Nanowire sensors and emitters for infrared astronomy and medical applications

WIRES

Consortium Composition

	Organization
Coordinator	INFN Pavia – Università di Pavia
Partner	NEST Scuola Normale Pisa
Partner	Università dell'Aquila

Duration: 3 years

Consortium composition

Pavia

	Nome	Età	Contratto	Qualifica	%
1	**Bellani Vittorio**		Associato	Ricercatore	**100**
2	**Boffelli Fabrizio**		Associato	Ricercatore	**20**
3	**Borsista**		Associato	Ricercatore	**100**
4	**Dondi Daniele**		Associato	Professore	**70**
5	**Fontana Andrea**		Dipendente	Ricercatore	**20**
6	**Giroletti Elio**		Associato	Ricercatore	**90**
	Numero Totale Ricercatori			5	FTE: 4.0

Pisa

	Nome	Età	Contratto	Qualifica	%
1	**Prete Dominic**		Associato	Ricercatore	**100**
2	**Rossella Francesco**		Associato	Ricercatore	**100**
3	**Sorba Lucia**		Associato	Direttore di ricerca	**100**
4	**Zannier Valentina**		Associato	Ricercatore	**100**
	Numero Totale Ricercatori			4	FTE: 3.7

L’Aquila

	Nome	Età	Contratto	Qualifica	%
1	**Antonelli Cristian**		Associato	Ricercatore	**100**
2	**Marini Andrea**		Associato	Ricercatore	**100**
3	**Mecozzi Antonio**		Associato	Professore	**100**
	Numero Totale Ricercatori			3	FTE: 3.0

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Infrared astronomy

From Wikipedia, the free encyclopedia

Infrared astronomy is the branch of astronomy and astrophysics that studies astronomical objects visible in infrared (IR) radiation. The wavelength of infrared light ranges from 0.75 to 300 micrometers. Infrared falls in between visible radiation, which ranges from 380 to 750 nanometers, and submillimeter waves.

Carina Nebula in infrared light captured by the Hubble's Wide Field Camera 3.

Infrared astronomy began in the 1830s, a few decades after the discovery of infrared light by William Herschel in 1800. Early progress was limited, and it was not until the early 20th century that conclusive detections of astronomical objects other than the Sun and Moon were made in infrared light. After a number of discoveries were made in the 1950s and 1960s in radio astronomy, astronomers realized the information available outside the visible wavelength range, and modern infrared astronomy was established.

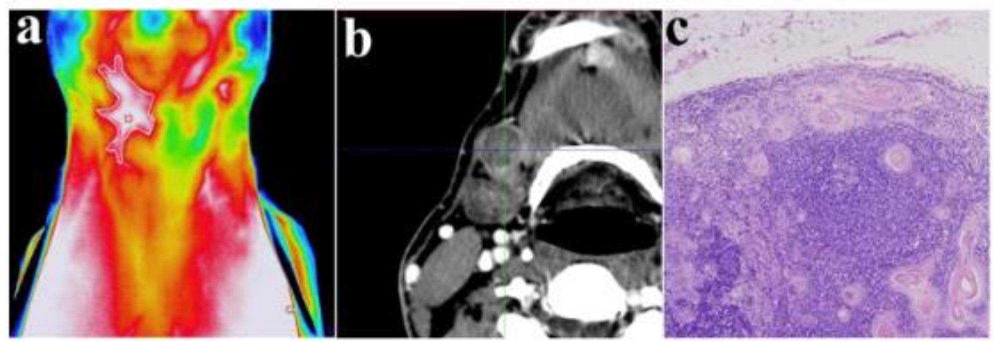
SCIENTIFIC REPORTS

Article | OPEN | Published: 08 May 2018

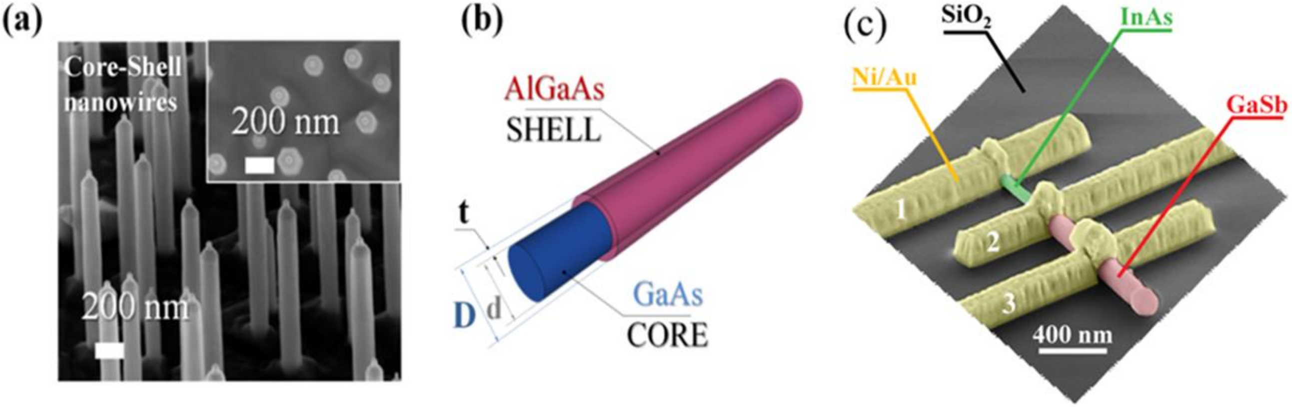
Detection of cervical lymph node metastasis from oral cavity cancer using a non-radiating, noninvasive digital infrared thermal imaging system

