Poster Session 1: Monday 1 September (18:00-19:30, Queen’s Tower Room)

General

P.53 A strain-tunable quantum dot embedded in a nanowire antenna

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Quantum dots (QDs) embedded in photonic nanowires have proved promising as sources of single photons [1–3] for applications in quantum information protocols. Investigations have shown that the brightness of these light sources depend on the diameter and taper of the nanowire as well as the axial and lateral position of the quantum dot dipole within it. In addition to efficient collection of the spontaneous emission into a single optical mode, a crucial requirement for scalable quantum dot devices is spectral tunability, e.g., to facilitate the generation of indistinguishable photons from remote QDs. Such spectral tunability has not been previously demonstrated for nanowire QDs.

Here we demonstrate a highly efficient strain tuneable single-photon source comprised of a single QD embedded in a nanowire waveguide integrated onto a piezoelectric crystal. The nanowires are deterministically fabricated via top-down plasma etching into a stretchable GaAs membrane containing QDs. We observe photon collection efficiencies as high as ≈ 57% and a mean of 13±10% for 40 quantum dots in 16 nominally identical nanowires. At low excitation powers, resolution-limited linewidths are observed. However, at high excitation powers, increased inhomogeneous linewidths and DC Stark shifts are observed due to filling of nanowire surface states leading to lateral electric fields. Finally, we demonstrate reversible strain tuning of single exciton states in the devices of up to 1:18meV, with average tuning slopes of 39±31µeV/Vpiezo for 25 quantum dots in nanowires. These results are promising for future technologies requiring a bright but tunable source of single photons.

General

P.54 Microdroplet rheology with Optoelectrowetting
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The rheological properties of a cell can be an important bio-marker for its state of health and can also provide information about the cell's possible fate with cell stiffness being linked to the differentiation of stem cells and the metastatic potential of cancerous cells. Using synthetic biology techniques it may be possible to re-create the mechanisms that result in a change in cell stiffness and thus elucidate the pathways associated with a pathologic outcome.

Opto ElectroWetting (OEW) uses a photoconductive device to allow an optical pattern to be converted into a pattern of electrical field across a dielectric layer under a droplet. This allows the deformation of droplets, similar to other electro-wetting on dielectric devices, but with the additional control of being able to move the light and hence the electrical pattern. In this way individual or multiple microdroplets can be interrogated in a controlled reproducible fashion producing an ideal technique to measure their viscosity.

In this paper we present the first use of OEW to measure the viscosity or the interfacial tension of a microdroplet. This technique could be used on cell like microdroplets containing synthetically engineered components. After using OEW to deform the droplets of interest we then measure their relaxation to their original shape to gain an understanding of the system's rheological parameters. In particular, we have measured the relative rate of change of the droplet's diameter for two solutions (continuous/disperse phases): oil/water and oil/(water+10% glycerol). We found that the ratio of relaxation rates for the two systems is 1.7, which is in good agreement with the ratio of droplet diameter multiplied by the viscosity of disperse phase of the two systems, i.e 1.6; giving an error of just 6% between the results and those theoretically predicted.
P.55 Nanocrystal lasing dynamics probed with tunable optical microcavities

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We present progress in the use of tuneable, open access optical microcavities containing thin films of semiconductor nanocrystals to develop a detailed understanding of the dynamics of the nanocrystal lasing process. By measuring the dependence of the lasing threshold on the spectral position of the cavity mode we can infer information regarding internal photo-physics of the lasing process such as the balance between absorption and emission processes in the pumped system. We also examine the threshold as a function of other parameters such as nanocrystal packing density and film thickness of the quantum dots to provide further insight into the lasing dynamics of the system as a whole. It is hoped that this will inform the development of optimal resonant optical feedback structures and of nanocrystal materials with reduced gain thresholds.

