



SUPA PHOTONICS

2014/15

Martin Dawson and Gerald Buller

International Year of Light



- *Launch events in Paris and London*
 - 19th/20th January in Paris: attended by SUPA representatives
 - 28th January at St James's Palace: attended by many SUPA representatives
- *Launch event in Scotland*
 - 23rd February at the RSE including extensive demonstrations and keynote talks, ~ 100 school children attended during the day and ~ 200 adults in the evening
- *Other events in Scotland planned or held*
 - Light works exhibition in Edinburgh (March 2015)
 - Lecture by David A.B. Miller FRSE, FRS at the RSE (17th March 2015)
 - Eclipse event in Shetland, with talk by Giles Hammond
 - Touring light-themed "lab in a lorry"
 - "Maxwell's Baton" link between Scotland's science festivals
 - 20th Anniversary of the Institute of Photonics (4th Nov 2015)
 - Closing event with Jim Al-Khalili at Heriot-Watt University (2nd December 2015)
 - ... plus many more events being planned by SUPA universities



REF 2014



- *Strong contribution to REF 2014 results from SUPA Photonics across all partner universities*
- *Major contributor to Research Outputs and Impact Case Studies*

Individual case studies, including:

Glasgow: 'Development of ultra-stable lasers for metrology, spectroscopy and imaging'
'Optical techniques for oil and gas prospecting'

St A: 'Manufacturing and commercialisation of novel laser devices, and their applications'
'Ultrashort pulse lasers as the underpinning technology for ultrafast technology'
'Light-emitting dendrimers'

HW: 'Optoscribe, Chromacity, Helia, working with Renishaw, Selex, AWE...'

Strath: 'Creation of a cluster of innovative laser companies serving global markets'
'Market leading sales of fluorescence spectrometers for multidisciplinary apps'

SUPA and Quantum Tech



- *£270M QT Initiative by UK Government in 2013 Autumn Statement*

- Heavy SUPA partner engagement in DSTL, Innovate and EPSRC planning and scoping meetings throughout 2014
- SUPA partnerships *in all four of the QT Hubs funded*, led respectively by Glasgow, Oxford, Birmingham and York
- **Glasgow Hub** (Padgett/Beaumont) 'Quantic' on Quantum Enhanced Imaging
£23M over 5 years, with strong support from SFC (£3M) and DSTL
partners: Glasgow, Strathclyde, Heriot-Watt, Edinburgh, Oxford, Bristol
- **Birmingham Hub** (Bongs) on Sensors and Metrology
£35.5M over 5 years
partners: Birmingham, Glasgow, Strathclyde, Nottingham, Sussex, and S'ton
- **Oxford Hub** (Walmsley): NQIT, Networked Quantum Information Technologies
£38M over 5 years
partners: Oxford, Edinburgh, Strathclyde, Leeds, Camb, W'wick, Bath, S'ton, S'sex
- **York Hub** (Spiller) on Quantum Communications Technologies
£24M over 5 years
partners: York, Heriot-Watt, Strathclyde, Cambridge, Bristol, Leeds, Sheffield, Royal Holloway
- Involvement of Fraunhofer CAP in Birmingham, Oxford and Glasgow Hubs

Cross-university initiatives



- *IMPP: 'Measurement and Observation at the Quantum Limit'*
 - Virtual Centre: gravitational physics/astro-photonics ; quantum optics; solid state
 - Partners: Glasgow, Strathclyde, St. Andrews, HW and Edinburgh
 - Partner MPI's: Hannover (Gravitational Physics), Erlangen (Science of Light), Garching (Quantum Optics), Dresden (Chem Phys of Solids), Stuttgart (Solid St)
 - 3x ERC Advanced Research grants to IMPP partners: Padgett (Glasgow), Leuchs (Erlangen) and Schnabel (Hannover/Hamburg)
 - 5 workshops in relevant areas planned/arranged funded by EPSRC/STFC:
 - *Condensed matter systems for future quantum technologies (Aug 2014)
 - *Open quantum systems (Oct 2014)
 - *Macroscopic quantum coherence (June 2015)
 - *Engineering quantum states for quantum info applications (summer 2015)
 - *Optical analogues of fundamental quantum field theories
- *UK National Physical Laboratory*
 - Strathclyde (with Surrey, Huddersfield and Cambridge) took over operational responsibility for NPL on 1st January 2015
 - Regional Hub in Glasgow
 - Joint research centres: low carbon energy, quantum tech., advanced mfg.
 - Postgraduate Institute