Fan Dong, Chuansibo Tao, Ji Wu, Ying Su, Yuguang Wang, Yong Wang, Chuanbin Guo & Peijun Lyu

Figure 4



Representative case correctly confirmed with both IR imaging and contrast-enhanced CT. (**a**) Elevated surface temperature and increased vascular density on the right side using IR imaging; (**b**) Metastatic lymph node in contrast-enhanced CT; (**c**) Microscopic appearance of metastatic lymph nodes (hematoxylin and eosin staining, original magnification ×200).

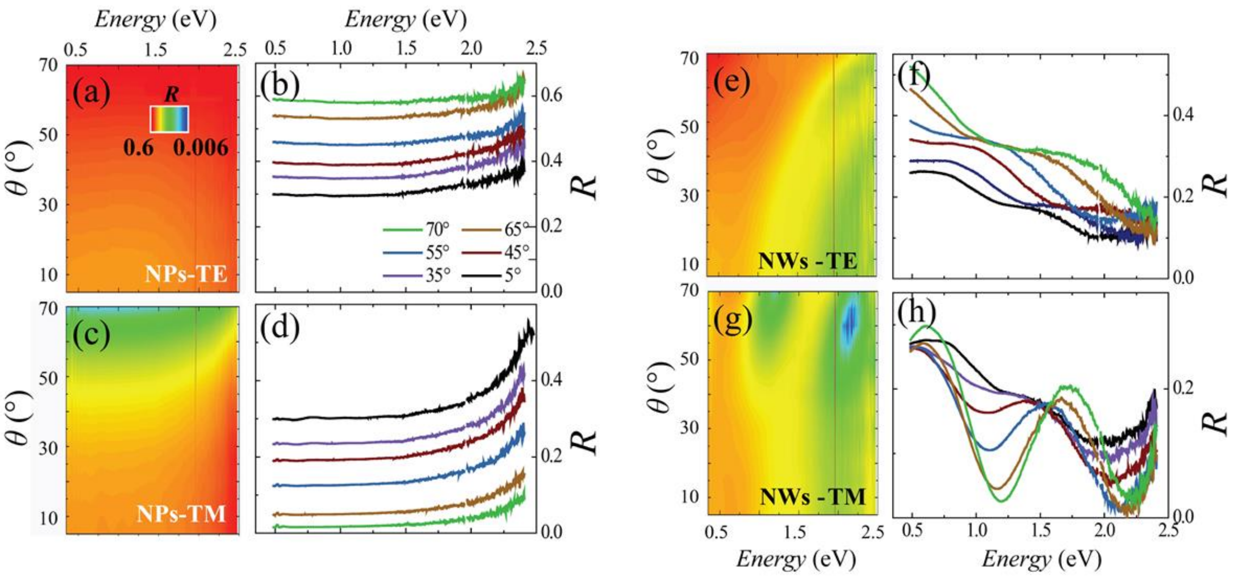


45° tilted scanning electron micrograph of one of our GaAs-AlGaAs core-shell nanowire samples (nanowire average length ≈ 960 nm, diameter ≈ 150 nm, density ≈ 10 NW/μm^2).

(b) Sketch of a core-shell NW. The core and shell materials and typical dimensions are indicated: inner diameter d ≈ 50nm, outer diameter D ≈ 150nm, shell thickness t ≈ 30 nm.

