RESUMEN CONFERENCIAS ORALES

PONENTE	TÍTULO	
Frustaglia	**Quantum optics with electrons: adapted methods for entanglement production and detection** D. Frustaglia	**O-01**
Gontard L.C.	**3D characterisation of electronirradiation effectsin Ge-doped SiO_2** L.C. Gontard,* H.Ou ,J.R. Jinscheck,J. Verbeeck and R.E. Dunin Borkowski	**O-03**
Maragkou	**Controlling the properties of single photon emitters** M. Maragkou* A. K. Nowak, H. P. van der Meulen, I. Prieto, L. J. Martinez, P. A. Postigo, and J. M. Calleja	**O-04**
Molina de Pablo P.	**Silver nanoparticle wires on ferroelectric domain patterns in laser crystals** E. Yraola, P. Molina*, M.O. Ramírez, J.L. Plaza and L.E. Bausá	**O-07**
Moshtaghioun B. M.	**Sintering behavior and microstructure of boron carbide ceramics processed by spark plasma sintering** B. M. Moshtaghioun*, R. Poyato, F. Gutiérrez-Mora, A. Monshi, M. H. Abbasi, D. Gómez-García	**O-02**
Munuera C	**Nanoscale visualization of topographic and ferroelectric domain evolution of BTO at low temperatures** C. Munuera,*, F.J. Mompean, A. Alberca, N.M. Nemes, M. García-Hernández	**O-05**
Tosi G.	**Vortex dynamics in polariton OPO superfluids** G. Tosi,* F. M. Marchetti, C. Antón, M. D. Martin, D. Sanvitto, M. H. Szymańska, A. Berceanu, L. Marrucci, A. Lemaître, J. Bloch, C.Tejedor and L. Viña	**O-06**

Quantum optics with electrons: adapted methods for entanglement production and detection

D. Frustaglia

Dep. Física Aplicada II, Universidad de Sevilla, Spain.

Experimental progress in quantum information requires reliable sources of entanglement. In quantum optics, spontaneous parametric down conversion is a natural source of entangled photons. This source and the existence of efficient methods for distributing photons explain the success of quantum optics for long-distance quantum communication. Besides, solid-state nanostructures offer advantages for the local processing of quantum information. This has provoked a major scientific effort towards the development of quantum electronics. In particular, there is a research program for translating optical technologies which have already proved their applicability for quantum information processing into quantum electronics. In my talk I present a brief review of our contributions to this program: I first introduce an electronic version [1] of the Hong-Ou-Mandel interferometer originally design for photon-bunching detection. The corresponding electron (anti)bunching is detected through current-noise cross correlation measurements, acting as an entanglement witness. I secondly show a generalization [2] of the previous scheme to situations where the input electronic state has several delocalized components. In this case, the observables are current cross correlations instead of current noise. This allows to distinguish between standard mode entanglement and occupation-number entanglement (an almost unexplored kind of electronic entanglement shown to be a useful resource). Finally, I present a proposal [3] for a source of electron-hole entanglement in quantum Hall systems inspired by a recently introduced [4] (and eventually realized [5]) optical interferometer. We show that all topological constraints from the optical setup-- the basis of its working principle-- can be satisfied and the problems derived from Fermionic statistics can be overcome by making use of the last developments in quantum-Hall physics. The detection procedure is based on the measurement of current-noise correlators in the tunneling regime.

[1] V. Giovannetti, D. Frustaglia, F. Taddei, and R. Fazio, Phys. Rev. B **74**, 115315 (2006).
[2] V. Giovannetti, D. Frustaglia, F. Taddei, and R. Fazio, Phys. Rev. B **75**, 241305(R) (2007).
[3] D. Frustaglia and A. Cabello, Phys. Rev. B **80**, 201312(R) (2009).
[4] A. Cabello, A. Rossi, G. Vallone, F. De Martini, and P. Mataloni, Phys. Rev. Lett. **102**, 040401 (2009).
[5] G. Lima, G. Vallone, A. Chiuri, A. Cabello, and P. Mataloni Phys. Rev. A **81**, 040101 (2010).

