44th ”Jaszowiec” 2015
International School & Conference on the Physics of Semiconductors

WISŁA, POLAND
June 20th – 25th, 2015

Organized by:
Institute of Physics, Polish Academy of Sciences
Faculty of Physics, University of Warsaw
Institute of High Pressure Physics, Polish Academy of Sciences
Departments of Experimental and Theoretical Physics,
Wrocław University of Technology
Institute of Electron Technology

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Exhibitors:
Welcome to 44th Jaszowiec Conference

It is my great pleasure to welcome all of you to the 44th Jaszowiec International School and Conference on Physics of Semiconductors. The third consecutive year the Conference is convened in Wisła, in close neighborhood of the Conference original site in Jaszowiec. This Conference continues long tradition of Jaszowiec meetings devoted to physics of semiconductors.

We are honored to host many distinguished scientists, who will present scholarly lectures at the School and plenary lectures at the Conference. I would like to take this opportunity to thank them all for accepting our invitation. My particular thanks are directed to Professor Amano, 2014 Nobel Laureate in Physics who was so kind to accept our invitation to give opening lecture at the Conference.

We are delighted that the number of contributed talks has drastically increased this year, covering many topics, including synthesis, properties and characterization, theory and innovative applications of semiconductor materials and structures. This reflects new efforts of organizers aimed at giving more opportunity for young researchers to present their achievements to wide audience. The poster presentations by their mere number provide a bright perspective for future semiconductor physics in Poland.

I address my warmest words of gratitude to the members of the Program Committee and the International Advisory Committee who graciously used their time and efforts to shape an outstanding program of the School and the Conference. I would like to thank the members of Organizing Committee for their efforts in shaping technical side of the Conference. I would also like to thank the organizations who have generously supported 44th Jaszowiec Conference and I gratefully acknowledge the support of our sponsors.

I wish you all a pleasant time during the Jaszowiec Conference.

Stanislaw Krukowski
Saturday, June 20th, 2015

8:50 – 9:00 Łukasz Kłopotowski – School opening address

INVITED LECTURES (SaPLN-S1 - SaPLN-S3)

9:00 – 11:00 Dmitri R. Yakovlev (Technische Universität Dortmund, Germany)
Spins in Colloidal Nanocrystals

11:00 – 11:30 Coffee Break

11:30 – 13:30 Anna Fontcuberta i Morral (École Polytechnique Fédérale de Lausanne, Switzerland)
Growth and properties of semiconductor nanowires

13:30 – 15:30 Lunch break

15:30 – 17:30 Lorenzo Rigutti (University and INSA of Rouen, France)
Atom Probe Tomography and Semiconductor Nanostructures: Principles, Applications, and Correlative Approaches

19:00 Barbecue

Sunday, June 21st, 2015

INVITED LECTURES (SuPLN-S1 - SuPLN-S3)

9:00 – 11:00 Duncan K. Maude, B.A. Piot, W. Desrat, L.B. Rigal, P. Plochocka
(Laboratoire National des Champs Magnétiques Intenses - Toulouse, France)
The Quantum Hall Effect Revisited

11:00 – 11:30 Coffee Break

11:30 – 13:30 Łukasz Cywiński (Institute of Physics of the Polish Academy of Sciences, Poland)
Interaction of a quantum system with its environment: from linewidth of optical transitions to decoherence of qubits

13:30 – 15:30 Lunch break

15:30 – 17:30 Kirill I. Bolotin (Physics Department, Vanderbilt University, USA)
Mechanics, electronic transport and optics of two-dimensional atomic crystals

19:00 – 20:00 Concert – chamber music performed by young artists, laureates of international music competitions

20:05 Welcoming glass of wine
Monday, June 22nd, 2015

8:50 – 9:00  Stanislaw Krukowski – Conference opening address
OPENING PLENARY LECTURE (MoPLN)
9:00 – 10:00 Hiroshi Amano (Nagoya University, Japan)
Development of GaN based devices and future prospects
PLENARY LECTURES (MoPLN2 - MoPLN4)
10:00 – 11:00 Claude Weisbuch (UCSB Santa Barbara, USA)
Challenges and new concepts of semiconductor light emitters
11:00 – 11:20 Coffee Break
11:20 – 12:20 Martin Kamp (University of Würzburg, Germany)
High-performance interband cascade lasers for the 3-7 µm wavelength range
12:20 – 13:20 Robin Nicholas (Oxford University, United Kingdom)
Quantum Hall effect in graphene: Breakdown, disorder and energy loss rates
13:20 – 15:20 Lunch break

