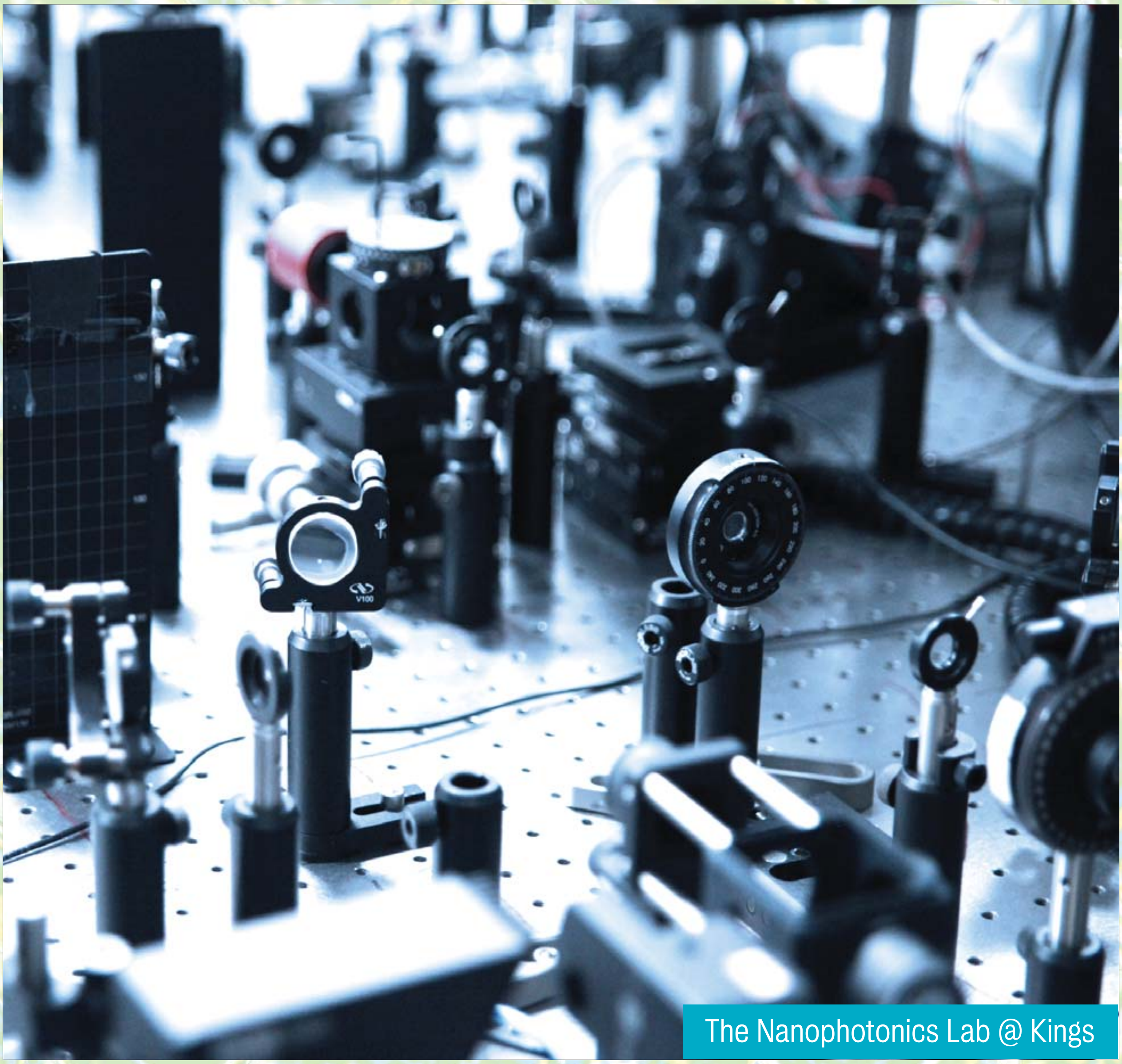
KING'S College LONDON

Faculty of Natural & Mathermatical Sciences
Department of Physics

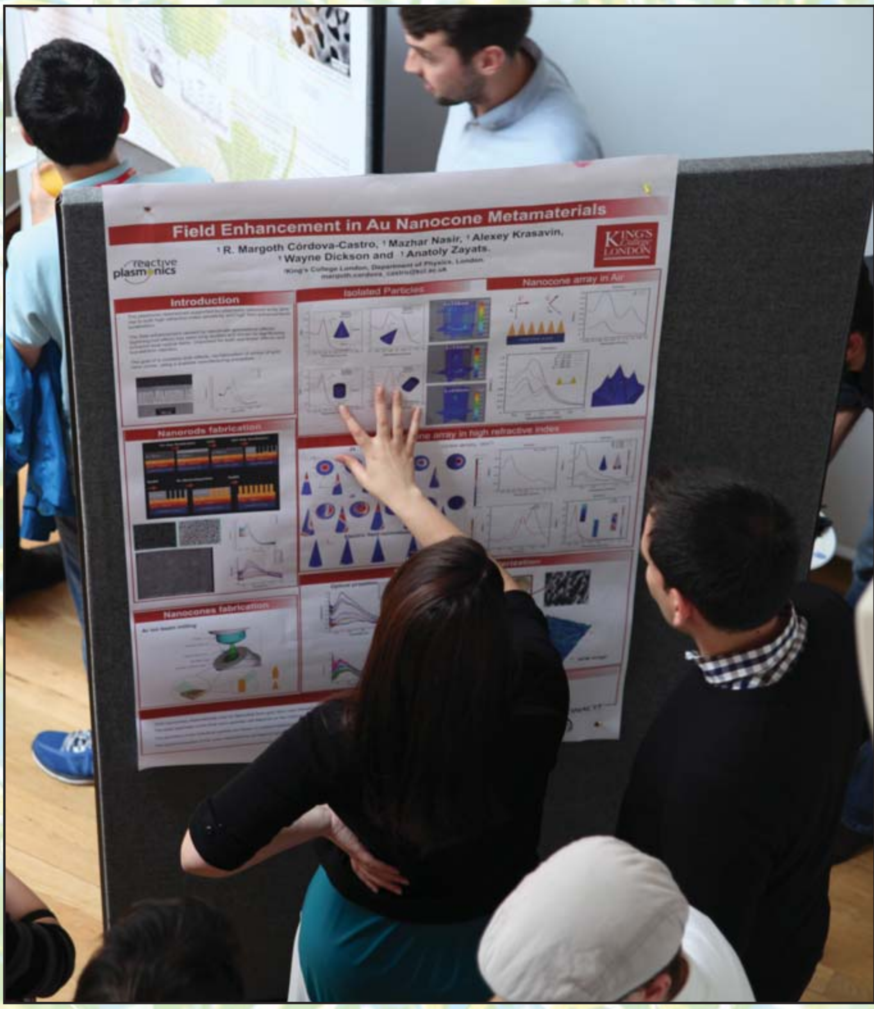
2016 Review

Nanostrand

The Experimental Biophysics & Nanotechnology Reseach Group



The Nanophotonics Lab @ Kings



Anatoly Zayats Head of EBN

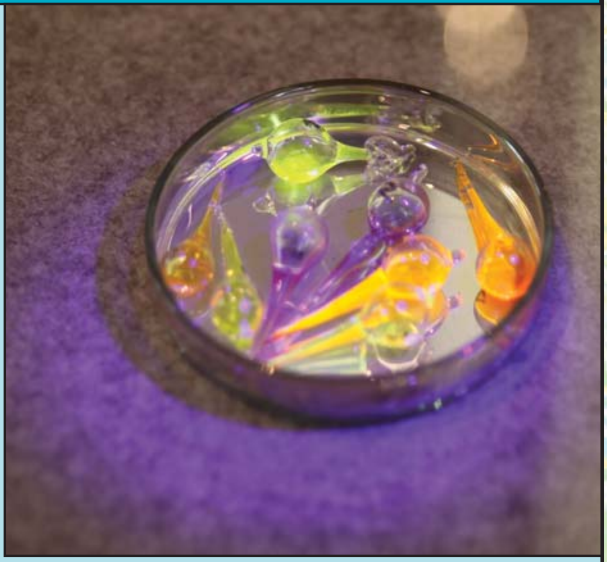
I am delighted to present this second edition of The Nanostrand with a brief snapshot of the past year. 2016 felt like a very short year despite being longer than usual. During this challenging year, EBN was busy doing cutting edge research, building new experimental capabilities in nanophotonics and biophysics and developing new academic and industrial collaborations within London, UK and world-wide. Our truly interdisciplinary EBN family has grown to over 70 researchers working on diverse topics linking biology, chemistry, materials science, and optics. Amongst notable successes, I would like mention a Leverhulme Leadership Award to Professor Sergi Garcia Manyes to work on mechanochemical biology, the ERC Starting Grant of Dr Francisco Rodrigues Fortuno to research spin-orbit interactions of light and Dr Alexander Minovich for the Royal Society Newton International Fellowship. This issue also covers several research stories from 2016 and several unforgettable events including the Wheatstone lecture and London Plasmonic Forum. In EBN, we do research designed to understand how the nature works in order to provide solutions to real world problems. Physics and Technology related research features prominently in the recently unveiled King's Strategic Vision 2029 and we all look forward to contribute to its implementation.