We will report lasing using CdSe/CdS core shell nanocrystals with a measured pump pulse energy threshold of order 120 pJ (at 400 nm), corresponding to an average pumped exciton population per nanocrystal of about 5, and describe these results with an intuitive cascade model of exciton relaxation in which gain is preserved over multiple Auger lifetimes. Ultrafast transient absorption measurements reveal Auger rates of order 200 ps and provide further information about the relaxation process.
General

P.56 Optical study on the affect of defect filters on the emission of InAs QDs grown on Si substrates

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For many years integration of optical components on the same chip as electronic circuitry has been seen as the ‘holy grail’. Significant progress has been achieved with the realisation of waveguides, modulators, splitters and detectors. However, light sources have always been problematic due the indirect nature of the Si bandgap. Growing III-V materials directly onto Si is a method to overcome this, but is difficult, not least, because of the large difference in lattice constant between e.g. GaAs and Si. This lattice mismatch results in the formation of a large number of defects in the active layers, degrading optical efficiency. The inclusion of a defect filter layer (DFL) just above the Si / III-V interface can ameliorate this problem. By moving defects laterally they are able to annihilate, reducing their density in the active layers.

The effects of different DFL designs based on strained QWs or QD layers, on the optical properties of subsequently grown quantum dots are studied. The samples are characterised using broad area (BA-PL) and limited area (LA-PL) photoluminescence at room and low temperature. Optimum emission efficiency is obtained for a DFL based on AlInAs strained QWs.
P.57 Novel trapping potentials for ultracold atoms using radio-frequency and microwave dressing: ring-traps and self-trapping 2D periodic potentials

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Atom-chips are flexible platforms for trapping and manipulation of neutral ultracold atomic matter, where a combination of inhomogeneous DC and AC magnetic fields tailors the atomic potential landscape to a fraction of a micron. Spatial modulation of the fields occur naturally at close proximity to their sources (e.g. current-carrying conductors and permanent magnets). This sets the device working distance to the same range as the scale of the trapping elements, i.e. between 1 – 10s microns. This condition makes atom-chips a convenient technology for realizing hybrid quantum systems where atomic degrees of freedom are coupled to quantum devices such as plasmonic excitations \cite{1} and quantum point contacts \cite{2} or superconducting flux qubits \cite{3}.

In this work we describe two atom-chip designs that produce self-trapping potential landscapes with interesting geometries. Both designs rely on the dressing of the hyperfine structure of the ground state of alkali atoms, which allows us to define complex adiabatic potentials. The first proposal demonstrates a multiply-connected trapping geometry (ring trap) produced by inter-manifold dressing of Zeeman split states, where the intensity of the dressing field is modulated by inductive effects over a microstructured conducting ring \cite{4}. The second application consist of a periodic potential that results from an intra-manifold coupling of Zeeman split levels. In this last case, the required spatial dependence of the fields is produced by a pair of crossed arrays of current-carrying wires \cite{5}. In both cases, we demonstrate its feasibility for experimental realization with currently available technology.

\begin{thebibliography}{9}
\bibitem{5} Sinuco-Leon, et al., \textit{in preparation}.
\end{thebibliography}
The field of quantum metrology promises to enable higher precision measurements than any that can be achieved using classical techniques [1]. Recently, there has been a great deal of attention on some non-ideal effects, present in realistic measurement scenarios, and their ability to deteriorate much of the enhancement offered by non-classical techniques [2].

In optical quantum metrology, prior investigations into non-ideal scenarios have focused on the effects of photon loss [3,4]. Distinguishability has not received much systematic quantitative analysis in the context of photonic quantum sensors. In a conventional two mode Mach-Zehnder interferometer the interference fringes, used to estimate phase, are intimately related to the distinguishability of the particles passing through the interferometer.

We report a wide class of states which, in an otherwise ideal scenario, are largely impervious to the deteriorating effects of particle distinguishability. Formally, we use the quantum Fisher information [5] to quantify the statistical information about the unknown phase in our protocol. For these probe states, coarse grained measurements, which are unable to resolve any additional distinguishing degrees of freedom the particles posses, are found to be as good as any other measurements at extracting information about the phase from the probe states. This is in stark contrast to the catastrophic effect particle distinguishability typically has on achievable precision.

An experiment using probe states originating from type-I spontaneous parametric down conversion is performed to verify the resilience of these states. Distinguishability between photons is experimentally controlled via temporal mode mismatch which allows us to expose the transition in utility between probe states with distinguishable and indistinguishable particles. The combined effects of indistinguishability and photon loss are necessary to provide a full explanation of the experimental data obtained. This constitutes a more complete picture of non-ideal effects in optical quantum metrology required for realising practical quantum-enhanced systems.