CONTRIBUTED TALKS (MoO1 - MoO7)
Coherent nonlinear spectroscopy of an InAs quantum dot embedded in a photonic trumpet
Propagation, scattering and absorption of exciton-polaritons in GaAs
15:50 – 16:05 J.V. Buller, E.A. Cerda-Mendez, R.E. Balderas-Navarro, K. Biermann, P.V. Santos
Dynamical and Tuneable Modulation of Tamm-Plasmon/Exciton-Polariton Hybrid States using Surface Acoustic Waves
Determination of internal electric fields in binary GaN/AlN multi-quantum wells: experimental and ab initio comparative study
16:20 – 16:35 Break
Composition fluctuations in high indium content InGaN quantum wells - dependence on substrate polarity
Unexpected low-temperature behavior of photoluminescence in InGaN/GaN light emitting diodes. Role of potential fluctuations

17:05 – 17:20  P. Strak, P. Kempisty, K. Sakowski, S. Krukowski  
Polar AlN surface under nitrification determined by density functional theory

17:20 – 19:00  Break

CONTRIBUTED TALKS (MoO8 – MoO14)

19:00 – 19:15  V. Delmonte, T. Jakubczyk, K. Nogajewski, M. Koperski, A. Arora, C. Faugeras, W. Langbein, M. Potemski, J. Kasprzak  
Exciton inter-valley scattering in monolayers of WSe2

19:15 – 19:30  M. Grzeszczyk, K. Gołasa, M. Pilat, K. Nogajewski, M. Potemski, A. Babiński  
Optical signature of few monolayer MoTe2

19:30 – 19:45  K. Gołasa, M. Grzeszczyk, M. Pilat, K. Nogajewski, M. Potemski, A. Babiński  
Raman spectroscopy of shear modes in a freestanding few-layer MoS2

Asymmetric composition dependence of lattice dynamics in MoS,Se2–4 layers

20:00 – 20:15  Break

20:15 – 20:30  L. Gladczuk, J.A. Majewski  
First-principles study of group IV honeycomb layers and their binary alloys

20:30 – 20:45  A. Jamroz, J.A. Majewski  
Ordering in binary BxC1–x, NxC1–x and ternary B0.25N0.25C0.5 honeycomb graphene-like alloys

20:45 – 21:00  M. Pele, W. Jaskólski, A. Ayuela, L. Chico  
Electronic Properties of Corrugated Bilayer Graphene

21:00 – 21:05  Break

21:05 – 23:00  MONDAY POSTER SESSION (MoP1 … MoP59)
Tuesday, June 23rd, 2015

PLENARY LECTURES (TuPLN1 - TuPLN4)

9:00 – 10:00  Qi-Kun Xue (Department of Physics, Tsinghua University, Beijing, China)
Atomic-Level Control of Quantum Material Growth: From Quantized Anomalous Hall Effect to Interface-Enhanced High Tc Superconductivity

10:00 – 11:00  Marcin Konczykowski (Ecole Polytechnique, France)
Irradiation induced doping of topological insulators

11:00 – 11:20  Coffee Break

11:20 – 12:20  Sebastian Loth (Max Planck Institute for Solid State Research, Stuttgart, Germany)
Fundamentals of quantum-limited spintronics with atoms on surfaces

12:20 – 13:20  Paweł Prystawko (Institute of High Pressure Physics of the Polish Academy of Sciences, Poland)
Electronic Devices based on 2DEG in Nitride polar structures

13:20 – 15:20  Lunch break

CONTRIBUTED TALKS (TuO1 - TuO7)

19:00 – 19:15  S. Safaei, M. Galicka, P. Kacman, R. Buczek
Quantum Spin Hall Effect in IV-VI Topological Crystalline Insulators

Observation of the de Haas - van Alphen Effect in Topological Crystalline Insulator SnTe

19:30 – 19:45  D. Zdulski, K. Byczuk
Thermodynamic and topological phase diagrams of correlated topological insulators

