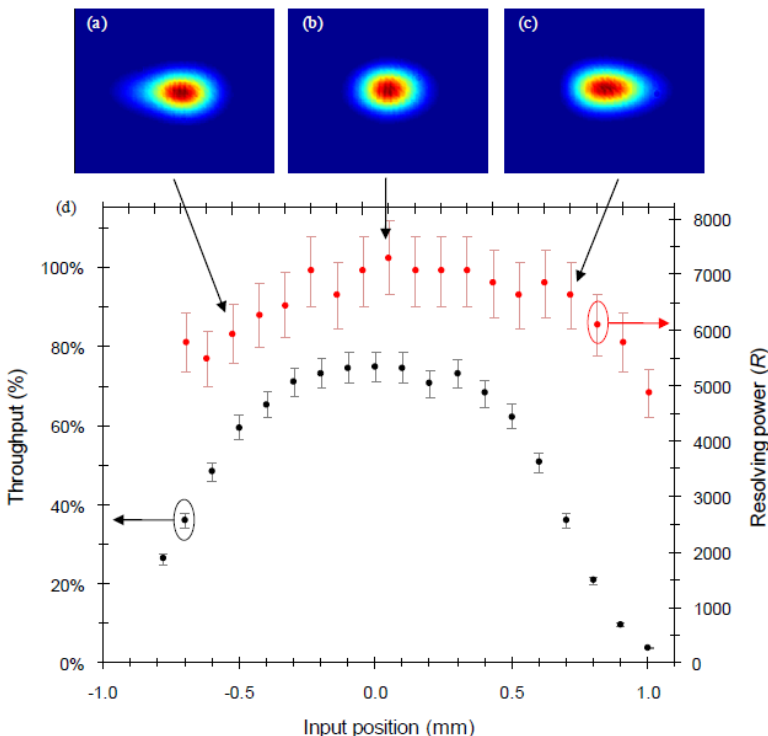
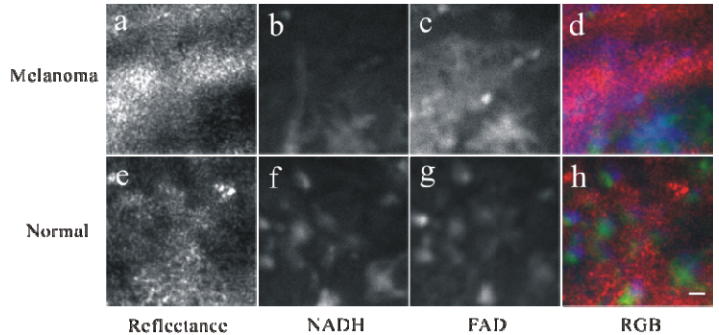
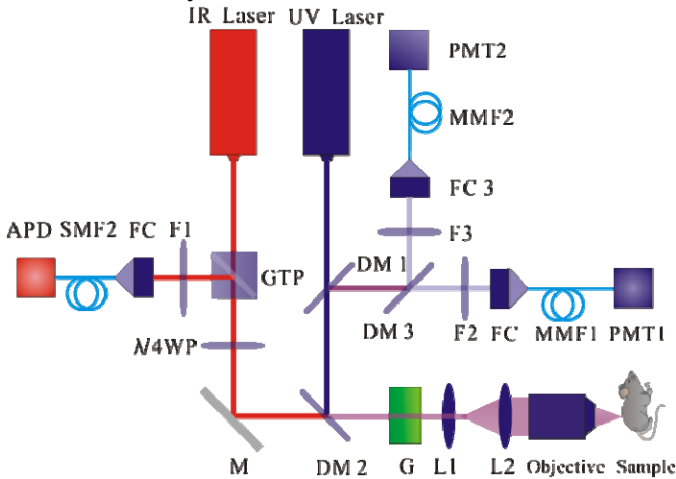


Figure 4. The resolving power is shown for input fiber positions across the input surface (red). The resolving power drops off for fibers placed further off centre. The throughput as a function of input fiber position is shown in black. The measurements were taken at 1540 nm.