Industrial engagement and KT



- *Fraunhofer Centre for Applied Photonics (F-CAP)*
 - Growth to 17 staff & 12 PhD/EngD students in 2014 in line with business plan
 - Students (so far) with Strathclyde, St Andrews, Heriot-Watt
 - >20 competitively won projects in first 3 years (including 14x TSB, 4x EU)
 - Total (new) project value awarded £13M of which £3.5M to Fraunhofer CAP
 - Supporting 4 successful CDTs in photonics:
 - *Applied Photonics (Heriot-Watt); *Diamond Science & Technology (Warwick)
 - *Electromag. metamaterials (Exeter); *Integ. Photonic/Electronic Sys. (UCL/Cam)
 - Royal Society/Fraunhofer 'From Mind to Market' event, May 2014
 - Fraunhofer/RAEng Research Chair in Advanced Lasers (Alan Kemp)
 - Key engagement in UK Quantum Tech initiative and supporting 3 Hubs
 - Supporting Heriot-Watt led Centre for Innovation Manufacturing
 - Partner of the International Year of Light (UK)

Industrial engagement and KT

- *EPSRC CIM in Laser-based production processes*
 - Heriot-Watt lead, with Cambridge, Cranfield, L'pool, Manchester
 - 12 industrial partners
 - £5.6M EPSRC contribution, £4.8M industrial support
- *Industry-interfacing chairs:*
 - Daniel Esser, SELEX ES Chair of Laser Devices and Engineering (HW)
 - Alan Kemp Fraunhofer/RAEng Chair in Advanced Lasers (Strath)
- *Intelligent Lighting Centre at Strathclyde*
 - linked to EPSRC Programme Grant on Ultra-parallel Visible Light Communications, £4.6M (Strath lead, with Edinburgh and St A)
- *EPSRC CDT in Applied Photonics*
 - HW lead with Strathclyde, St Andrews, Glasgow, Dundee
 - 24 industrial partners, £4.5M EPSRC contribution, started Sept.'14
- *EPSRC CDT in Integrative Sensing and Measurement*
 - Glasgow (Harvey)/Edinburgh, £4.7M EPSRC

Selected research highlights



- *Quantum photonics and fundamentals of photonics*

- Nature/Science/Physical Review/Optica journal publications include:

- Realization of quantum digital signatures w/out req. quantum memory (HW & Strathclyde)

- Ep'tal implementation of a quantum optical state comparison amplifier (HW, Strath, Gla)

- Discriminating single-photon states unambiguously in high dimensions (HW, Glasgow)

- Spatially-structured photons that travel in free space slower than the speed of light (Gla, HW)

- Coherent perfect absorption in the single photon regime (Strath, HW)

- Gravitational parameter estimation in a waveguide (St Andrews, HW)

- Triggering extreme events at the nanoscale in photonic seas (St Andrews)

- Imaging with a small number of photons (Gla)

- Single pixel infrared and visible microscope (Gla)

- Optomechanical self-structuring in a cold atomic gas (Strath)

- Inductively-guided circuits for ultracold dressed atoms (Strath)

- *Neurophotonics and Biophotonics*

- Photovoltaic restoration of sight with high visual acuity (Strath /Stanford)

- Leading developments in neurological optogenetic probe technology (GaN/Si)

