UK NATIONAL
QUANTUM
TECHNOLOGIES
PROGRAMME

QUANTIC

The UK Quantum Technology Hub
in Quantum Enhanced Imaging

Making the invisible visible

QuantIC is the UK Quantum Technology Hub in Quantum Enhanced Imaging bringing together scientists, engineers and industry to collaborate on the next generation of ground-breaking imaging technologies. We are part of the UK National Quantum Technologies Programme which aims to translate cutting edge quantum science into game changing applications.

Our imaging technologies have the potential to deliver improved performance, lower cost and new applications across a variety of sectors, including defence and security, autonomous vehicles, scientific instrumentation, agriculture, oil and gas, environmental monitoring, medical imaging and space.

Our research focus includes:

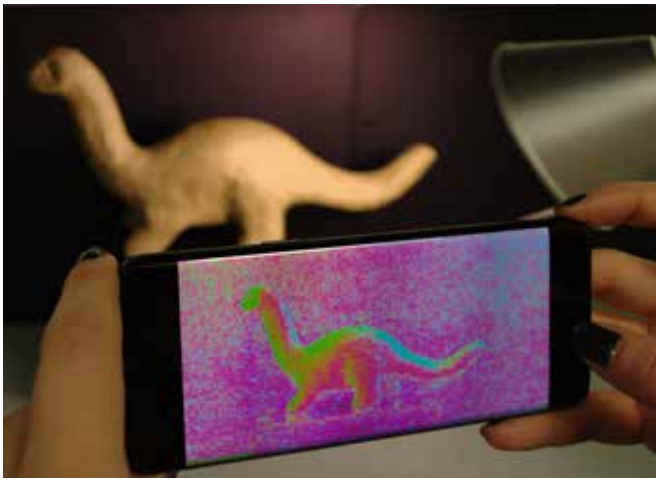
- Real-time 3D imaging in scattering media using SPAD arrays
- Underwater sparse-photon imaging
- Non-line-of-sight imaging
- Imaging through the body
- Imaging through single-fibres
- Quantum illumination microscopy
- Sub-shot noise imaging
- Few-photon spatio-temporally correlated imaging
- Gas sensing without detection

Innovation

Collaboration is central to innovation at QuantIC and we work in close partnership with industry throughout the technology development process, from proof of concept in the early stages of innovation, to field testing, system and component prototyping and commercialisation. Some of the Industry partners we have worked with include Leonardo, Thales, Lockheed Martin, ST Microelectronics, M Squared Lasers, Horiba, Clyde Space, Gooch and Housego and Dstl.

Automated 3D video surveillance

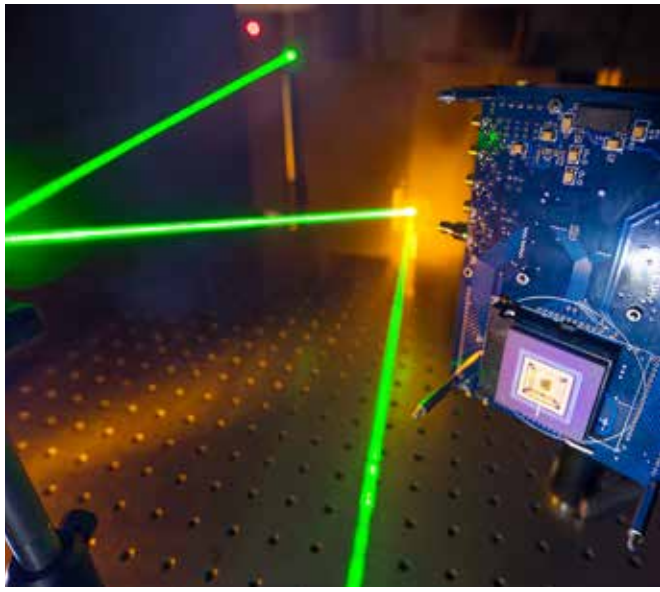
QuantIC researchers at the University of Strathclyde have developed micro-LED arrays which offer unparalleled frame rates and energy efficiency. In collaboration with Aralia, we are investigating the feasibility of employing LED visible light sources to simplify the hardware of 3D capable surveillance systems. This imaging system allows reconstruction of the topology of the scene and greatly improves the automated video analytics task. The introduction of visible LED sources will offer significant cost benefits to the system, increase covertness and provide the opportunity for further system functionality including LiFi communications and position sensing.