19:45 – 20:00  P. Potasz, J. Fernandez-Rossier
Robust orbital nanomagnets

20:00 – 20:15  Break

Magnetophotoluminescence of Nanocrystalline Zinc Oxide with Fe3+ Ions

Energy gap variation and valence band mixing in strained (Zn,Mn)Te/(Zn,Mg)Te core/shell nanowires

21:05 – 23:00  TUESDAY POSTER SESSION (TuP1 ... TuP60)
Wednesday, June 24th, 2015

INVITED LECTURES (WePLN1 - WePLN4)

9:00 – 10:00 Rudolf Bratschitsch (Universität Münster, Germany)
Atomically thin semiconductors light up

10:00 – 11:00 Cezary Śliwa (Institute of Physics of the Polish Academy of Sciences, Poland)
The physics of ferromagnetic semiconductors: from symmetry to micromagnetic properties

11:00 – 11:20 Coffee Break

11:20 – 12:20 Benjamin Piot (LNCMI, Grenoble, France)
Using Nuclear Spins To Probe New Electronic States In Low Dimensional Systems

12:20 – 13:20 Steven H. Simon (University of Oxford, United Kingdom)
Topological Matter and Why You Should be Interested

13:20 – 15:20 Lunch break

CONTRIBUTED TALKS (WeO1 - WeO7)

Giant Zeeman effect in semi-magnetic exciton-polaritons

Magneto-photoluminescence studies of charged exciton localization in GaAs/AlxGa1-xAs quantum wells

Ladder of exciton-polariton resonances in magnetic field

Rydberg excitons in cuprous oxide

16:20 – 16:35 Break

Lasing of semimagnetic polaritons in (Cd,Zn,Mg)Te based microcavities

16:50 – 17:05 A. Bojarska, I. Makarowa, P. Wiśniewski, R. Czernecki, T. Suski, P. Perlin
Thermally dependent processes in nitride laser diodes

17:05 – 17:20 A. Skierkowski, J.A. Majewski
Spin-orbit coupling caused spin splitting in doped graphene like layered materials

20:00 Conference Banquet
Thursday, June 25th, 2015

PLENARY LECTURES (ThPLN1 - ThPLN4)

9:00 – 10:00 Aymeric Delteil (ETH Zurich, Switzerland)
Spin-photon interface and distant entanglement of quantum dot spins

10:00 – 11:00 Mateusz Goryca (Institute of Experimental Physics, University of Warsaw, Poland)
Coherent Precession of an Individual 5/2 Spin

11:00 – 11:20 Coffee Break

11:20 – 12:20 Artur Podhorodecki (Institute of Physics, Wroclaw University of Technology, Poland)
Lanthanides doped nanocrystals - synthesis, optical properties and biomedical applications

12:20 – 13:20 Andreas Knorr (Technical University Berlin, Germany)
Ultrafast electron kinetics in graphene

13:20 – 15:00 Lunch break

15:00 – 16:30 THURSDAY POSTER SESSION (ThP1 … ThP60)

CONTRIBUTED TALKS (ThO1 - ThO7)

Atom probe tomography study of quantum dots formed by alloy fluctuation in GaAs/AlGaAs core-multishell nanowires

16:45 – 17:00 G. Michalek, T. Domański, B.R. Bulka, M. Urbaniak, K.I. Wysokiński
Local and non-local resistances of the three-terminal hybrid nanostructures

17:00 – 17:15 K. Roszak, R. Filip, T. Novotný
Decoherence control by quantum decoherence itself

17:15 – 17:30 J. Kobak, T. Smoleński, M. Papaj, A. Golnik, W. Pacuski
Direct Measurement of Zero Field Splitting of a Cobalt Ion in a CdTe/ZnTe Quantum Dot

17:30 – 17:45 Break

17:45 – 18:00 T. Smoleński, T. Kazimierczuk, J. Kobak, M. Goryca, A. Golnik, P. Kossacki, W. Pacuski
Magnetic Ground State of an Individual Fe$^{2+}$ Ion in a Strained Semiconductor Quantum Dot

18:00 – 18:15 V. Křápek, P. Klenovský, T. Šikola
Excitonic fine structure splitting in type-II quantum dots