O-03

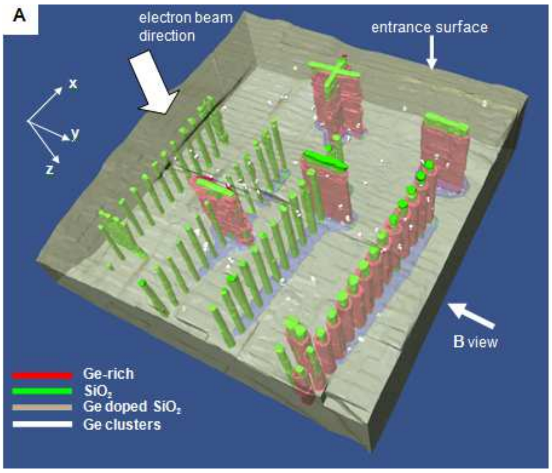
3D characterisation of electronirradiation effectsin Ge-doped SiO_2

L.C. Gontard[1,*], H.Ou[2],J.R. Jinscheck[3],J. Verbeeck[4]andR.E. Dunin-Borkowski[5]

1 Instituto de Ciencia de Materiales de Sevilla (CSIC-US), C/AméricoVespucio, 49, 41092 Sevilla, Spain
2 Department of Photonics, Technical University of Denmark, DK-2800, Kgs. Lyngby, Denmark
3 FEI Company bb. Eindhoven, The Netherlands
4 EMAT, University of Antwerp, Groenenborgerlaan 171, B-2020 Antwerp, Belgium
5 Ernst Ruska-Centre for Microscopy and Spectroscopy with Electrons D-52425 Juelich, Germany

Proton beams can be used for irradiating cells in the treatment of cancer; insulating materials are used as protection layers in fusion and fision reactors; and semiconductors are routinely used for detecting particles in high-energy physics.In many technological and scientific applications poor conducting material materials are irradiated with high-energetic charged particles but no single experimental technique exists which allows to measure directly the effects of irradiation in three-dimensions with nanometer spatial resolution.

In this study, the narrow electron beamof a transmission electron microscope has been used to irradiate with high spatial resolution a sample of amorphous SiO_2 (silica) doped with Ge. The same electron microscope has been used to study in three-dimensions the transformation occurred to the sample by using high-angle annular dark-field scanning TEM (HAADF STEM) tomography [1], confirming the formation of Ge/Si core-shell nanocylinders, clusters or voids (figure below).Regular arrays of core-shell cylinders can be easily created with well-defined diameters and pitch, and are stable over time.



The results presented suggest that localized electron irradiationmay be used to modify in a controlled way the dopant concentrationin Ge-doped glasses with nanometer resolution, and may result in new applications of novel nanoscale photonic and electronic devices.

[1]L.C. Gontard, R.E. Dunin-Borkowski, M.H. Gass, A.L. Bleloch, D. Ozkaya, Journal of Electron Microscopy**58(3)**, (2009) 167-174

Controlling the properties of single photon emitters

M. Maragkou,[1*] A. K. Nowak,[1] H. P. van der Meulen,[1] I. Prieto,[2]
L. J. Martinez,[2] P. A. Postigo,[2] and J. M. Calleja[1]

[1]Departamento de Física de Materiales, Universidad Autónoma de Madrid, E-28049 Madrid, Spain

[2] IMM-Instituto de Microelectrónica de Madrid (CNM-CSIC), E-28760 Tres Cantos, Madrid, Spain

We report on the simultaneous and continuous control of the antibunching time, the $g^2(0)$ value and the angle of the linear polarization of the light emitted by a single photon emitter based on a InAs quantum dot (QD) weakly coupled to a photonic crystal microcavity.[1] The optical emission properties of single InAs/GaAs ring-like shaped[2] QDs embedded in a photonic crystal microcavity are investigated. Under continuous wave excitation, resonant with the QD p-shell, the polarization angle of the linearly polarized QD emission changes continuously from nearly perpendicular to the cavity mode polarization at large detunings (positive or negative), to parallel at zero detuning (Figure 1a).