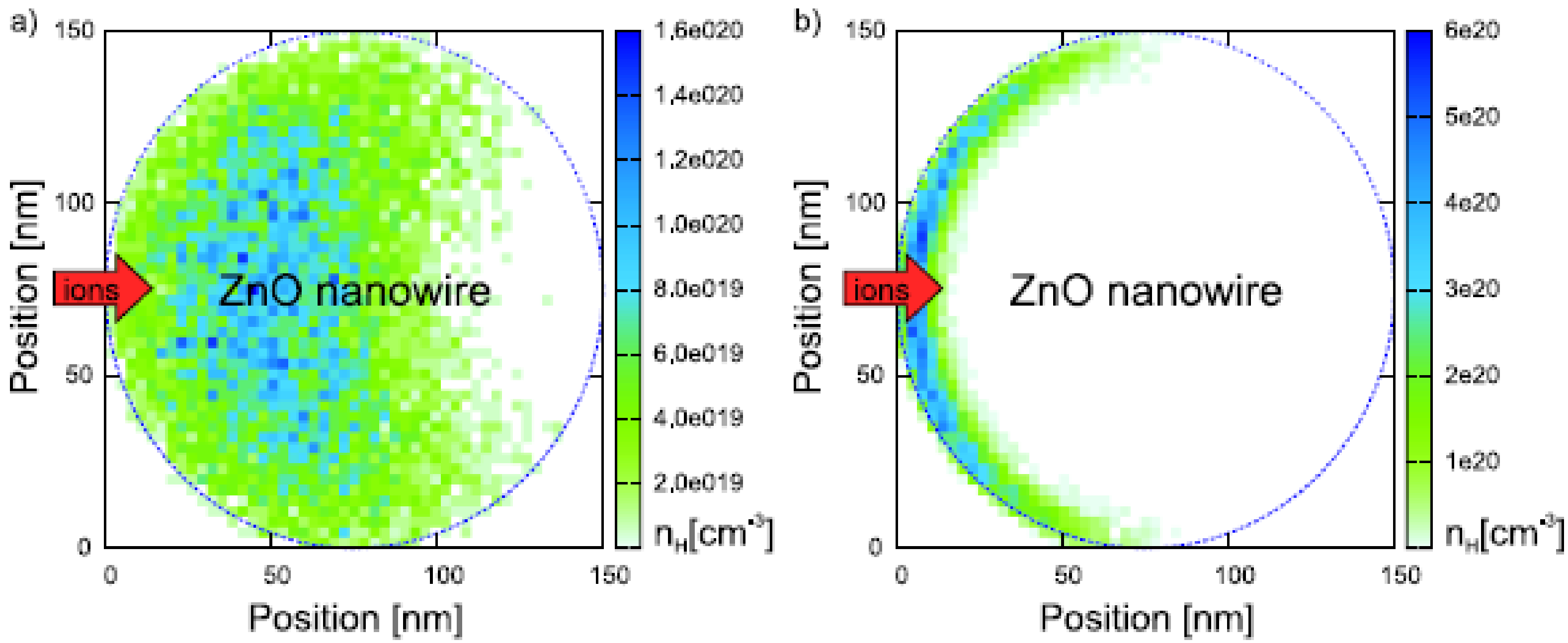
(c) SEM image (60° tilt) of a typical InAs/GaSb IR sensor, deposited on a SiO2/p-Si substrate.

F. Floris, L. Fornasari, A. Marini, V. Bellani, F. Banfi, S. Roddaro, D. Ercolani, M. Rocci, F. Beltram, M. Cecchini, L. Sorba and F. Rossella, *Self-Assembled InAs Nanowires as Optical Reflectors*, Nanomaterials 7, 400 (2017).



Angle- and energy-resolved specular reflectance measured on the InAs substrate with the dispersed Au-rich NPs (**a**,**c**) and on the InAs NWs (**e**,**g**). Reflectance spectra measured at different incident photon angle θ for the Au-rich NPs dispersed on the InAs substrate (**b**,**d**) and for the InAs NWs (**f**,**h**). Transverse electric (TE) and magnetic (TM) light polarizations are indicated by labels.

F. Floris, L. Fornasari, V. Bellani, A. Marini, F. Banfi, F. Marabelli, F. Beltram, L. Sorba and F. Rossella, *Strong Modulations of Optical Reflectance in Tapered Core-shell Nanowires,* Materials MDPI, in press (2019).



We will study the selective modification of the electrical and optical response of the NWs by means of ion implantation. Simulation using numerical using GEANT4 code, with the Livermore low energy package, will allow to evaluate the energy deposit and the range the ions on the nanoscale . This code also simulates emission of scintillation and fluorescent light following irradiation and could be exploited to evaluate the photon spectrum emitted by the NWs. The selective control of the nanowire properties, by modifying either the wire composition or the surface conditions, will allow the development of novel, functional elements for next generation semiconductor devices.

A.L. Bulin, A. Vasil'ev, A. Belsky, D. Amans, G. Ledoux and C. Dujardin, *Modelling energy deposition in nanoscintillators to predict the efficiency of the X-ray-induced photodynamic effect,* Nanoscale 7, 5744 (2015).

Mobility details

Experiments at CINT Livermore

Measurements of the photo-conductivity at milli-Kelvin temperatures and high fields, to explore the sensors sensitivity and energy band line-up

Experiments at EMFL Grenoble, Nijmegen

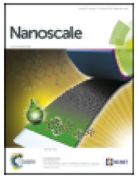
Study of the electrical response at high field, to get information on energy band profile, I-V characteristic with and without illumination

Experiments at LPENS Paris

Determination of the ultrafast electro-optical response of the devices, with radiation in the far-IR and THz

Experiments at MagLab Tallahassee

Photoluminescence measurements on the NWS at high field for the study of the emission mechanisms