Quantum LiDAR

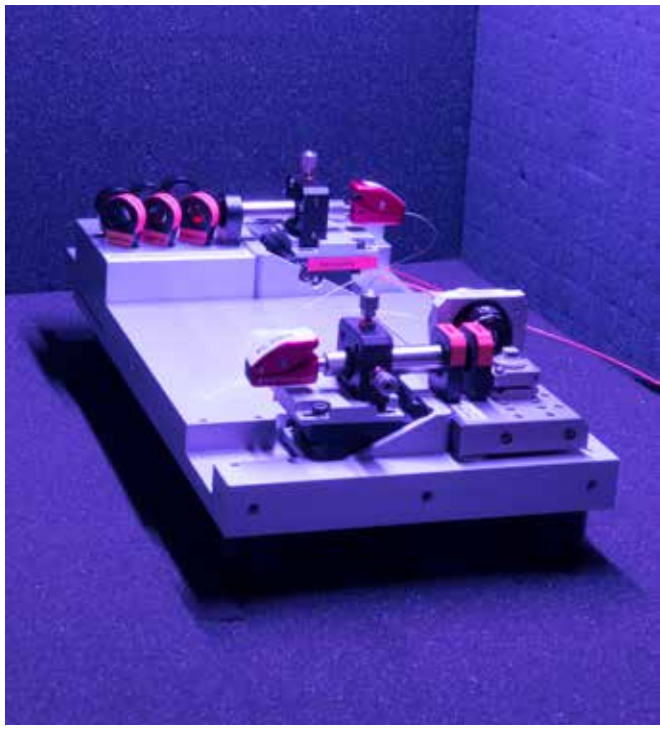
ID Quantique is collaborating with QuantIC on developing a new form of 'intelligent' LIDAR (i-LIDAR) that offers the potential to introduce a paradigm-shift in the way LIDAR is performed relying on a single pixel and AI data processing. Working with quantum imaging and computational experts at the University of Glasgow (UofG) the research is demonstrating that the temporal information encoding of photon arrival times on just one SPAD pixel is potentially sufficient to build a full 3D image of the scene.

The advantages of this approach are: (i) no need for scanning parts; (ii) potential for a very compact device, essentially limited only by laser size (single pixel SPADs or single-point SPAD arrays are already employed in cell phones); (iii) potential for multi-kHz frame rates due to absence of scanning parts.



"Blu" Source

Building on their success in near infrared sub shot noise imaging in their "Q Source" project, QuantIC researchers at the University of Bristol have developed a revolutionary source that produces micro-watt level blue quantum light for sub-shot noise imaging and sensing, bright enough to see with the naked eye. By increasing source brightness by several orders of magnitude and moving to novel wavelengths, the Blu Source unlocks new capabilities in high-precision quantum imaging of biological samples at near-UV wavelengths for medical and life science applications.



16 Channel Time Tagger

QuantIC researchers have also developed a multi-channel time-tagger technology, capable of timing single photon events in 16 channels with 24ps RMS resolution using USB3 interfacing to extend tag rates to 40 million per second. Applications in multichannel fluorescence lifetime and multiphoton quantum information experiments are being explored.

Industrial Field Testing

As research is translated into new technology, it will have to move out of the lab and be tested in real-life scenarios to determine its feasibility and opportunity for market commercialisation. QuantIC has worked with industry to facilitate field trials for its research. For example, working in collaboration with Lockheed Martin and Sikorsky Helicopters, QuantIC researchers at Heriot Watt University brought their quantum state imager to the NATO White-out trials in the Swiss Alps to field test the system and its ability to see through scattering media in a real-world scenario. QuantIC's Wee-g, a tiny gravity sensor for subterranean imaging application, has also seen significant industrial interest from companies like QinetiQ, Bridgeport, Schlumberger and Clyde Space and is undergoing field trials.

Wee-g: an ultra-sensitive gravity imager

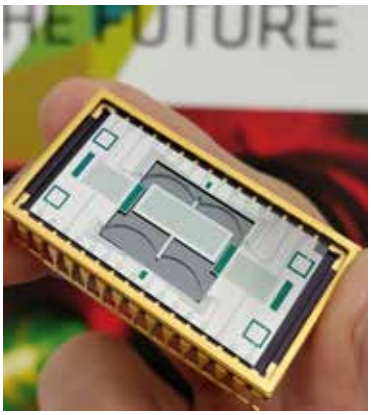
Accurate measurements of gravity enable the detection of subterranean variations in density. Gravity surveys are therefore regularly used for oil and gas prospecting, environmental monitoring and security applications. The use of gravimetry for these applications, however, has been limited by the high cost and size of existing equipment. There is a gap in the market for cheaper, smaller (yet sensitive) devices that can be used to provide high-resolution gravity maps at a fraction of the cost.