Second order time correlation measurements of the QD excitonic emission, performed for various detuning conditions reveal a strong antibunching peak at zero time delay. We obtain $g^{(2)}(0)$ values below 0.5 (black solid circles in Figure 1b), indicating single photon emission. A linear dependence of the recharging time τ_R of the QD emission with respect to the detuning is also observed (red solid squares in Figure 1b).

These results pave the way for the use of weakly coupled QD-cavity systems for quantum information applications.[3]

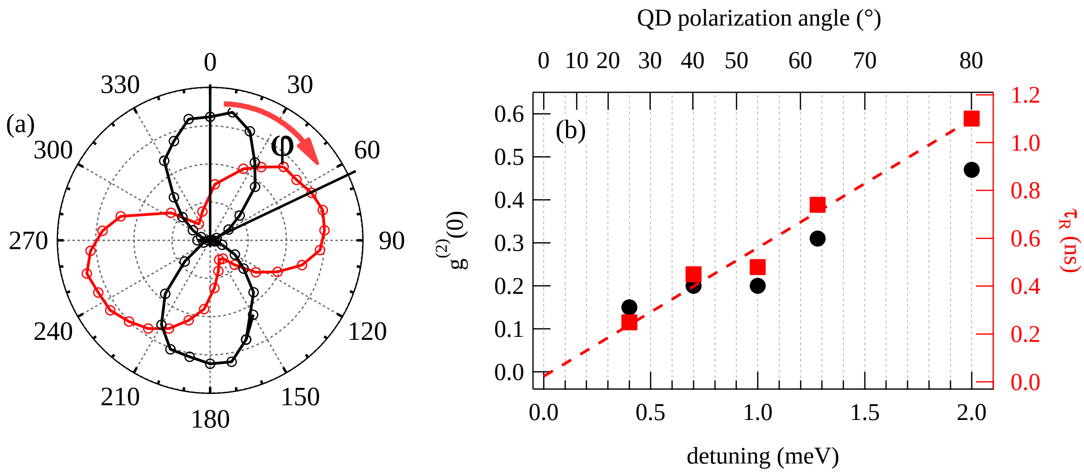


Figure 1: (a) CMX (black circles) and QD polarization polar plots (red circles) for δ=1.2meV. The polarization angle φ=0º (90º) corresponds to X (Y) polarization (b) $g^{(2)}(0)$ autocorrelation values for the QD emission (black solid circles) and recharging times τ_R (red solid rectangles) with respect to the detuning

[1] E. Gallardo, L. J. Martínez, A. K. Nowak, H. P. van der Meulen, J. M. Calleja, C. Tejedor, I. Prieto, D. Granados, A. G. Taboada, J. M. García, P. A. Postigo, Optics Express **18**, (2010) 13301

[2] D. Granados, J. M. García, Appl. Phys. Lett. **82**, (2003) 2401

[3] J.L. O'Brien, Science **318**, (2007) 1567

Silver nanoparticle wires on ferroelectric domain patterns in laser crystals

E. Yraola*, P. Molina, M.O. Ramírez, J.L. Plaza and L.E. Bausá

Dpto. Física de Materiales, Universidad Autónoma de Madrid, 28049-Madrid, Spain

Metallic nanostructures are attracting great interest since they may provide mechanisms for tailoring and manipulating local optical electric fields in a subwavelength domain, which allow the design of devices with applications such as sensing, biomedicine, imaging and information technology. Additionally, the association of metallic nanostructures with different laser gain media has recently given rise to successful configurations such as nanolasers or lasing-spaser [1-3].
Here we report on the possibility of assembling metallic nanostructures on a solid state laser based on a ferroelectric crystal on which a pattern of ferroelectric domains was fabricated. As a laser system we have chosen Nd^{3+} doped $LiNbO_3$:MgO on which different types of domain structures were produced [4]. By means of a photochemical process, using an aqueous solution, we demonstrate the selective deposition of Ag nanoparticle wires on the ferroelectric domain boundaries. The size of the nanoparticles ranges from tens to hundreds of nm depending on the preparation conditions. The shapes of the alignments were either straight (40 μm long) or polygonal lines, depending on the ferroelectric domain pattern on the laser material.
The results constitute a needed step to study the interaction between the metal structure and the optically-active and nonlinear substrate, which may be of interest in the field of all-optical circuits or submicrometric lasers.