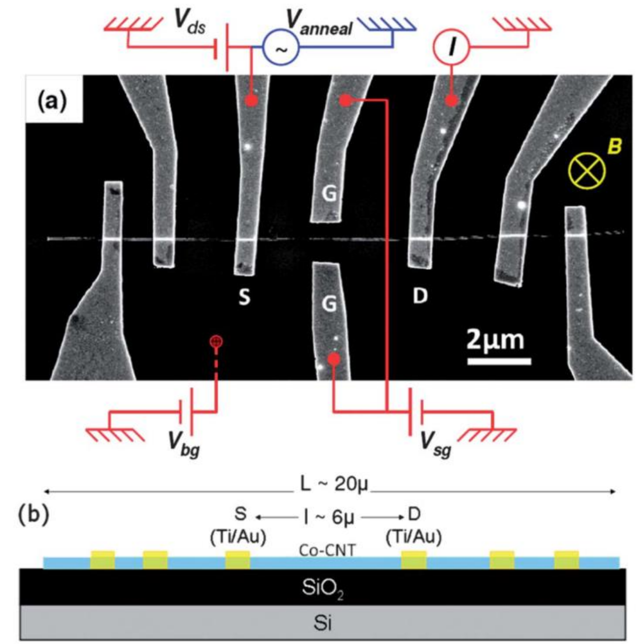


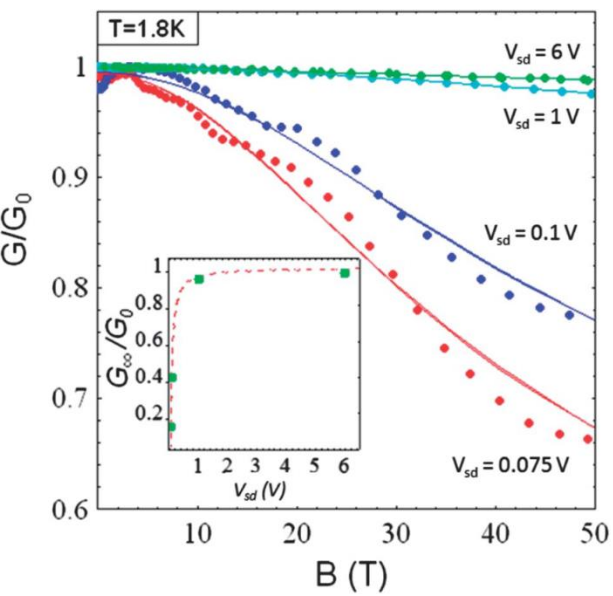
From the journal:
Nanoscale

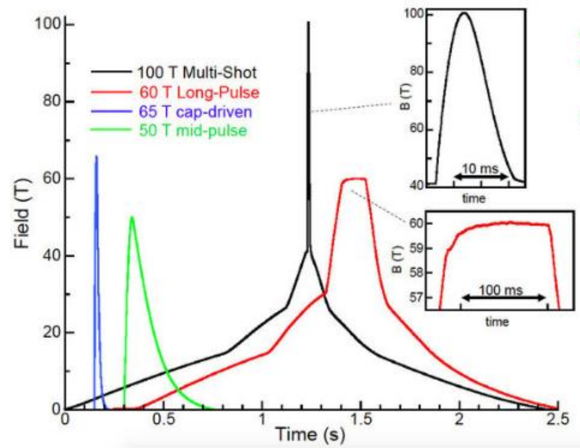
European Magnetic Field Laboratory

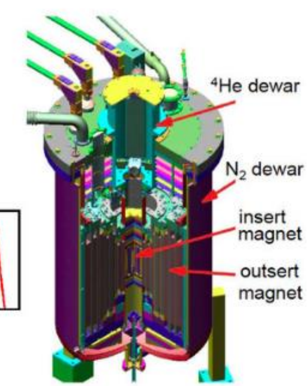
Tuning electronic transport in cobalt-filled carbon nanotubes using magnetic fields

Francesco Rossella,*[a] Caterina Soldano,[b] Pasquale Onorato[a] and Vittorio Bellani[a]

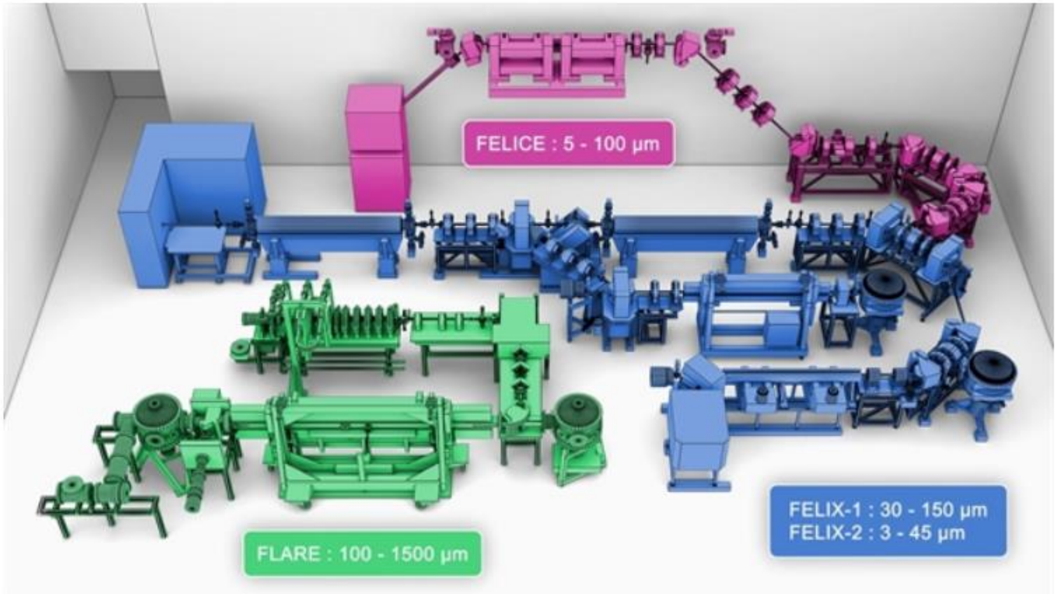








Normalized magneto-conductance, G(B)/G0 measured at T = 1.8 K for different biases. Solid lines are fits according to theoretical models