Welcome to NanoStrand, the newsletter for the Experimental Biophysics & Nanotechnology Group at King's College London.

The EBN is one of the three research groups based in the Department of Physics at King's College London. We build upon a rich history of experimental physics at King's where Sir Charles Wheatstone made the first electric telegraph, James Clerk Maxwell wrote his equations and developed the first colour photography, and Rosalind Franklin took the first (famous 51st) picture of DNA.

The research in the Group involves the development and applications of advanced optical and scanning-probe imaging techniques and of novel nanomaterials to address modern challenges in biological and material sciences and photonics. The Group adopts an interdisciplinary approach to provide leading-edge research in optical, mechanical and structural properties of nanostructures, underpinning their applications in nanophotonics, cell and protein imaging, sensing and soft-matter technologies.

Conjugated Polymers and why their unique optical properties make them special for nanoparticle synthesis - Struan Bourke PhD Student

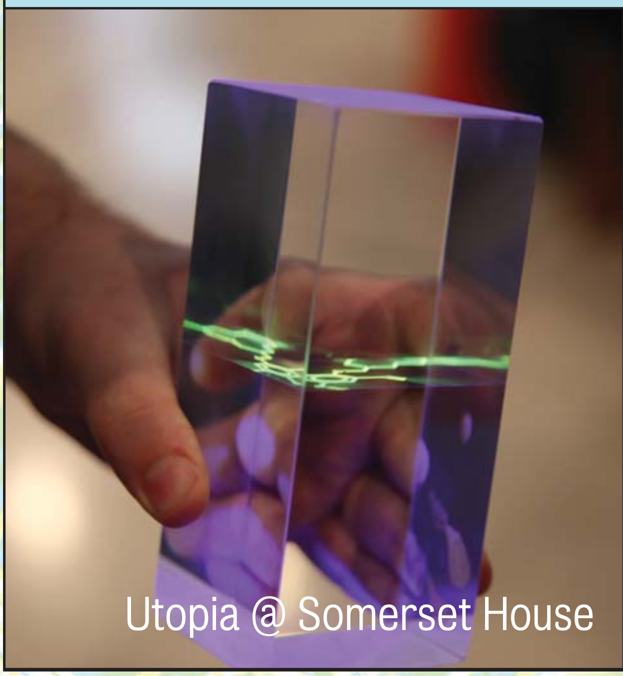


One of the most important things in developing a tool to aid in diagnostics, is having an imaging agent that continues to fluoresce and doesn't become quenched. While a number of techniques have developed software and equipment that works to enhance current probes, I am interested in the actual particles that can be used in vitro and in vivo. Which is what my PhD with Professor Mark Green is looking into. More specifically, I am looking at conjugated polymers, which are able to photoluminescence due to their unique properties.

These molecules have been studied since 1950, but it wasn't until 1977 that their optical properties were actually studied and used. In 2000, Alan J. Heeger, Alan MacDiarmid and Hideki Shirakawa were awarded the Nobel Prize in Chemistry for this work, and since then most OLEDs have emerged as applying conjugated polymers. As the polymers are plastics, there is a lot of interest in using them for: solar cells; electronic circuits; bio sensors; and flexible transparent displays. However, the work I do is turning these polymers into nanoparticles that are suitable for imaging within biological systems.