QuantIC researchers at the University of Glasgow have developed Wee-g: a compact, ultra-stable, Micro Electro Mechanical System (MEMS) based gravimeter capable of measuring tiny changes in the gravitational field. This device will enable entirely new imaging modalities – networks of gravimeters will be used instead of making single point measurements; and airborne gravity surveys could be carried out on UAVs instead of aeroplanes.

Wee-g has undergone field trials through a QuantIC Partnership Resource funded project with Bridgeporth, a specialist geosciences company. These trials have shown the device is capable of monitoring changes in gravity while outside in harsh environmental conditions. Wee-g is now being used to create the first volcano gravity imager at Mount Etna – as part of an H2020 project called 'NEWTON-g'. Tens of devices will be networked around the volcano to monitor the movement of magma under the volcano in real time. Work is also underway on a UAV-mounted sensor, and a sub-sea version for coastal monitoring. In addition to Wee-g, we are also working on another device: 'Wee-Grad', which measures gradients in gravity. This device is being made in partnership with Clyde Space, and will be used to determine the attitude of small satellites.

Imaging Component Prototyping

QuantIC has developed a range of prototype component technologies fom imaging sensors with increased sensitivity to single photons at challenging wavelengths and higher count rates, to integrated SPAD detectors which allow imaging at multiple wavelengths simultaneously. Our prototype components have game changing applications across a number of industry sectors such as life sciences, security and defence, environmental monitoring and autonomous vehicles and we are seeking collaborative opportunities to further develop these component prototypes for commercialisation.



Wee-g

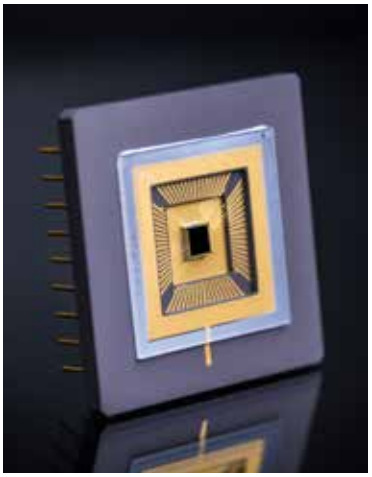
Wee-g is a compact, ultra-stable Micro Electro Mechanical Systems (MEMS) based accelerometer capable of measuring tiny changes in the gravitational field.

Potential applications

Oil and gas prospecting / environmental monitoring and volcanology / detection of underground structures / navigation

Present performance specs

Has sufficient stability and sensitivity to monitor the Earth tides (200μGal) over several days
Short-term acceleration sensitivity: <10 μGal/sqrt(Hz)
Thermal stabilisation control: <1mK over several days
Field demonstrator: 12 V battery powered system, <5 kg in weight



QuantICAM SPAD

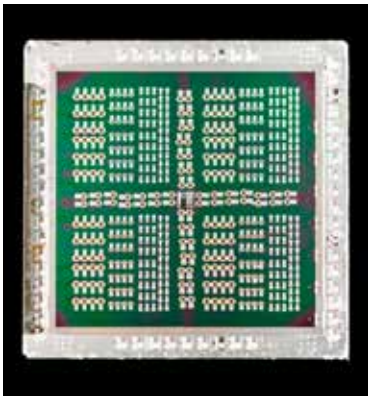
Miniaturised single photon detectors based on CMOS fabrication technology offering both single photon sensitivity and high precision time of arrival detection. There are currently two versions – (V1) 192 x 128 40nm TCSPC SPAD and (V2) 256 x 256 40nm/90nm CMOS 3D stacked SPAD.

Potential applications

LIDAR / fluorescence imaging / optical communications / security and defence

Present performance specs

(V1) Pixel pitch 18.4 x 9.2 μm with a fill-factor of 13%, timing range of 135-491ns, resolution tunable from 33-120ps and frame rate of 18.6k fps. Total sensor power consumption <10 mW (for count rates below the sensor pile-up limit) to 140 mW under high illumination.
(V2) Pixel pitch 9.2μm with a fill-factor of 51% and time-to-digital (TDC) resolution 35-560ps, offers 64 x 64 image resolution for LIDAR measurement for wavelengths up to 671nm and 50m imaging range. Peak sensor power consumption is at 77.6 mW.