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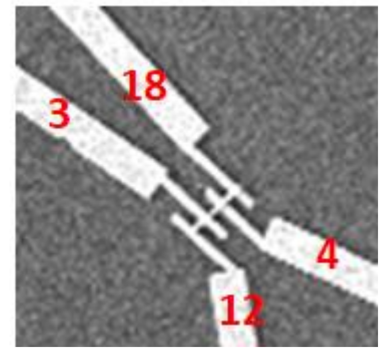
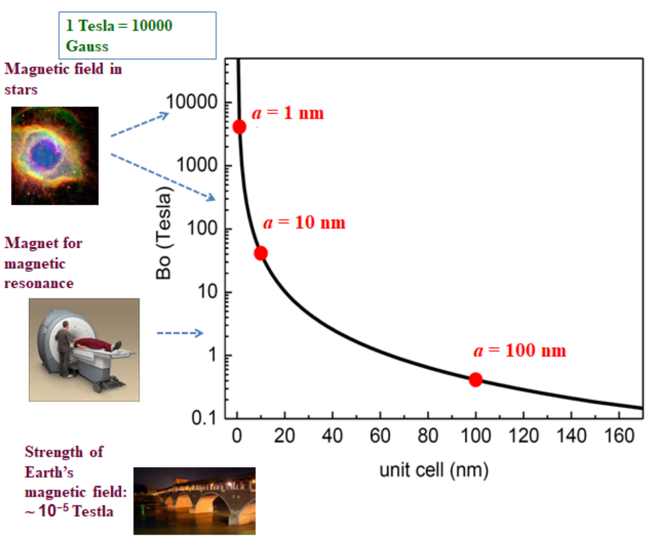
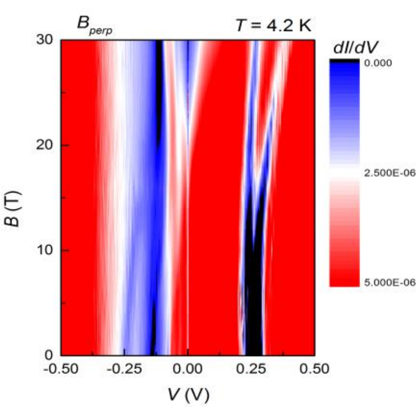
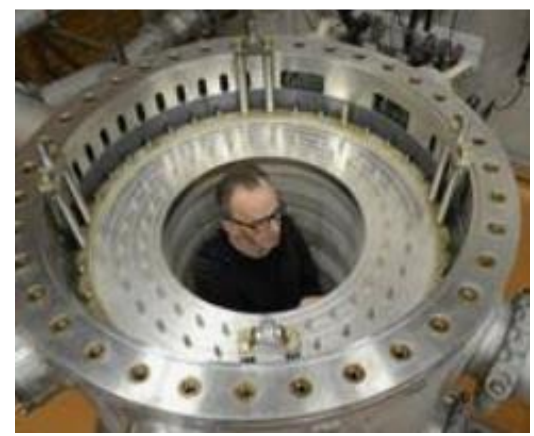




European Magnetic Field Laboratory





PHYSICAL REVIEW B
covering condensed matter and materials physics

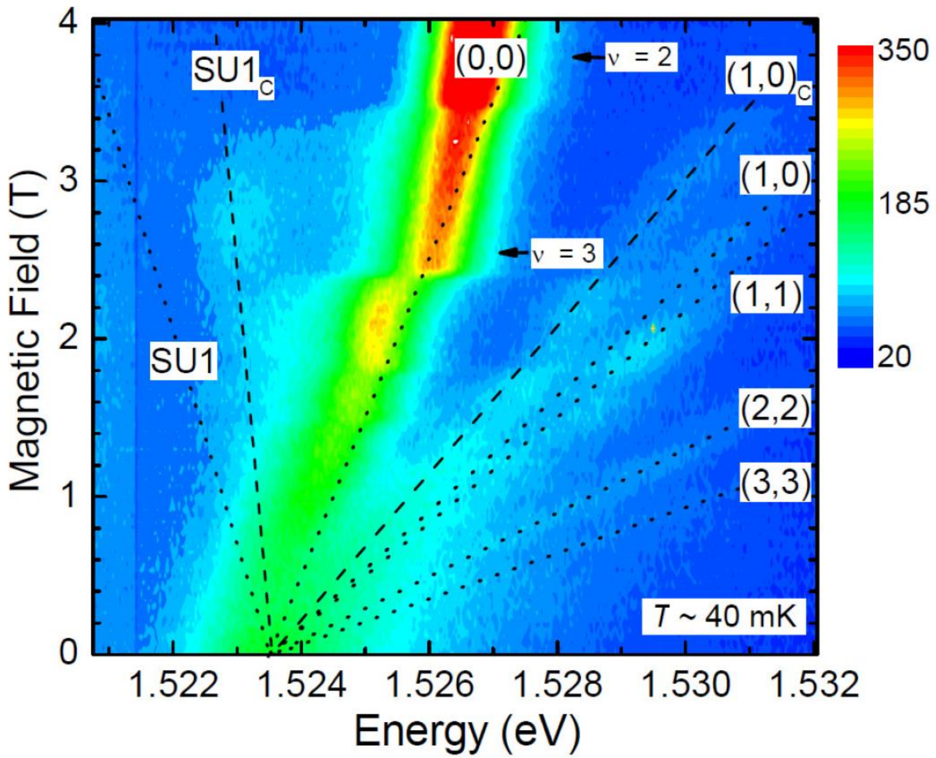
Optical detection of quantum Hall effect of composite fermions and evidence of the $\nu = 3/8$ state