In 2013, 300,000 people were diagnosed with cancer with 150,000 people dying from cancer in 2012. There is clear evidence that if cancer is both detected and diagnosed at an earlier stage, it's possible to treat it more successfully and increase the patient's chance of survival. As well as this, I am interested in how the nanoparticles could be utilised to treat and only target the cancer cells. This means that the clinician would be able to spare a greater degree of healthy tissue which will also improve the patient. Ultimately the grand aim is to turn cancer into a treatable, and curable condition.

As part of the "Parallel Practice" (a project to demonstrate the benefits of collaboration between scientific academics and makers) I worked with Shelley James, a glass maker based in Dartford. Initially the question we wanted to answer was, could the Conjugated Polymer nanoparticles be put in glass? By blowing glass spheres, we were able to incorporate the nanoparticles into the spheres and showed that they still emitted brightly when excited by a UV lamp (above). This suggested to us that the nanoparticles remained stable in the glass, and that the glass itself didn't inhibit the unique optical properties. By utilising a 3D printer, we were able to create a mould that the glass can be melted to create the final piece (bottom left)



Newsflash

A recent article that the King's Nano-Optics team collaborated on has been selected as one of the Journal of Optics Highlights of 2016. The article 'Transformation quantum optics: designing spontaneous emission using coordinate transformations' by Jingjing Zhang, Martijn Wubs, Pavel Ginzburg, Gregory Wurtz and Anatoly V Zayats can be viewed on the IOPscience website.

Wheatstone Innovation Lab

The WLab is the brainchild of EBN's Riccardo Sapienza and Informatics Lecturuer Matthew Howard. This innovative enviromnent aims to provide an creative space where students and staff can experiment with ideas and knowlege can be exchanged. In conjuction with the Crafts Council and the Cultural Institue at King's, the Wlab hosted 'Learning Through Making', a project which aims to demonstrate the mutual benefits and value of collaboration between medical and scientific academics and makers. This years partnerships included glass maker Shelley James who used new glass techniques and experimentation to broaden learning and confidence. The Wheatstone Lab is accessible to staff and students in the Faculty of Natural & Mathematical Sciences

Creativity @ Home - How may things be different?

Reactive Plamonics is a multidisciplinary collaborative project between King's College London and Imperial College London researching nanoplasmonics and is funded by the Engineering and Physical Sciences Research Council (EPSRC). Creativty @ Home is an EPSRC initiative to generate and nurture new and creative ways of thinking that can potentially lead to transformative research. The Reactive Plasmonics Creativity @ Home journey started on a sunny October day at the Strand Campus of King's College London.

Dennis Sherwood from Silver Bullet Machine led a fantastic day where creativity was explained using Koestler's Law. Many people believe that creativity strikes out of the blue, like a bolt of lightning and that genius just happens. This means that some people go through life believing that they 'aren't creative' and therefore don't get the chance to present new ideas. Dennis explained that being creative is taking things that already exist and asking the question 'How might things be different?'

To ask the question 'How might things be different?' you have to define how things are. Once you have defined reality as it currently is, you can come up with ways to see how it can be different. It's only when you've asked the question do you know if it has an answer and if that answer is viable.

An iPhone was not a brand new idea, Apple took products that already existed (phone, music player, camere etc) then shuffled and combined different elements to create something new. This was a solution to something we didn't know we needed. Rather than carry separate elements, we now carry one piece of tech be it Apple or Android or and other smart phone.

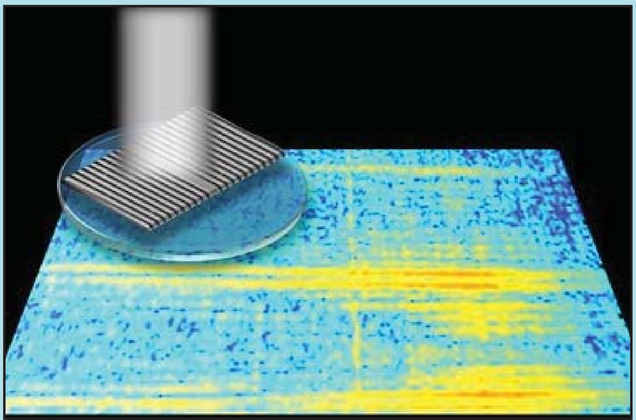
Taking part in the event has changed the way that many of the researchers think about things. To be creative you should be observant and be willing to share and listen to ideas. You will never know how things can be improved, if you never ask the question of how if might be different.