18:15 – 18:30 K. Sawicki, W. Pacuski, M. Nawrocki, J. Sufficyński
Towards increased extraction of the light emitted by epitaxially grown quantum dots

18:30 – 19:45 Break
CONTRIBUTED TALKS (ThO8 – ThO13)


*Virtual Many-particle Excitations in a Polariton Condensate under Nonresonant Pumping*


*Single photon emitters in exfoliated WSe$_2$ structures*


*Towards deterministic highly efficient single photon sources based on circular Bragg grating cavities*

20:30 – 20:45  Break

20:45 – 21:00  M. Ściesiek, W. Pacuski, J.G. Rousset, M. Parlińska-Wojtan, J. Suffićzyński, A. Golnik

*Growth and spectroscopy of coupled ZnTe planar microcavities*

21:00 – 21:15  M. Wlazło, J.A. Majewski

*First Principles Study of Gas Adsorption Dynamics on Pristine and Defected Graphene*


*Spontaneous magnetization of composite fermions in second Landau level of graphene*

21:30 – 21:45  Stanislaw Krukowski – Conference closing address
1. Z.R. Kudrynskyi, A.P. Bakhtinov, V.B. Boledzyuk, Z.D. Kovalyuk, V.E. Slyn'ko
   Nanocomposite magnetic compounds based on layered semiconductors synthesized by
   electrochemical intercalation in gradient magnetic field

2. V. Romanyuk, N. Dmytruk, O. Kondratenko, M. Taborska, G. Lashkarev, V. Karpyna,
   V. Popovyych, M. Dranchuk, G. Dovbeshko, I. Dmytruk, R. Pietruszka, M. Godlewski
   Optical properties of highly doped ZnO:Al films deposited by ALD process on Si substrate in
   visible and near infrared region

3. M.A. Borysiewicz, M. Ekielski, M. Wzorek, M. Myśliwiec
   Nanocoral ZnO-based Transparent Supercapacitor

4. K. Wichrowska, T. Wosiński, S. Kret, M. Rawski, O. Yastrubchak, S. Chusnutdinow,
   G. Karczewski
   Extended Defects in MBE-Grown p-ZnTe/n-CdTe Heterojunctions

5. K. Paradowska, E. Placzek-Popko, M.A. Pietrzyk, A. Kozanecki
   Electrical Characteristics of p-Si/MgO/ n-Zn$_{1-x}$Mg$_x$O Heterojunction

   Teraherz pulse emission from InGaAs and GaMnAs nanowires

7. P. Klenovský, V. Křápek, J. Humlíček
   Application of InAs/GaAsSb/GaAs type-II Quantum Dots as quantum gates

8. I.G. Orletsky, E.V. Maistruk, V.V. Brus, D.P. Koziarskyi, P.D. Maryanchuk
   The effect of the elemental composition of the spray-solution on the properties of SnS thin films

   Pressure Induced Decrease of the Curie Temperature in (Ga,Mn)As Non-metallic Sample

10. B.S. Witkowski, Ł. Wachnicki, S. Gierałtowska, R. Pietruszka, M. Godlewski
    Highly sensitive photoresistor based on ZnO nanorods grown by the hydrothermal method

    Complex quantum nanostructures as transistors and rectifiers

    L. Rigutti
    Nanoscale Study of AlGaN/GaN multi-Quantum Wells by Comparative Atom Probe Tomography,
    Scanning Transmission Electron Microscopy and Micro-Photoluminescence

13. P. Podemski, M. Pieczarka, A. Maryński, J. Misiewicz, A. Loffler, S. Hofling, S. Reitzenstein,
    G. Sęk
    Carrier Transfer Processes in In$_{0.5}$Ga$_{0.5}$As/GaAs Self-assembled System on Single Dot Level

    Large-scale spatial mapping of photoluminescence from type II InAs/GaInSb W-shaped quantum
    wells in the mid-infrared spectral range
15. L.I. Ovsiannikova, I. Shtepliuk, G.V. Lashkarev, V.V. Kartuzov
   *A study of an effect of clusterization of CdO phase in ZnCdO alloys by using Zn_{44}Cd_{4}O_{48} cluster*