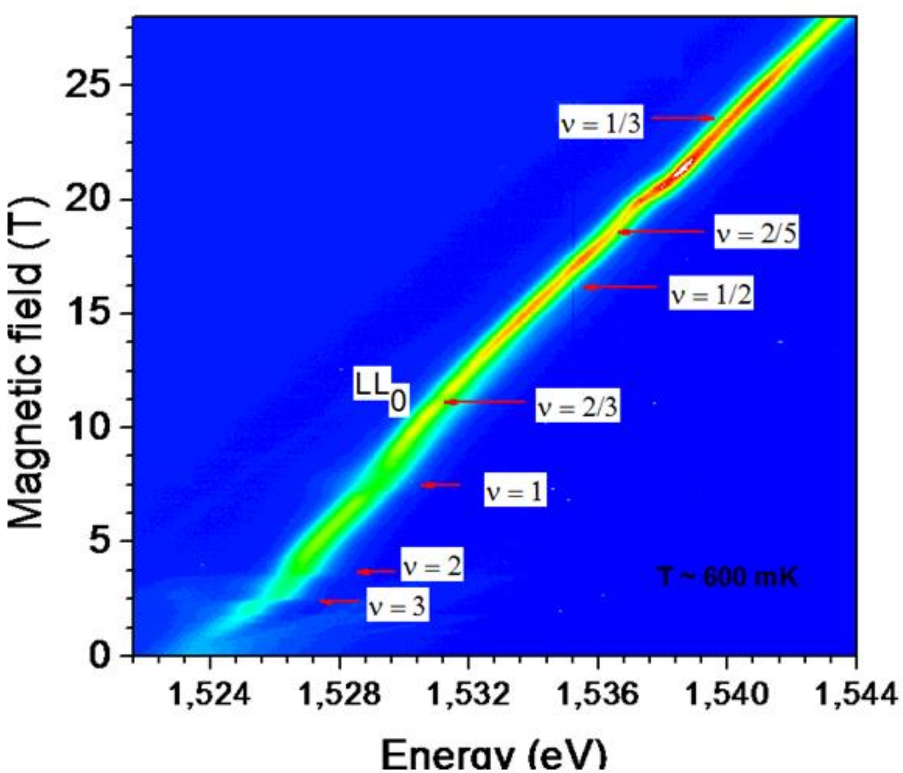
V. Bellani, F. Dionigi, F. Rossella, M. Amado, E. Diez, G. Biasiol, and L. Sorba
Phys. Rev. B **81**, 155316 – Published 21 April 2010

New Journal of Physics
The open access journal at the forefront of physics

Optical probing of the metal-to-insulator transition in a two-dimensional high-mobility electron gas

F Dionigi[1,7], F Rossella[1], V Bellani[1,8], M Amado[2,3], E Diez[3], K Kowalik[4,9], G Biasiol[5] and L Sorba[6]
Published 1 June 2011 • IOP Publishing and Deutsche Physikalische Gesellschaft
New Journal of Physics, Volume 13, June 2011





New J. Phys. **20** (2018) 053062

New Journal of Physics

The open access journal at the forefront of physics

PAPER

Anomalously large resistance at the charge neutrality point in a zero-gap InAs/GaSb bilayer

W Yu[1], V Clericò[2], C Hernández Fuentevilla[2], X Shi[1,11], Y Jiang[3], D Saha[4], W K Lou[5], K Chang[5], D H Huang[6], G Gumbs[7], D Smirnov[8], C J Stanton[4], Z Jiang[3], V Bellani[9,10], Y Meziani[2], E Diez[2,12], W Pan[1,12], S D Hawkins[1] and J F Klem[1]