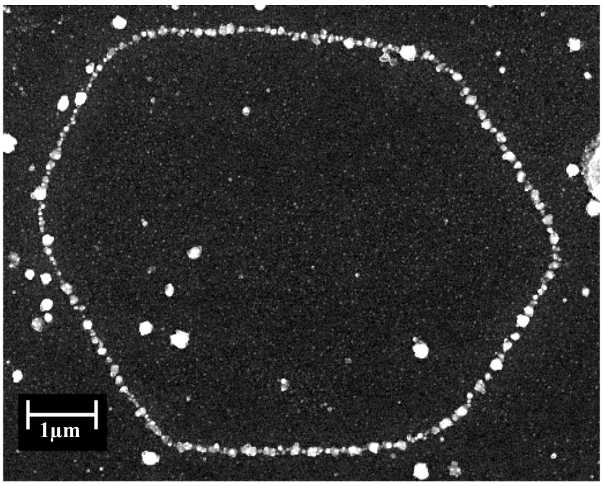


Figure 1. SEM image of an Ag nanoparticle wire on a ferroelectric domain wall in a $LiNbO_3$:MgO:Nd^{3+} laser crystal.

[1] R.F. Oulton *et al Nature,* **461,** 629-631 (2009)
[2] N.I Zheludev et *Nature Photonics* **2**, 351-354 (2008)
[3] M.A Noginov *et al Nature,* **460,** 1110-1112 (2009)
[4] P. Molina et al, *Applied Physics Letters* **96**, 261111 (2010)

*Electronic mail: eduardo.yraola@uam.es

Sintering behavior and microstructure of boron carbide ceramics processed by spark plasma sintering

B. M. Moshtaghioun[1,2], R. Poyato[3], F. Gutiérrez-Mora, A. Monshi[2], M. H. Abbasi[2], D. Gómez-García[1]

[1]Department of Condensed Matter Physics, University of Sevilla, Sevilla, Spain
[2]Materials Science Institute of Sevilla (CSIC-Univ.Sevilla), Sevilla, Spain
[3] Department of Materials Engineering, Isfahan University of Technology, Isfahan, Iran

Boron carbide (B_4C) ceramics have excellent properties, such as ultrahigh hardness, corrosion resistance, chemical stability, and neutron absorption. However, it is difficult to obtain a fully densified sintered body because of the covalent bond in its configuration [1]. Even if it is sintered at around melting point (ca. 2200 ◦C), few substance transports will occur, and the relative density of the sintered body is usually under 80%, together with abnormal grain growth and surface melting. Meanwhile, many researchers have tried to improve its low strength and fracture toughness and to reduce the sintering temperature by using various approaches [2].

In the recent years, Spark plasma sintering (SPS) has become a popular technology as it allows improved densification of different materials at relatively low temperatures and pressures and reduced sintering times [3].

In this work, the sintering behavior of boron carbide ceramic, processed by spark plasma sintering in the absence of any sintering additive was studied. Different sintering parameters (pressure, sintering temperature and time) were used in order to obtain completely densified boron carbide ceramic. The sintering procedure was conducted in the 1600-1750 °C temperature ranges under 50 or 75 MPa pressure. The holding time at the highest temperature was 0-5 min. Fully densified ceramics were obtained after SPS treatment at 1700 °C without holding time. A homogenous microstructure was obtained in all the samples with grain sizes in the 1-5 μm range, as revealed by the scanning electron microscopy study.

References:

[1] P.C. Kang, Z.W. Cao, G.H. Wu, J.H. Zhang, D.J. Wei and L.T. Lin, Phase identification of Al–B4C ceramic composites synthesized by reaction hot-press sintering, Int. Journal of Refractory Metals & Hard Materials 28 (2010) 297–300.

[2] W. Zhang, L. Gao, Y. Lei, B. Yang, J. Li, L. Xiao, Y. Yin, TiAl/B_4C composite fabricated by high energy ball milling and hot press sintering processes and its mechanical properties, Materials Science and Engineering A 527 (2010) 7436–7441.