Reactive Plasmonics researchers from King's College London and Imperial College

Technology can be applied to medicine, healthcare, materials study.

original article by
Edwin L. Aguirre
UMassLowell website

Scientists from King's College London and UMass Lowell in the U.S.A have demonstrated a new way of capturing ultrasharp images of structures of extremely tiny objects measuring billionths of a meter in size.



By combining a diffraction grating (a special, finely ruled plate shown above) with a conventional optical microscope, scientists are able to dramatically increase the microscope's resolution to below the wavelength of light.

Called "interscale mixing microscopy," or IMM, the technique can obtain details in viruses and nanoparticles much smaller than the wavelength of light. Such technology would be helpful in developing new vaccines against pathogens as well as innovative nanomaterials for industrial applications and novel pharmaceutical drugs to fight diseases.

"Our research addresses a fundamental problem in the field of microscopy," says physics Prof. Viktor Podolskiy, who is the principal investigator for the UMass Lowell team. "When an object is smaller than the wavelength of light, you cannot really resolve the object's size, shape or structure. Our technique is designed to go beyond this so-called 'diffraction limit.' "

Podolskiy adds: "Sub-wavelength imaging with IMM can potentially be used to obtain the colors, or spectra, of small objects such as bacteria, viruses and nanoparticles. By knowing their color signatures we can rapidly identify and characterize the objects and determine their precise chemical composition."

The team's findings were recently published in Optica, the prestigious journal of The Optical Society. Funding for the research was provided by the U.S. National Science Foundation and the U.K.'s Engineering and Physical Sciences Research Council, Royal Society and Wolfson Foundation.

"Conventional optical microscopes, such as those found in biology classrooms and hospital labs, use lenses to bend light and form images of everything, from tissues down to dust, pollen and blood cells," explains Podolskiy. "However, objects whose size is smaller than the wavelength of light cannot be seen or even detected with these optical microscopes."
He says while other imaging techniques, such as fluorescence microscopy, electron microscopy or scanning near-field microscopy, can in principle be used to assess the properties of small objects, none of these techniques is versatile or rapid enough in imaging and characterizing relatively large objects.

"A scanning electron microscope [SEM] has a tip that scans the surface of an object point by point. You then record the backscattering of light from that tip to build up an image," says Podolskiy. "For large objects, this can take a long time."

The IMM technique uses a conventional optical microscope and ingenious signal processing to decode the object's properties based on the measurement of light that gets scattered by the object in close proximity to a special, finely ruled plate called a diffraction grating. The researchers showed that a single measurement with the grating may be enough to decipher with great precision the position, size and optical spectrum of the object.

Wheatstone Lecture 2016 - Professor Jenny Nelson FRS

The 2016 Wheatstone Lecture, delivered by Professor Jenny Nelson was entitled 'New materials for solar to electric energy conversion: Opportunities and challenges'

With climate change being one of the biggest problems that the human race is facing, the work that physicists are currently doing may help solve this problem. Professor Nelson said that solar power is abundant, sustainable, versatile and available but we need cheaper materials and technology to increase uptake and make it available to everyone. Nano- and molecular materials offer the potential for this with radically cheaper technology but there are challenges remaining at a basic level in terms of integrating this technology into the current energy system.

From left to right:
Professor Edward Byrne, President and Principal of King's College London, Professor Jenny Nelson of Imperial College London and Professors Peter Main & Anatoly Zayats of the Department of Physics at King's.

London Plasmonics Forum 2016

The 2nd London Plasmonics Forum was held on the 9th June at King's College London.

Dr Mark Gubbins from Seagate Technology gave a keynote talk on Data Storage Technology and Nanophotonics. With a growing demand for bigger data storage capacity, the hard disk drive (HDD) industry is constantly working on developing new solutions to increase the areal density of their devices.