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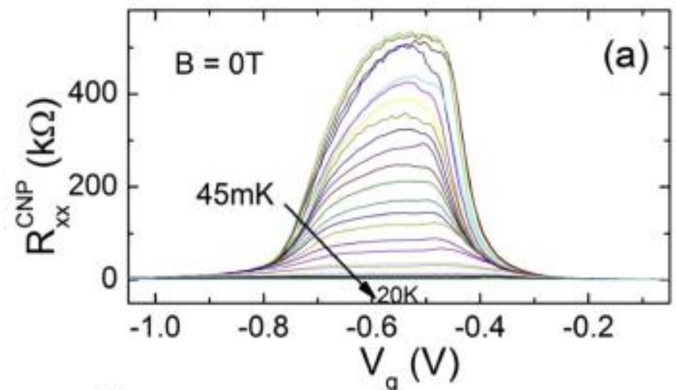
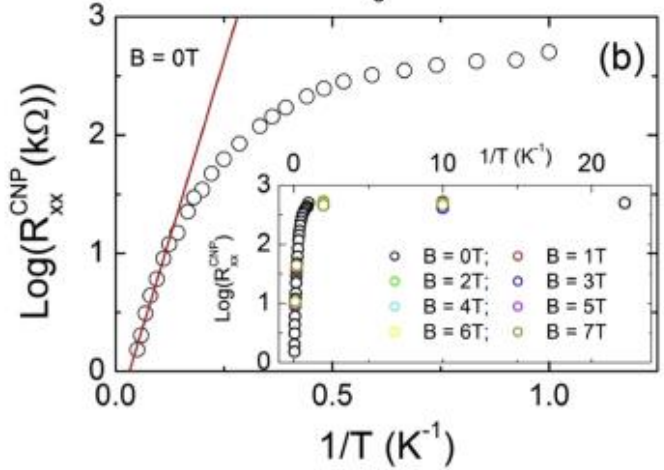
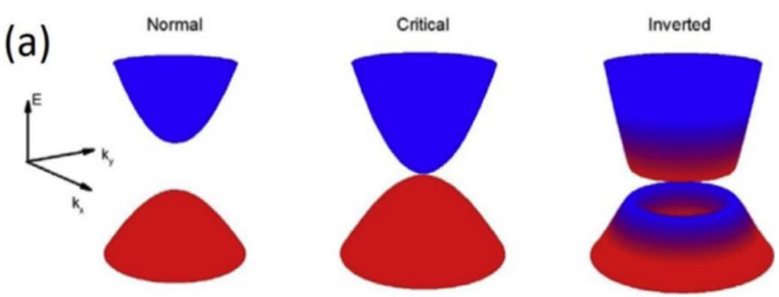
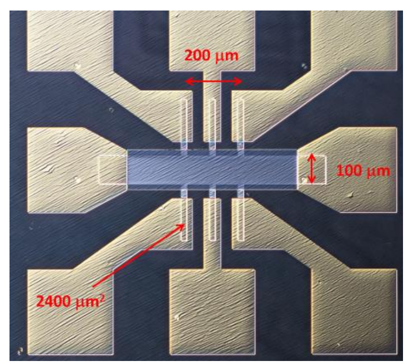
[3] School of Physics, Georgia Institute of Technology, Atlanta, GA 30332, United States of America
[4] Department of Physics, University of Florida, Gainesville, FL 32611, United States of America
[5] SKLSM, Institute of Semiconductors, Chinese Academy of Sciences, 100083 Beijing, People's Republic of China
[6] Air Force Research Laboratory, Space Vehicles Directorate, Kirtland Air Force Base, Albuquerque NM 87117, United States of America
[7] Department of Physics and Astronomy, Hunter College of the City University of New York, New York, NY 10065, United States of America
[8] National High Magnetic Field Laboratory, Tallahassee, FL 32310, United States of America
[9] Department of Physics, University of California at Berkeley, Berkeley, CA 94720, United States of America
[10] Department of Physics, University of Pavia, I-27100 Pavia, Italy
[11] Present address: Department of Physics, The University of Texas at Dallas, Richardson, TX 75080, United States of America.









(a) Band structures of the InAs/GaSb DQWs calculated using the eight-band k·p method.

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Proposal P17862

Title:	High magnetic field photoluminescence study of InAs quantum wells and InP crystal-phase quantum disks in core-multishell InP-InAs-InP nanowires
Discipline:	Condensed Matter Physics
Status:	Reviewed
Date Submitted:	10/30/2018
Review Facility:	DC Field
Excluded Reviewers:	
Proposal:	Download File.pdf - (Download)

Proposal Participants

Role	Name(s)
Submitter	Vittorio Bellani (S)
PI	Vittorio Bellani (S)
Collaborator(s)	Dmitry Smirnov (S) Zhengguang Lu (G)

Experiments

ID#	Title	Date Submitted	Status
P17862-E001-DC	Magnetic photoluminescence study of InAs quantum wells and InP crystal-phase quantum disks in core-multishell InP-InAs-InP nanowires	10/30/2018	Scheduled

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Reviews on Proposal P17862

Grade: B
Date Created: 11/16/2018 6:19:30 PM
Date Edited:
Comment:
The proposed experiments follow from prior work at the NHMFL by the PI. The ready availability of high quality samples is a strong feature of this proposal. The main goal is to study the g-factor and exciton dynamics in wrutize InP via photoluminescence spectroscopy techniques already used by the PI. The experiments appear to be feasible with the systems already present at NHMFL. This is a good proposal that should have priority for access to systems at NHMFL.