- *Hybrid and Flexible Photonics*

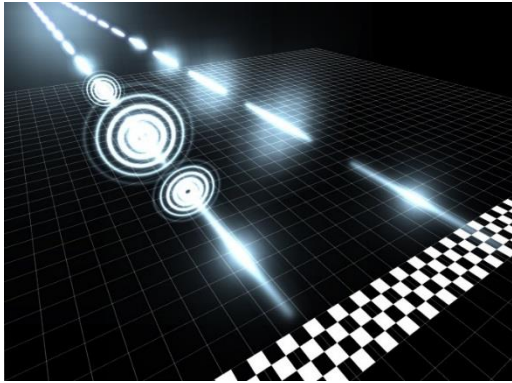
- nm-thickness single-xtal diamond platelets; printing GaN and III-P's on diamond (Strath)

- LED-based visible light communications at >3Gb/s (48 citations in less than 1 year, Ed, Strath, Gla +...): including high-definition video over 10 m using a single micro-LED

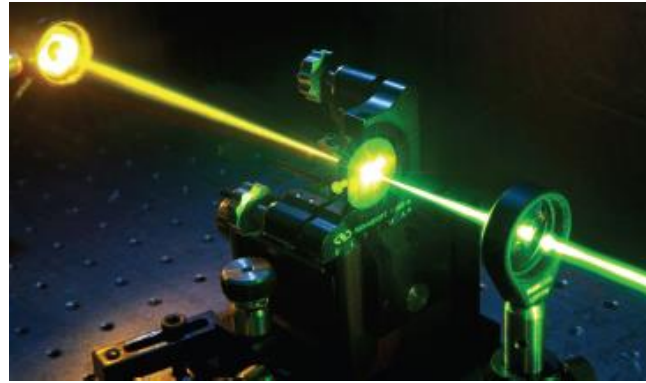
- White light visible light communications at >1Gb/s (St A, Strath, Edinburgh +...)

- Diode-pumped and mechanically flexible organic lasers encapsulated by ultra-thin glass (Strath)