Ge on Si SPAD

A low-cost technology that allows infrared single pixel and large pixel array cameras to be manufactured using widely available standard silicon processing.

Potential applications

LIDAR / medical imaging / quantum communications / security imaging

Present performance specs

Single photon detection up to 1450nm wavelength (to date)
Currently working up to 200K – targetting >250K for 1550nm wavelength operation.
At 125K maximum 38% efficiency (better than available InGaAs/InP SPADs)
Jitter < 130ps – ideal for LIDAR
Dark count rates of 3KHz at low temperatures

Fresnel Cones

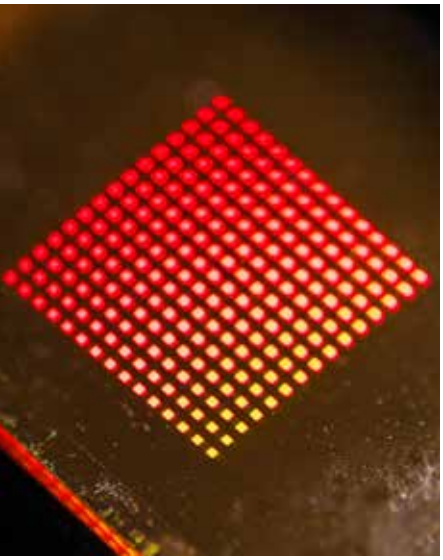
Fresnel cones offer a low cost, innovative method of generating structured polarisation beams with improved focussing to achieve increased resolution and peak power.

Potential optical applications

Precision manufacturing / nanotechnology / 2-Photon Microscopy

Present performance specs

2-Photon microscopy resolution increase from 500nm down to <300nm
Non- linear techniques should achieve further resolution enhancement



Plasmonic Polarimetry

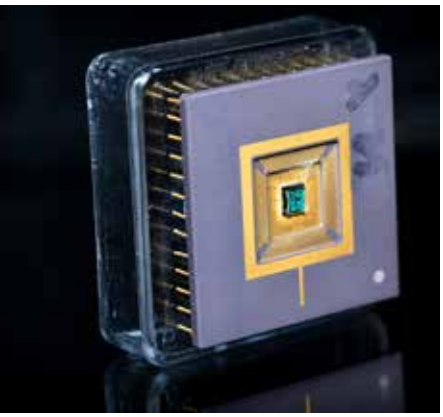
Plasmonic Polarimetry is a new form of rapid, label-free spectroscopy using a disposable sensor slide (shown on the left) and a microscope instrument that performs measurements of the slide. The technique depends on quantum interactions between illuminated nanostructures and biomolecular structure to provide vital information on the difference in the structure of proteins and detection of protein interactions. This will enable a new tool for better understanding protein-protein interactions and new technology for rapid diagnostics.

Potential applications

Bio-sensing / polarimetry / medical diagnostics / drug discovery

Present performance specs

The instrument is capable of measuring resonance peak positions with an error of <0.1nm and optical rotation dispersion with an error of <0.2 degrees. It can measure between 500-900nm of the VIS spectrum and measurement times are estimated to be ~5-20mins depending on the settings. The whole package for biosensing is able to detect binding events spatially over square shaped areas of lengths between 100-5000 micrometers and can detect picomole quantities of proteins.



Mosaic Filter Array

QuantIC has used a flip-chip bonding technique to develop a discrete, fully integrated component consisting of a SPAD array chip and mosaic filter allowing images from multiple wavelengths to be acquired simultaneously.

Potential applications

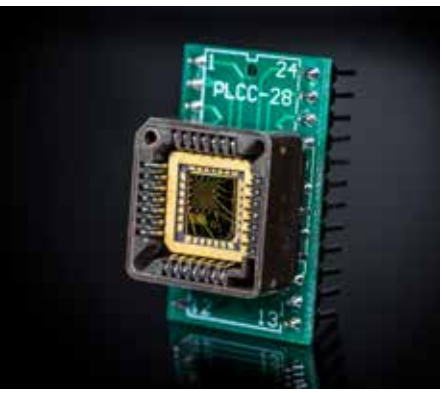
Multi spectral imaging

Present performance specs

Integration approach for mosaic filters with SPAD arrays sustainable even at very small pixel diameters (ie < 10 µm)

No performance degradation with fast illumination (ie f/2) in camera lens configuration

Operating at wavelengths of 460-1000nm



IndiPix™

IndiPix™ is a low cost and portable mid-infrared imager based on a unique indium antimonide pixel technology which eliminates the need for a flip-chipped read-out integrated circuit.

