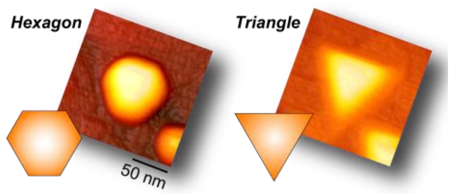
Symmetric [111] grown GaAs droplet dots for quantum optics and spintronics

T. Kuroda[2], T. Mano[2], L.Bouet[1], M. Vidal[1], G. Wang[1], T. Amand[1], X. Marie[1], K. Sakoda[2], M. Durnev[3], M. Glazov[3], E. Ivchenko[3] and B. Urbaszek[1].

[1]Université de Toulouse, INSA-CNRS-UPS, LPCNO, Toulouse, France
[2]National Institute for Material Science, Namiki 1-1, Tsukuba 305-0044, Japan
[3]Ioffe Physical-Technical Institute of the RAS, 194021 St.-Petersburg, Russia

E-mail: urbaszek@insa-toulouse.fr



AFM images of GaAs quantum dots grown on (111)A substrates reveal the triagonal symmetry of the dots, with shapes varying from irregular hexagons to equilateral triangles depending on

Due to spatial confinement in all 3 dimensions, the energy states of an electron trapped inside a nano-crystal called Quantum Dot (QD) are discrete, in strong analogy to discrete energy states in atoms. We are able today to address and manipulate the quantum state of a single electron, in particular his spin state, confined in the dot in optical spectroscopy experiments [1].

InAs QDs in a GaAs matrix represent a model system for strain driven QD formation (Stransky-Krastanov growth mode) using Molecular Beam Epitaxy (MBE). Although technical progress has been impressive, this growth method has its limits: First, not all technical useful QD / barrier material combinations with different lattice constants can be grown. Second, growth along the crystallographic axis like 111 for symmetric quantum emitters is not possible.
These problems can be overcome by an alternative growth method : In this talk we present work on GaAs QDs grown by **droplet epitaxy** in an MBE machine at the NIMS, Tsukuba by the group that invented this growth technique [2].

We demonstrate charge tuning in **strain free** GaAs/AlGaAs QDs grown on a GaAs(**111**)A substrate [3]. Application of a bias voltage allows the controlled charging of the QDs from -3|e| to +2|e|. The resulting changes in QD emission energy and exciton fine-structure are recorded in micro-photoluminescence experiments at T=4K. We investigate optical pumping of the electron and also nuclear spins of the Ga and As atoms that form the dot in this system with a strong hyperfine interaction [1] and fascinating magneto-optical properties [4-6].

We also show that these symmetric 111 grown QDs can be used as efficient sources of highly entangled photons [7]. The emitted photons reveal a fidelity to the Bell state as high as 86 % without postselection. We show a violation of Bell's inequality by more than five times the standard deviation, a prerequisite to test a quantum cryptography channel for eavesdropping. The remaining decoherence channels of the photon source are ascribed to random charge and nuclear spin fluctuations in and near the dot.

We acknowledge partial funding from ERC project 306719.

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Bernhard URBASZEK
Director of Research at CNRS
LPCNO INSA-CNRS-UPS
INSA Genie Physique ; 135 Avenue de Rangueil
31077 Toulouse, France
urbaszek@insa-toulouse.fr tel +33 561 55 96 43

1997 - 2000 **PhD** at Heriot Watt University (Edinburgh):
Excitonic properties of II-VI semiconductors

2000 - 2003 **Postdoc** in group of Richard Warburton at Heriot Watt University:
Optical spectroscopy of single quantum dots

2004 - 2008 **Lecturer** (*MCF*), Physical Engineering Department, INSA Toulouse

since **2008** tenured researcher at CNRS in the **Quantum Optoelectronics Group** at the **LPCNO**, Toulouse

Fields of Research
Optical spectroscopy, quantum dots, 2D semiconductors, spin and valley physics, transition metal dichalcogenides, nuclear spins

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