At the heart of the next generation of HDDs is a new technology called Heat Assisted Magnetic Recording (HAMR) which is pushing up disk drive areal densities beyond 1.5 Tb/in2. The principle of HAMR technology relies on the brief and local heating of the magnetic recording media with a laser in order to lower its coercivity and ease the writing process. Here, plasmonics plays an essential role as the key component of HAMR technology is a plasmonic near field transducer (NFT) based on a gold disk acting as a localized surface plasmon resonator and a smaller peg allowing the sub-wavelength localization of the laser light via the lightning rod effect. This type of NFT benefits from the presence of a large field enhancement used to deliver enough power to the magnetic media with only small incident laser power in order to reduce self-heating of the NFT as much as possible. As thermal effects are affecting the reliability and durability of the NFTs, research towards new low-loss plasmonic materials such as metallic alloys or transition-metal nitrides could open up new routes to the development of the HAMR technology. Dr Gubbin's talk set the tone for the rest of this exciting London Plasmonics Forum by highlighting the importance and the potential of the research in plasmonics for cutting-edge technologies.

Research News

Professor Sergi Garcia Maynes has been awarded a prestigious Leverhulme Research Leadership Award. The Research Leadership Awards supports talented researchers who have successfully launched a university career but who need to build a research team of sufficient scale to tackle a distinctive research problem. This creates an opportunity for the development and demonstration of research leadership; that is, for the direction of a modest team or group, whose research may significantly change the established landscape in a particular field of inquiry. Professor Garcia Maynes and his team will be researching 'Mechanochemical biology: a force to be reckoned with'

Francisco Rodríguez Fortuño has been awarded a European Union grant entitled 'Particle-Surface Interactions in Near Field Optics: Spin-orbit Effects of Light and Optical/Casimir Forces'. Long-distance data transmission was revolutionized by photonics through the use of optical fibres. Today's communication bottleneck lies on the switching and routing of signals, which still depend on electronic processing. Ultrafast light routing at the nanoscale would provide a huge boost in bandwidth, a greatly reduced power consumption of great environmental and economic importance. The research will look at the possibilties of how Spin-orbit interactions can solve some of the problems with today's communcations.

A selection of our recent publications:

Modal Coupling of Single Photon Emitters Within Nanofiber Waveguides
Michele Gaio, Maria Moffa, Marta Castro-Lopez, Dario Pisignano, Andrea Camposeo, and Riccardo Sapienza. ACS Nano 10 (6), 6125–6130) 2016

Protein S-sulfenylation is a fleeting molecular switch that regulates non-enzymatic oxidative folding
Amy E. M. Beedle, Steven Lynham, Sergi Garcia-Manyes, Nature Communications 7, 12490 (2016) doi:10.1038/ncomms12490

Repulsion of polarised particles from anisotropic materials with a near-zero permittivity component
Francisco J Rodríguez-Fortuño and Anatoly V Zayats, Light: Science and Applications 5, e16022 (2016) doi:10.1038/lsa.2016.22

Fast live-cell conventional fluorophore nanoscopy with ImageJ through super-resolution radial fluctuations
Nils Gustafsson, Siân Culley, George Ashdown, Dylan M. Owen, Pedro Matos Pereira & Ricardo Henriques (Nature Communications 7, 12471 (2016) doi:10.1038/ncomms12471

A Bayesian cluster analysis method for single-molecule localization microscopy data
Juliette Griffié, Michael Shannon, Claire L Bromley, Lies Boelen, Garth L Burn, David J Williamson, Nicholas A Heard, Andrew P Cope, Dylan M Owen & Patrick Rubin-Delanchy Nature Protocols 11, 2499–2514 (2016)

Integrated plasmonic circuitry on a vertical-cavity surface-emitting semiconductor laser platform
Cillian P. T. McPolin, Jean-Sebastien Bouillard, Sebastien Vilain, Alexey V. Krasavin, Wayne Dickson, Daniel O'Connor, Gregory A. Wurtz, John Justice, Brian Corbett & Anatoly V. Zayats Nature Communications 7, 12409 (2016) doi:10.1038/ncomms12409

Spontaneous Emission in Nonlocal Materials
Diane J Roth, Mazhar E Nasir, Paulina Segovia, Olvera, Alexey V Krasavin, James Levitt, Liisa M Hirvonen, Brian Wells, Klaus Suhling, David Richards, Viktor A Podolskiy and Anatoly V Zayats Light: Science & Applications (2017) 6, e16273; doi: 10.1038/lsa.2016.273.