Potential applications

Gas sensing / bio-imaging / agricultural and environmental monitoring

Present performance specs

Resolution and frame rate, 64x64 pixel at 80 fps

Chip size 10x10 mm, Pixel pitch 110x110 µm, fill factor 25%, integrated multiplexing electronics

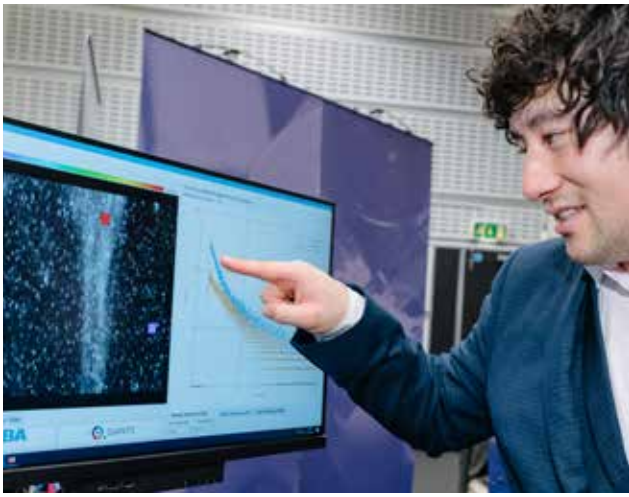
Technology is scalable to larger arrays in production

28% quantum efficiency at room temperature

QuantIC Marketplace

QuantIC's ultimate aim is to translate its cutting edge research into technology that is ready for commercialisation either through industrial collaboration, joint ventures or spinouts. A number of our technologies are already available.

FLIMERA : Wide field fluorescence imaging (FLIM) camera for microscopy



QuantIC and Horiba Jobin Yvon IBH in Glasgow have developed a novel molecular camera which enables real-time video rate studies of the fundamental cellular processes that are critical to biology and healthcare.

The FLIMERA uses the QuantICAM, a 192 x 128 pixel array developed by QuantIC researchers at University of Edinburgh, which allows each pixel to have an individual detector and its own time-correlated single-photon counting (TCSPC) timing circuitry. Horiba has developed bespoke firmware and software and integrated it into existing commercial system to produce a wide field FLIM camera for microscopy. The parallel nature of the fluorescence data acquisition means that it is over an order of magnitude faster than conventional scanning FLIM microscopes. The result enables real time video rate FLIM to be realised, thereby permitting the study of mobile samples such as live cells and fluid biopsy for cancer screening.

About Horiba Jobin Yvon IBH Horiba Jobin Yvon IBH Ltd manufactures software and instrumentation for time-correlated single- photon counting (TCSPC). IBH pioneered the TCSPC industry for the measurement of time-resolved fluorescence. Originally a Strathclyde University spin-out the company was acquired by HORIBA in 2003 and is now the market leader in time-resolved fluorescence systems worldwide.

HORIBA Scientific

QLM Technology: Quantum optical Tunable Diode Lidar for gas detection

QLM is a start-up founded by QuantIC researchers at the University of Bristol working to help limit pollution and greenhouse gas emissions by developing compact, high-sensitivity, low-power, Tuneable Diode Lidar (TDLidar) gas detection and imaging systems based on single-photon detection that are far more cost effective and practical than existing products.

www.qlmtec.com

QLM

Collaborate with us

QuantIC is keen to work with companies in identifying potential applications and industrial challenges where our imaging research may be able to address or provide a competitive edge and be developed into new technology. We can offer:

Funding
Our Partnership Resource Fund is designed to accelerate technology uptake by industry through supporting industry-led projects and two-way staff secondments.

Innovation Space
We have a dedicated Innovation Centre at the University of Glasgow which offers laboratory and hot desking facilities where companies can work alongside our researchers to accelerate technology development and exploitation.

Industrial Studentships
We offer a fully funded Industrial Studentship Programme which is designed to develop both academic and technical excellence in the next generation of quantum engineers.

For more information and to discuss industrial opportunities, please contact:

Kevin McIver
QuantIC Business Development Manager
Kevin.Mciver@glasgow.ac.uk
Tel: 0141 330 4080

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QuantIC Innovation Space
James Watt South Building
University of Glasgow
Glasgow, G12 8QQ

info@quantic.ac.uk
quantic.ac.uk
@QuantIC_QTHub