Grade: A
Date Created: 11/23/2018 1:36:38 AM
Date Edited:
Comment:
The PI is proposing to study the electronic properties of quantum wells and quantum dots in InP-InAs-InP nanowire radial heterostructures. The PI has a demonstrated track record of crystalline semiconductor nanowire synthesis and preparation and a track record of investigating their electronic properties. The proposed work is a photoluminescence study of the nanowires in high magnetic field of 30-35 T. It will provide fundamental information, such as specific anisotropy, g-factor, and magneto-excitonic effects. The PI and his team have developed two different methods of sample preparation to study individual nanowires in magnetic. They also collected photoluminescence data on individual nanowires in low magnetic field up to 10 T. The proposed photoluminescence work in high magnetic field should provide new fundamental knowledge and result in high-impact publications.

Reviews Complete: 2
Reviews Not Completed: 0

View Proposal

Comments & Questions | Security & Privacy   Version 4.4.6   © 1995 - 2019 National High Magnetic Field Laboratory
1800 E. Paul Dirac Drive, Tallahassee, FL 32310 - 3706
Phone: (850) 644-0311

CINT USER PROPOSAL FORM

Electrical transport in InAs-GaSb nanowires for optoelectronic quantum devices.

Proposal Number:	2019AU0021
Date Submitted:	Friday, March 22, 2019
Continuation Of:	
Prior Accomplishments:	
Progress:	
Funding Source:	Foreign

PI

Name:	Bellani, Vittorio, Prof. [University of Pavia and INFN Pavia]
Affiliation Type:	University
Affiliation:	University of Pavia
Department:	Department of Physics
E-mail:	vittorio.bellani@unipv.it
Office Phone:	
Citizenship:	Italy
Country of Origin:	
Employer Nationality:	
Category:	Faculty member / professional staff / research scientist
Person Category (if other):	
Employer Type:	
Employer Type (if other):	

PROPOSAL INFORMATION

Enter basic information about your proposal.

Check if Research is Proprietary (i.e. you will not publish yourproject results and will be accessing the facilities for full cost recovery) ☐

Is the technical content of this proposal subject to U.S. export control limitations? No

Subject MaterialSciences

Have you been in contact with CINT staff regarding this proposal? Yes

If yes, name of staff member? Wei Pan

How did you hear about CINT?
- ☐ I am a previous CINT user.
- ☐ CINT User Meeting
- ☐ CINT Website
- ☐ NSRC Portal Website
- ☐ Expo Booth
- ☑ CINT Scientist Presentation
- ☐ CINT Scientist or Publication

Project Implementation, Budget Breakdown and Final Deliverables

How the project will be implemented (steps)

- Year 1: NW fabrication and optical and electrical measurements
- Year 2: Sensors and emitters fabrication and optical measurements
- Year 3: Sensors and emitters electro-optical measurements and test

The project deliverables after the first year (2020)

- Fabrication of core-shell the GaAs-AlAs and InAs GaSb NWs
- Optical measurements of the nano-wires (NWs) with micro Raman photo-luminescence and reflectance
- Photoluminescence study of the NWs emission up to 18 Tesla
- Magneto-transports investigation of the electrical transport mechanisms up to 12 Tesla and down to 50 milliKelvin temperatures
- Simulation of the NWs optical response using LUMERICAL and effect of implantation using GEANT4

Budget: Option 1

<u>Project budget breakdown in cost voices for the first year (2020). 2021 and 2022 will be similar</u>

Instrumentation
25 K€: Micro positioning and optical elements for upgrade of the photo-luminescence setup in Pavia, for improving spatial resolution and stability

Consumables

10 K€: Cryogenic liquid for low temperature photo-luminescence (Pavia), electronic and optical consumables. Photo-lithography chemicals and epitaxy materials (Pisa). Informatics material (l'Aquila)

Mobility

15 K€: *Experiments at CINT , EMFL, LPENS, MagLab (see nex slide for the details)*
- Measurements of the photo-conductivity at milli-Kelvin temperatures and high fields, to explore the sensors sensitivity and energy band line-up
- Study of the electrical response at high field, to get information on energy band profile, I-V characteristic with and without illumination
- Determination of the ultrafast electro-optical response of the devices, with radiation in the far-IR and THz
- Photoluminescence measurements on the NWS at high field for the study of the emission mechanisms

____

50 K€ project total for 2020 (similar in 2021 and 2022)

Experiments at CINT Livermore

1 months, 1 scientist: 4 K€

Measurements of the photo-conductivity at milli-Kelvin temperatures and high fields, to explore the sensors sensitivity and energy band line-up.

Experiments at EMFL Nijmegen

2 weeks, 2 scientists: 5 K€

Study of the electrical response at high field, to get information on energy band profile, I-V characteristic with and without illumination.

Experiments at LPENS Paris

1 month 1 scientist: 3 K€

Determination of the ultrafast electro-optical response of the devices, with radiation in the far-IR and THz.

Experiments at MagLab Tallahassee

2 weeks, 1 scientist: 3 K€

Photoluminescence measurements on the NWS at high field for the study of the emission mechanisms.