   *Physical properties and band parameters of crystals Cu_{2}ZnSnTe_{4}*

17. G.O. Andrushchak, P.D. Marianchuk
   *Optical Properties of Hg_{1-x}MnxS and Hg_{1-x-y}MnxFe_{y}S*

   *Optical Properties of Molecular-beam-epitaxy-grown InAs/InAlGaAs/InP Quantum Dots as 1.55 μm Emitters in Tunnel Injection Lasers*

19. K. Sakowski, P. Strąk, S. Krukowski, L. Marcinkowski
   *Optimization of InGaN laser diodes based on numerical simulations*

20. A. Maryński, M. Pieczarka, P. Podmski, J. Misiewicz, P.D. Spencer, R. Murray, G. Sęk
   *Energy transfer processes in InAs/GaAs quantum dot bilayer structure*

   *Magnetic field control of fine structure splitting in a single quantum dash for entangled photon pairs at telecommunication wavelengths*

22. Z. Gumienny, K. Skrzynska, E. Placzek-Popko, K. Gwozdz, L.B. Chang
   *Photoluminescence studies of BN/AlN/GaN layer structure on sapphire substrate*

   *The Metalorganic Vapour Phase Epitaxy Growth of A^{III}B^{V} Heterostructures Observed by Reflection Anisotropy Spectroscopy*

24. T. Groń, E. Filipek, G. Dąbrowska, H. Duda, B. Sawicki
   *Influence of Cr-substitution on the electrical properties of Fe_{1-x}Cr_{x}SnSbO_{6}*

   *Pressure dependence of GaN/AlN quantum wells properties by density functional theory with half occupation technique correction*

   *The UV detectors based on p-n and p-i-n heterostructures (p-ZnO, n-GaN and i-Al_{2}O_{3}): electrical and optical properties*

27. V.Yu. Ivanov, A. Dejneka, M. Godlewski
   *Photo-ESR and spin-echo photo-ESR investigations of ZnO:Co*

   *Comparative optical studies of ReS_{2-x}Se_{2-x} alloys*
29. M. Kozub, M. Dyksik, M. Motyka, G. Sęk, J. Misiewicz, K. Nishisaka, T. Maemoto, S. Sasa
   Optical Determination of Carrier Concentration in Degenerately Doped InAs Thin Films in
   Radiation Generating Devices in the THz Region

30. D. Ziemkiewicz, S. Zielinska-Raczyńska, G. Czajkowski
   Optical Spectra of Wide Parabolic Quantum Wells

   R. Stepniewski
   Structural and Optical Properties of Boron Nitride Grown by MOVPE

32. E. Pozingytė, A. Rimkus, R. Nedzińskas, B. Čechavičius, J. Kavaliauskas, G. Valušis, L.H. Li, 
   E.H. Linfield
   Temperature-dependent Photomodulated Reflectance of InAs/InGaAs Dots-in-a-Well Quantum 
   Structures

   Comparison between PbTe and SnTe oxidation processes

34. B. Sadovy, M. Amilusik, G. Staszcak, M. Bockowski, I. Grzegory, S. Porowski, L. Konczewicz, 
   V. Tsybylsky, M. Panasyuk, V. Rudyk, V. Kapustiany, E. Litwin-Staszewska, R. Piotrkowski
   The influence of growth direction on electrical and optical properties of GaN:Mg single crystals 
   grown by High Nitrogen Pressure Solution method

35. M. Stachowicz, D. Jarosz, M.A. Pietrzyk, J.M. Sajkowski, E. Przedziecka, A. Sarakovsky, 
   A. Kozanecki
   Optical investigation of coupled double asymmetric ZnO/MgZn1−xO quantum wells grown on 
   nonpolar substrates by MBE

   Pressure induced increase of exciton-phonon interactions in a single ZnO/(ZnMg)O 
   quantum well

37. Ł. Bala, P. Kaźmierczak, M. Zając, M. Iwińska, R. Stepniewski, A. Wysmolek
   Determination of low carrier concentration in GaN structures using spatially resolved Raman 
   spectroscopy

38. A. Pieniążek, B.S. Witkowski, A. Reszka, Ł. Wachnicki, S. Gierałtowska, M. Godlewski, 
   B.J. Kowalski
   Defect-related green emission from ZnO microrods – a cathodoluminescence study

