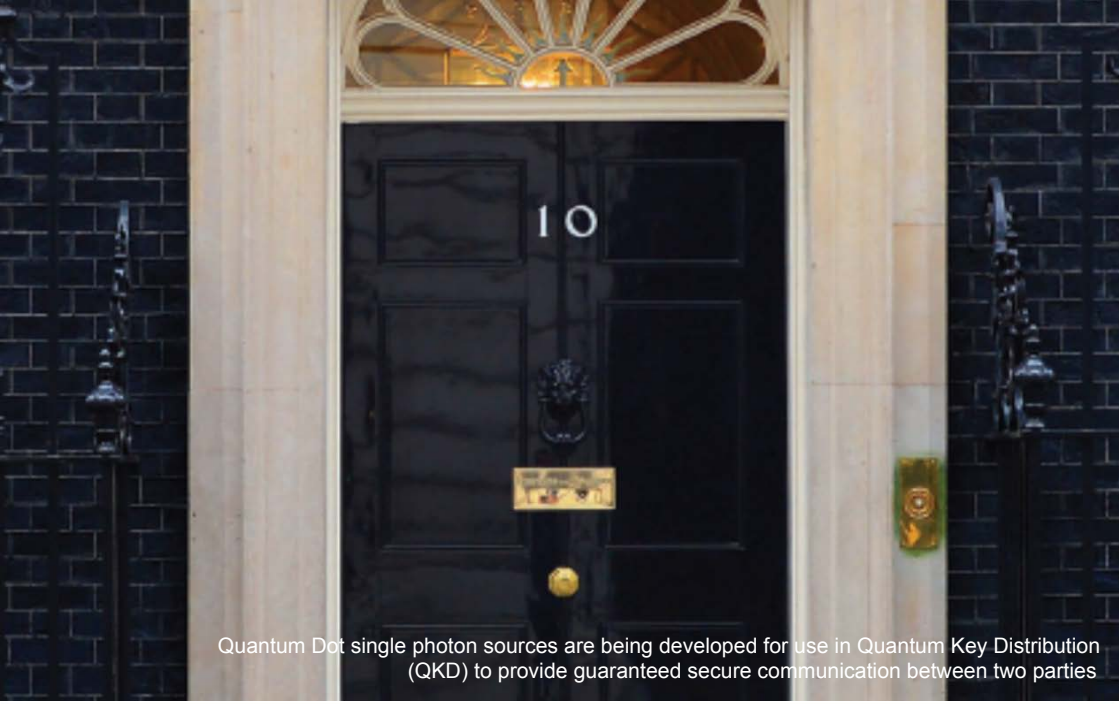

Quantum Dot single photon sources are being developed for use in Quantum Key Distribution (QKD) to provide guaranteed secure communication between two parties

NATIONAL EPITAXY FACILITY | EPSRC Engineering and Physical Science Research Council

UNIVERSITIES OF SHEFFIELD, CAMBRIDGE AND UNIVERSITY COLLEGE LONDON

Case Study - Semiconductor Quantum Dots

Quantum Dots are zero-dimensional structures which exhibit unique physical properties due to quantum mechanical effects. They have found applications across a huge range of semiconductor devices including lasers, LEDs, detectors, electronics, and fundamental quantum physics. Semiconductor quantum dots are typically fabricated by epitaxial methods or colloidal chemical synthesis methods.

Challenge

The epitaxial growth of Quantum Dots has been a subject of intense research for over 30 years. Much has been learned about the mechanism by which Quantum Dots form on a semiconductor surface and particularly the role of strain in the semiconductor layers during epitaxy.

Although there is a wealth of knowledge about the growth mechanisms, there remain major challenges in controlling the formation of dots; and issues such as precise control of the location and size of quantum dots is the subject of on-going research.

In addition, the formation of dots in different materials leads to new physical properties such new optical bandgaps or electrical transport properties. Incorporation of quantum dots in devices such as lasers has led to major advances in properties such as tempera-ture dependence of lasing and optical modulation speed. Control of dot formation is equally important in controlling these properties.

Solution

The National Epitaxy Facility has developed Quantum Dot Epitaxy and devices for over 20 years. We have developed Quantum Dots across a range of materials including InAs, InP, dilute nitrides, Sb-compounds and GaN.

Dot have also been incorporated in devices with unique and record perform-ances and underpin a large number of research grants, and industrial support.
Key factors allowing the National Epitaxy Facility to have a leading position in this technology are:

> Both MBE and MOVPE available for Quantum Dot Growth

> Large range of materials across Arsenides, Phosphides, Antimonides, and Nitrides

> Excellent characterisation facilities to allow for the optimisation of growth and targeted properties for the Quantum Dots

> Full fabrication facilities for devices and structures that enhance the properties of Quantum Dots

Notable achievements from the National Epitaxy Facility are:

> InAs QDs with densities from 108 cm-2 to >1010 cm-2. The low dot densities are very important for single dot spectroscopy and Quantum Technologies

> Demonstrated InAs and InP QD lasers with record performance across a range of wavelengths from visible to 1.3/1.55 µm wavelengths

> QD LEDs and amplifiers with emission and gain spectral band width >250nm

>Single photon emitters based on InAs QDs with linewidhts of <2 µeV

> Demonstration on-chip Quantum Technology for single photon entanglement in InAs Quantum Dots – a major contribution to an EPSRC platform grant on Quantum Circuits

Conclusion

The National Epitaxy Facility has wide ranging expertise and capability in quantum dot science and technology that is available to researchers and industrial customers in the UK. The National Epitaxy Facility continues to work with academic partners developing the technology further for both fundamental studies and applications.

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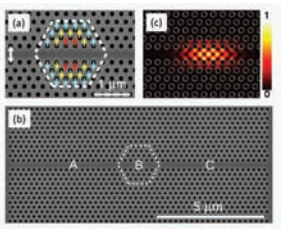
New directions include extending wavelengths using new materials for Quantum Dots, controlling the shape, size and positioning of Quantum dots through fundamental study of the growth dynamics, developing single photon emitters as the basis for fundamental observations of quantum mechanical effects such as entanglement and teleportation, demonstrating applications for broad band emitters, developing new lasers based on better control of Quantum Dot epitaxy and exploring new materials that exhibit spontaneous dot formation.

We welcome the opportu-nity to work with you in new areas that use and develop quantum dot science and applications through our comprehensive expertise.



Single InAs quantum dots in a photonic crystal waveguide exhibiting strong coupling

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