T Peng, H Xie, Y Ding, W Wang, Z Li, **D Jin**, Q Ren, Y Tang, P Xi, "CRAFT: Multimodality Confocal Skin Imaging for Early Cancer Diagnosis", *Journal of Biophotonics*, (2012) DOI: 10.1002/Jbio.201100124

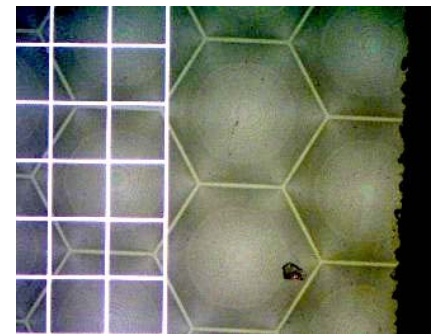
Abstract: Although histological analysis serves as a gold standard to cancer diagnosis, its application on skin cancer detection is largely prohibited due to its invasive nature. To obtain both the structural and pathological information in situ, a Confocal Reflectance/Auto-Fluorescence Tomography (CRAFT) system was established to examine the skin sites in vivo with both reflectance and autofluorescence modes simultaneously. Nude mice skin with cancerous sites and normal skin sites were imaged and compared with the system. The cellular density and reflective intensity in cancerous sites reflects the structural change of the tissue. With the decay coefficient analysis, the corresponding NAD(P)H decay index for cancerous sites is 1.65-fold that of normal sites, leading to a 97.8% of sensitivity and specificity for early cancer diagnosis. The results are verified by the followed histological analysis. Therefore, CRAFT may provide a novel method for the in vivo, non-invasive diagnosis of early cancer. The coefficients for the autofluorescence (NAD(P)H and FAD), and reflection. With the NAD(P)H coefficient analysis, the cancerous sites can be clearly differentiated from the normal sites.



People and Progress

Macquarie and AAO staff in a competitive \$6M conceptual design bid

Mike Ireland and Jon Lawrence, both with joint MQ and AAO positions, are leading a team that is designing a high-resolution spectrograph for the Gemini telescopes. Three teams were selected at \$300K each to conduct an intensive 6 month conceptual design study - the other two selected teams are US and Canadian-led. The novel part of the AAO bid has been to split each star image into many smaller images using several microlens arrays like the one shown in the picture, enabling the use of a more



compact and more stable fiber-fed spectrograph. As well as traditional optical and mechanical design aspects, the AAO bid includes comprehensive modeling of the effects of focal ratio degradation in the fiber feed, extending on the work of Macquarie postgraduate student Dione Haynes. The key results from the conceptual design will be presented at the dominant biennial astronomical telescopes and instrumentation SPIE conference in Amsterdam in July.

Mike Ireland

Supervisors stress captured at 4 microns

Dear colleagues,

I was sent this distressing image of one of our colleagues taken with the new FLIR MIR camera purchased with a RIBG. At 4-5 microns, the camera clearly reveals the extent of his stress and anxiety with students.

This camera is undergoing some basic tests but will become available to all very soon. It works from 1-5 microns and should enable the characterization of a range of new photonic devices in the years to come. It is currently housed in the astrophotonics lab (E7B219) if you want to sneak-a-peak. To use it in the short term you should chat to Mike Ireland as he is the only one who has played with it.

Nem Jovanovic



Welcomes:

We welcome **Dr Thanh Phong Vo** as a new Postdoctoral fellow in CUDOS. He has a PhD from France in which he studied the near field properties of Photonic crystals and he will continue his interest in near field scanning optical microscopy working on plasmonics in CUDOS.

We also welcome **Mr Alireza Maleki**, who has recently commenced a PhD working with Judith Dawes and Dayong Jin on nanoparticles and nanoantennas for plasmonics. Ali has a laser spectroscopy and quantum optics background and most recently completed a Masters degree in Optoelectronics at UNSW. Please make them both welcome!

Judith Dawes

Change of role:

Peter Ha has started a new role within MQ Photonics, namely Nanodiamond Facility Engineer for the Optofab Node, Australian National Fabrication Facility. Peter will be tasked with bringing online and managing a new suite of facilities enabling growth, ball milling and nano-manipulation of nanodiamond. His previous role was working with Robert Carman on ultraviolet discharge lamps.

David Inglis will be coordinating the MQ Photonics Seminar Series during Alex Fuerbach's OSP semester. The Series and I would be grateful for speaker suggestions, I am particularly thinking of your friends and colleagues from far away who will temporarily be in the area.

Mick Withford

News from afar:

Mushtaq Sobhan will soon be taking on a new post-doctoral position with Prof. Mafune at the University of Tokyo, starting April – May 2012. His research project is funded by the Toyota Motor corporation and involves synthesizing bimetallic nanoclusters in gas phase and studying its catalytic property.

New family arrivals:



Baby girl to Razia and Mushtaq Sobhan
on 11th January 2012



Baby to Wei Deng, November 2011