[3]S. Hayun, s.Kalabukhov, V. Ezersky, M. P. Dariel, N. Frage, Microstructural characterization of spark plasma sintered boron carbide ceramics, Ceramics International, 36 (2010) 451-457.

O-05

Nanoscale visualization of topographic and ferroelectric domain evolution of BTO at low temperatures

C. Munuera[1,*], F.J. Mompean[1], A. Alberca[1], N.M. Nemes[1,2], M. García-Hernández[1]

[1]Instituto de Ciencia de Materiales de Madrid, Consejo Superior de Investigaciones Científicas,Sor Juana Inés de la Cruz, 3, 28049 Madrid, Spain
[2]Departamento de FÍsica Aplicada III, Universidad Complutense, Ciudad Universitaria, 28040 Madrid, Spain

The continuous trend towards device miniaturization is mainly based on two strategies: the use of multifunctional materials, so that a single component can perform more than one task, and the implementation of new ways of material-property control. Based on these ideas, complex oxide systems constitutes an interesting approach offering the possibility of combining electronic and magnetic order parameters, and the potential to manipulate one through the other (so-called magnetoelectric effect). In particular, by exploiting the strain effects and electronic and orbital reconstructions occurring at the interfaces of correlated oxides, novel states are found and new functionalities can be implemented in spintronics and electronics architectures for practical devices [1].

Ferroelectric barium titanate ($BaTiO_3$; BTO) is a perfect candidate to explore interfacial effects on multiferroic heterostructures. Its low temperature structural changes (at T=278K and T=183K) provides a way of altering the strain profiles at the BTO surface. In addition, switching of the direction of spontaneous polarization (either due to phase transition or to selective poling) offers the possibility of modifying the electronic properties at the surface. Both, strain and electronic modifications at the BTO surface can translate, for example, into modifications of the magnetic and magnetotransport properties of a epitaxial layer of manganite grown on top [2].

However, for a proper understanding of how modifications at the BTO surface (strain or electronic) may affect the properties of a epitaxial layer grown on top, it is important to characterize the modifications themselves. By means of a Scanning Probe Microscope (SPM) we have carried out a thorough investigation on the evolution of BTO as function of the temperature, from 300K to 10K. Combining both, topographic and piezoresponse imaging, we were able to simultaneously follow morphology and ferroelectric domain configuration variations with nanometre resolution.

For the first time, direct visualization at the nanoscale of the spectacular modifications affecting strain and electronic configurations are observed (figure 1), which may indeed be used to influence the properties of any layer grown on top of BTO.

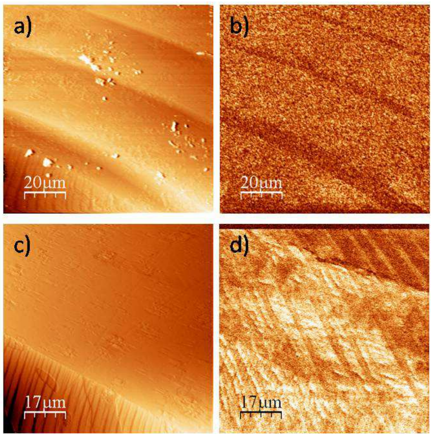


Figure 1. Simultaneous topographic (a, c) and piezoresponse (b, d) images of BTO acquired at 300K (top) and 210K (bottom).

[1] M. Bibes, J. E. Villegas and A. Barthélémy Advances in Physics **60**, (2011) 5.
[2] A. Alberca, N. M. Nemes, F. J. Mompean et al. Physical Review B **84**, (2011) 134402.

O-06

Vortex dynamics in polariton opo superfluids

G. Tosi,[1,*] F. M. Marchetti,[2] C. Antón,[1] M. D. Martin,[1] D. Sanvitto,[3] M. H. Szymańska,[4] A. Berceanu,[2] L. Marrucci,[5] A. Lemaître,[6] J. Bloch,[6] C.Tejedor[2] and L. Viña[1]

[1]Física de Materiales, Universidad Autónoma de Madrid, Madrid 28049, Spain

[2]Física Teórica de la Materia Condensada, Universidad Autónoma de Madrid, Madrid 28049, Spain