Nonlocality-driven supercontinuum white light generation in plasmonic nanostructures
A. V. Krasavin, P. Ginzburg, G. A. Wurtz & A. V. Zayats Nature Communications 7 11497 (2016) doi:10.1038/ncomms11497

Universal Switching of Plasmonic Signals using Optical Resonator Modes
Cillian PT McPolin, Nicolas Olivier, Jean-Sebastien Bouillard, Daniel O'Connor, Alexey V Krasavin, Wayne Dickson, Gregory A Wurtz and Anatoly V Zayats Light: Science & Applications 6, 2016 doi: 10.1038/lsa.2016.237

Superresolution imaging of the cytoplasmic phosphatase PTPN22 links integrin-mediated T cell adhesion with autoimmunity
Garth L. Burn, Georgina H. Cornish, Katarzyna Potrzebowska, Malin Samuelsson, Juliette Griffié, Sophie Minoughan, Mark Yates, George Ashdown, Nicolas Pernodet, Vicky L. Morrison, Cristina Sanchez-Blanco, Harriet Purvis, Fiona Clarke, Rebecca J. Brownlie, Timothy J. Vyse, Rose Zamoyska. Dylan M. Owen, Lena M. Svensson, and Andrew P. Cope, Sci. Signal., 9(448), pp.ra99-ra99. (2016)

NANOSTRAND WORDSEARCH

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BIOSYNTHESIS
IMAGING
NANOPARTICLES
OPTICAL

FLUORESCENCE
METAMATERIALS
NANOSCALE
SPECTROSCOPY

Search up, down, forward, backward, and on the diagonal to find the hidden words.

Investigator Spotlight – Dr Wayne Dickson

Wayne is a lecturer in Experimental Nanoscience at King's College London. He is a Co-investigator on Reactive Plasmonics and kindly volunteered to be the first person to be interviewed for the 'Investigator Spotlight' feature.

What is your particular research area?

My main research focus is the development and characterisation of new nanophotonic structures and plasmonic metamaterials.

What excites you the most about your area of research?

What's not to get excited about!? The optical generation of hot electrons is a relatively new field of study, and understanding the underlying physics is, in itself, exciting, but of course, one cannot help looking forward to the unforeseen applications. Plasmonically generated hot electrons have already shown promise in a number of important areas, not least water splitting for hydrogen generation, but there's much more to come. As we continue to develop our understanding of the mechanisms involved, it will enable us to optimise and design new nanophotonic and metamaterial architectures with a significant improvement in performance. From a personal perspective, harnessing the properties of new plasmonic materials (such as topological insulators) in a completely new way represents an incredible opportunity for any scientist in the field of nano-optics.

What are you currently working on?

That's a secret! Joking aside, I'm currently investigating metamaterials with a strong optical response from the deep ultraviolet to visible wavelengths using both conventional and unconventional approaches, as well as novel plasmonic metamaterials tailored to exploit hot electron processes. In order for these materials to have a sustainable impact, most of the fabrication approaches that I investigate tend to be inexpensive and scalable, a task that's not terribly straightforward on the nanoscale.

How do you spend your time outside of work?

What? Work stops? I don't have much time to devote to outside interests, but when I do have some free time I enjoy playing guitar, as well as building audio electronics as a hobby, which ties in well with my guitar playing. I'm also a keen runner, which helps me keep up with our enthusiastic undergraduate and post-graduate students!

Do you have any advice to young people who'd like to get into science?

I have the same advice that I would give to anyone who has a strong interest in any discipline, and that is to simply be led by that interest, and pursue it. In any field hard work is required and science is certainly no different, but if you relish exploring new scientific frontiers, as I do, then it seems less like work and more like a hobby.

As for practical advice, then read as much about the topics that interest you as possible, always ask questions and certainly don't be discouraged by what you don't know – science is a process of constant learning and discovery!