39. A. Piekarska, P. Potasz, A. Wójc
   The Quantum Spin Hall and Quantum Anomalous Hall Effects in a Two-Dimensional Decorated 
   Lattice with Spin-Orbit Coupling and Staggered Potential

40. J. Polaczyński, M. Szot, L. Kowalczyk, K. Dybko, A. Witowski, S. Chusnudinow, S. Kret, 
   T. Wojciechowski, S. Schreyeck, K. Bruner, C. Schumacher, T. Wojtowicz, L.W. Molenschamp, 
   T. Story, G. Karcewski
   Nanoscale shape control and optical properties of epitaxial PbTe/CdTe heterostructures

41. L. Kilanski, A. Avdonin, I. Kurylyszy-Kudelska
   Development of the Alternating Gradient Magnetometer System
42. Y. Yuan, M. Sawicki, M. Helm, S. Zhou
   *III-V:Mn Ferromagnetic semiconductors prepared by ion implantation*

43. A. Łusakowski, P. Bogusławski, T. Story
   *Single ion magnetic anisotropy in disordered Ge_1-xMn_xTe*

44. R. Kuna, J. Łażewski, S. Petit, P. Baroni, K. Gas, R. Minikayev, A. Szczerbakow,
   W. Szuszkiewicz
   *Neutron scattering studies of phonon dispersion in (Pb,Cd)Te solid solution*

   M. Albrecht, X.Q. Wang
   *In(Ga)N/GaN short period superlattices*

46. M. Baussenwein, F. Gerhard, C. Gould, L.W. Molenkamp
   *Investigating NiMnSb-Heterostructures for use in Spin Torque Oscillators*

47. S.A. Bercha, K.E. Glukhov, M. Sznajder
   *Construction of the adiabatic potential of a symmetric molecule in the vicinity of charged surface of semiconductor*

   K. Kopalko, A. Stonert, R. Ratajczak
   *Zinc oxide films grown at low temperature – electrical properties and hydrogen contamination*

49. G. Grabecki, K. Grasza, A. Avdonin, P. Skupiński, I. Yahniuk, R. Wawrzyńczak, M. Majewicz,
   T. Dietl
   *Quantum Transport in Three-Dimensional Dirac Semimetal Cd_3As_2*

   *Engineering of InGaN/GaN in-plane quantum wires grown along surface atomic steps*

51. J. Rybusiński, A. Gardias, I. Kamińska, B. Sikora, K. Fronc, M. Szewczyk, P. Stępień, D. Elbaum,
   A. Twardowski, J. Szczymlyk
   *Magnetic properties of Y_3Al_5O_12: Er^{3+},Yb^{3+} up-converting nanoparticles for bio-medical applications*

52. L.M. Szulakowska, P. Potasz, A. Wójs
   *DFT Studies of Magnetic Properties of MoS(Se) Nanoribbons*

53. P.S. Perkowska, M.R. Molas, A. Reszka, K.P. Korona, M. Sobanska, K. Klosek, M. Potemski,
   A. Wysmolek, Z.R. Zytikiewicz
   *Magnetoluminescence of excitonic emission in gallium nitride nanowires*

   *Single (In,Al,Ga)As quantum dot micro-photoluminescence at high surface density of dots – a possible role of Mn doping*
55. D.P. Żebrowski, B. Szafran
   *DFT study of the graphene nanoribbon quantum dots*

56. E. Shylko, J.A. Majewski
   *Modeling of zero-field spin splitting of energy bands in atomically thick layered structures*

57. N. Gonzalez Szwacki, T. Tarkowski, J. A. Majewski
   *2D Boron Allotropes: Structure, Properties, and Computational Hints Towards an Experimental Realization on a Large Scale*

58. M. Popielska, M. Marchwiany, J.A. Majewski
   *First-principles study of hydrogenated and fluorinated graphene layers on metallic substrates*

59. M. Sadek, J.A. Majewski
   *Ab initio studies of graphene and BN multilayers*
TUESDAY POSTER SESSION (ThP1 – ThP60)

   *Photovoltaic Characteristics of Si/ZnO Nanorods/Ag/AZO Plasmonic Cells*

   *Nanocrystalline Sputter-deposited ZnMgO:Al Film and its Application as a Transparent P-Type Electrode in GaN-Based 385 nm UV LED for Significant Emission Enhancement*