[3]NNL, Istituto Nanoscienze - CNR, Via Arnesano, 73100 Lecce, Italy

[4]Department of Physics, University of Warwick, Coventry, CV4 7AL, UK

[5]Dipartimento di Scienze Fisiche, Università di Napoli Federico II and CNR-SPIN, Napoli, Italy

[6]LPN/CNRS, Route de Nozay, 91460, Marcoussis, France

Resonantly pumped polaritons in the optical parametric oscillator (OPO) regime have been recently shown to exhibit persistent flow in the form of metastable quantum vortices, one of the landmarks of superfluidity [1]. By using a pulsed Laguerre-Gauss probe beam, two limits can be singled out [1,2]: in one case, the externally injected vortex cannot be imprinted and rotation lasts only during the extra population lifetime (typically for conditions close to OPO threshold); in a different regime (typically well above the OPO threshold), vorticity persists not only in absence of the rotating drive, but also longer than the gain induced by the probe, and therefore is transferred into to the OPO signal. These two limits are characterised by fundamentally different properties of the triggered vortices. In this work, we study experimentally the onset and dynamics of both singly (m=1) and doubly (m=2) quantised vortices in these two conditions.

In particular, for the case when only the extra parametrically-created population acquires rotation, we have found that it inherits the properties of its creating probe. Here, even doubly-quantised vortices, if generated at low enough group velocity, can persist until the last detectable signal [1,3] (Fig. 1-a). On the other hand, if a doubly-quantised vortex is imprinted on the steady state OPO signal, it suffers a drag from the underlying supercurrents and splits into two singly-quantised vortices (Fig. 1-b) [1,3]. Further, when vortices are imprinted from the probe to the OPO signal, phase-continuity arguments imply that a spontaneous antivortex has to appears at the border of the imprinted vortex [4] (Fig. 1-c). We show that this happens at positions where the background condensate and the injected extra population counter-propagate. Finally, we also show that counter-propagating superfluids, created by a simple Gaussian probe, can generate vortex-antivortex pairs.

* corresponding author : guilherme.tosi@uam.es

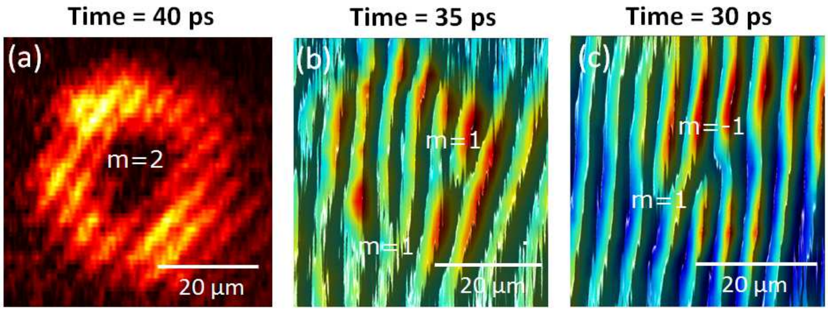


Figure 1: Interference images showing fork-like dislocations (vortices and antivortices). (a) Stable m=2 vortex on the condensate extra population. (b) Two vortices generated after the splitting of an m=2 vortex. (c) m=1 vortex imprinted by a Gauss-Laguerre beam and an additional spontaneous m=-1 antivortex.

The polariton signal is created after a parametric scattering process induced by pumping the lower polariton branch close to its inflection point, in a GaAs quantum well at the anti-node of a AlAs microcavity. After perturbing the system with a 2ps-pulsed laser, containing either a Gaussian or a Gaussian-Laguerre profile, the dynamics is followed in a streak camera and the phase analysed in a Mach-Zehnder interferometer.

References

[1] D. Sanvitto, *et al*, *Nature Phys.* **6**, 527 (2010); G. Tosi, *et al, J. Appl. Phys*. **109**, 102406 (2011)

[2] F.M. Marchetti, *et al*, *Phys. Rev. Lett.* **105**, 063902 (2010).

[3] M.H. Szymanska, *et al*, *Phys. Rev. Lett.* **105**, 236402 (2010).

[4] G. Tosi, *et al, Phys. Rev. Lett.* **107**, 036401 (2011).