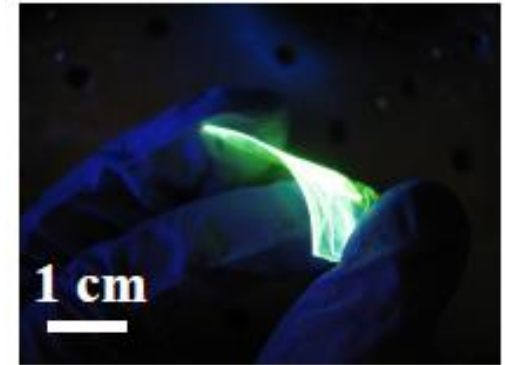
Selected research highlights



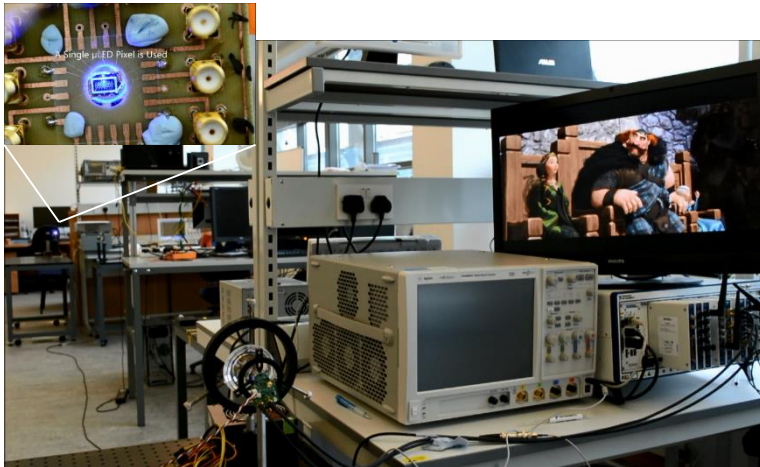
Slow light in free space



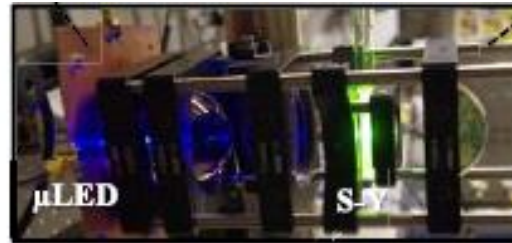
Monolithic diamond Raman laser



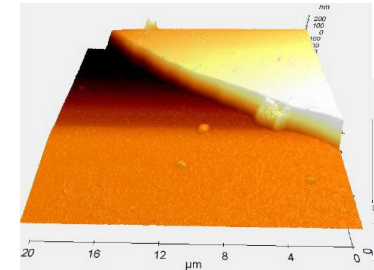
Organic and CQD lasers in flexible glass



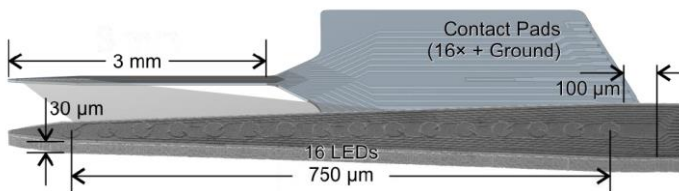
Real-time HD video trans. over 10m by VLC



LED/organic semiconductor hybrids & ultrafast white light modulation

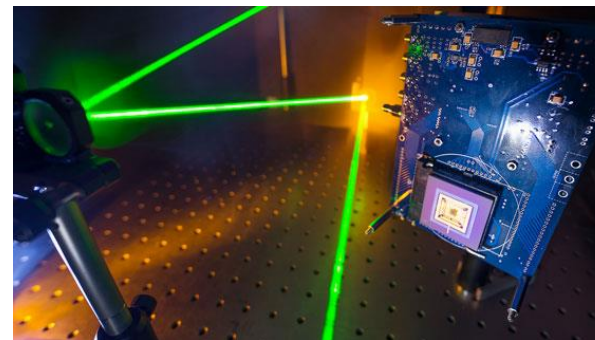


Sub- μm single xtal diamond platelets

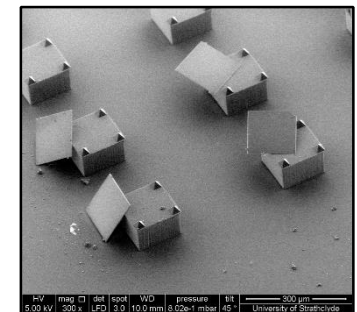


LEDs cover complete mouse neocortex

GaN/Si optogenetic probes



SPAD camera imaging



nm-accuracy transfer printing

Support/delivery mechanisms

- *EPSRC Programme Grants (PG), EU, ERC Starter & Advanced Grants*
 - Quantum Technology Hubs and associated Innovate UK support
 - Prog. Grnt. in 'Orbital angular momentum' (Padgett and Barnett: Glasgow)
 - Prog. Grnt. in 'Structured Light' (Dholakia: St. And)
 - Platform Grant 'Shaped light at the interface' (Dholakia: St A)
 - Prog. Grnt. in 'Visible Light Communications' (Dawson: Strath)
 - ERC Advanced Grant 'Twists and more' (Padgett: Glasgow)
 - ERC Starter Grant 'Advanced bioderived and biocompatible lasers (Gather: St A)
- *International Engagement and Profile Raising*
 - International Max Planck Partnership
 - Scotland-Stanford (SU2P) EPSRC Science Bridges Programme
 - Fraunhofer Centre for Applied Photonics

Major awards/marks of esteem

- Padgett: Prize for Research into Science of Light (2015)
- HW/Glasgow: 'Creative cameras' at Royal Society Summer Science Exhib. 2014
- Dawson: Rank Prize Lect. (2014) & Exhibit at RS: Science for a Successful Nation 2015
- Trager-Cowan: Fellowship of the RSE (2014)