   *Effect of Misfit Strain in (Ga,Mn)(Bi,As) Epitaxial Layers on their Magnetic and Magnetotransport Properties*

4. N. Podolska
   *Phase separation and interatomic distances in semiconductors with oxygen in the anion sublattice*

5. I. Ozfidan, M. Korkusinski, P. Hawrylak
   *Beyond graphene- Dirac Fermions in graphene quantum dots*

6. A. Mreńca, B. Szafran
   *Transport properties of hydrogen-passivated graphene systems*

7. K. Kolasiński, B. Szafrain, M.P. Nowak
   *Scanning gate microscopy simulations of the double slit electron interferometer*

8. I.G. Orletsky, E.V. Maistruk, V.V. Brus, D.P. Koziarskyi, P.D. Maryanchuk
   *Spray pyrolysis deposition and optical properties of Cu₂ZnSnS₄ thin films*

9. E.N. Osika, B. Szafran
   *Tight-binding calculations of two-electron energy spectra in carbon nanotube n-p quantum dots*

    *Correct Measurement of AlGaN/GaN and InGaN/GaN Heterostructure Composition by Atom Probe Tomography*

11. P. Wojnar 1, M. Wiater, K. Frone, J. Mikulski, Ł. Klopotowski, J. Kossut
    *Tuning the emission energy from CdTe and CdSe quantum dots by copper doping*

12. J. Aleknavičius, D. Dobrovolskas, G. Tamulaitis
    *Spatially Resolved Photoluminescence and Laser Annealing of GaBiAs Epitaxial Layers and Quantum Wells*

    *Charged exciton confined in an InGaAs/GaAs quantum rod as a single photon emitter at liquid nitrogen temperature*
*Magnetization of GaMnN nanopowders obtained by an anaerobic synthesis and high-pressure high-temperature sintering*

15. J. Kaczmarski, J. Grochowski, T. Boll, M.A. Borysiewicz, A. Taube, W. Jung, E. Kamińska, K. Stiller
*Effect of cathode current on trap states density in In-Ga-Zn-O thin films*

16. K. Szałowski
*Monolayer graphene nanoflakes in electric and magnetic field*

17. M.M. Solovan, N.M. Gavaleshko, V.V. Brus, P.D. Maryanchuk
*Electrical and photoelectrical properties of MoO₅/n-CdTe heterojunctions*

18. M. Papaj, Ł. Cywiński, G. Grabbecki, J. Wróbel, T. Dietl
*Numerical Modeling of Nanoconstrictions in Two-Dimensional Topological Insulators*

*Synthesis and magneto-spectroscopy characterization ZnO core based nanocrystals doped with copper ions*

20. K. Ryczko, G. Sęk, J. Misiewicz
*Type-II “W-shaped” quantum wells for mid-infrared emission with tensely – strained GaAsSb layer for confinement of holes*

*A new perspective on graphene based flow sensors*

*Tailoring the polarization anisotropy of a single InAs quantum dash by a post-growth modification of its dielectric environment*

*Dielectric properties of REₓW₂O₉ (RE = Pr, Sm-Gd)*

*Optical and structural properties of ZnO/ZnMgO nanostructures grown on r-plane Al₂O₃ substrates by MBE*

*Interplay of magnetic and transport properties in Ge₁₋ₓPbₓCr₅Te Composite System*

*Low temperature preparation of 1 μm x 1 μm HgTe/(Hg,Cd)Te Hall bars*

27. A. Ciechan, H. Przybylińska, P. Skupiński, A. Mycielski, P. Bogusławski, A. Suchocki
*Metastability of Mn³⁺/Mn²⁺ in ZnO: theory and experiment*
28. I. Bragar, Ł. Cywiński
   Dynamics of entanglement of two singlet-triplet qubits in GaAs-AlGaAs heterostructure

29. A.J. Zakrzewski
   Optical Spectra of Shallow Donors in Uniform Magnetic and Electric Field

   Influence of Oxidation Methods on the Volume of PbSnTe Thin Films Consumed during Oxidation

   Quantum transport in microstructures of InAs/GaSb heterostructures

32. B. Jaworowski, P. Potasz, A. Wójc
   Interplay of magnetic field and spin orbit interaction for Lieb lattice

33. A. Kamińska, D. Jarosz, M. Boćkowski, H. Teisseyre
   Hydrostatic pressure studies of gallium nitride doped with beryllium

34. T. Woźniak, M.J. Winiarski, P. Potasz, P. Scharoch, A. Wójc
   Ab-initio studies of geometry, electronic structure and adsorption properties of chosen transition metal dichalcogenides monolayers

35. G. Sęk, D.N. Krizhanovskii, V.D. Kulakovskii, S. Reitzenstein, M. Kamp
   Controlling the Biexciton-Exciton Cascade Kinetics in a Quantum Dot via Coupling to a Microcavity Optical Mode

   Lattice location of deep level impurities in hyperdoped Si by ion implantation and short-time annealing

   Shape of potential fluctuations in InGaN/GaN quantum wells as function of In composition

38. E. Wach, B. Szafran
   Simulations of imaging of the electron density in the planar quantum dots in transition to fractional quantum Hall regime

   Technology and characterization of silicon strip sensors with read-out gate dielectric of stacked SiO_2 and Si_N_x layers

   Bi_2Te_3Se – topological insulator with high resistivity

41. M. Grabowski, M. Szajdjer, J.A. Majewski
   Similarities in the physico-chemistry of the C/BN and SiC/AlN(GaN) interfaces: ab initio studies

42. B.A. Orłowski, A. Pieniazek, K. Goscinski, K. kopalko
   Quasi Fermi Level in Semiconductors Photovoltaic Heterojunction
   *Sidewall versus axial growth of CdTe insertions in ZnTe/ZnMgTe core-shell nanowires*

   *Investigations of Structural, Magnetic and Electrical Properties of Thin Epitaxial MnSi Layers*

   *Monte Carlo study of interacting magnetic nanoparticles with cubic magnetocrystalline anisotropy*

46. P. Onksiak, P. Kaźmierczak, J. Binder, W. Strupiński, R. Stepniewski, A. Wysmołek
   *The influence of aqueous solutions on electronic and optical properties of epitaxial graphene grown on SiC*

47. T. Słupiński, P. Stawicki, B. Piętka, M. Tokarczyk, G. Kowalski
   *Improved (Al,Ga)As-AlAs microcavities grown by MBE with in-situ simulated reflection spectra*

   *Ordered magnetic MnAs nanocrystals embedded in III-V semiconductor nanowire shells*

49. A. Płocharski, M. Klepuzewski, T. Kulka, K. Gołasa
   *Optical properties of graphene sheets from various origin*

50. J.G. Rousset, R. Rudniewski, A. Janaszek, V. Delmonte, T. Jakubczyk, J. Kasprzak, W. Pacuski
   *Antireflective photonic structure with CdTe/(Cd,Zn,Mg)Te QDs containing single Mn ions*

51. A. Mielpnik-Pyszczorski, K. Gawarecki, P. Machnikowski
   *Quantum well-quantum dot relaxation processes in the presence of the piezoelectric field*

52. M. Popielska, M. Sznajder, J.A. Majewski
   *First-principles study of energetics and magnetic interaction of Mn dimers on heteropolar zb-SiC/zb-GaN(001) interfaces*

53. P. Bugajny, P. Potasz, A. Wójc
   *Graphene-like ribbons with spin-orbit coupling in an external magnetic field*

   *GaAs/Al$_2$O$_3$ High-Contrast Grating structures for vertical cavity surface emitting lasers*

55. N. Gonzalez Szwacki, J. A. Majewski
   *Structural, Electronic, and Magnetic Properties of the Two-Dimensional Graphene-BN System Studied by First-Principles Simulations*

56. I. Nevinskas, R. Butkutė, A. Geižutis, A. Krotkus
   *InAs P-N Junction as a Surface Terahertz Emitter*

   *Spin Relaxation Dynamics of an Individual Co$^{2+}$ Ion in a CdTe/ZnTe Quantum Dot*

58. J.C. Tong, P.N. Ni, D.H. Zhang
   *InAsSb Photoconductive Infrared Photodetectors at Near Room Temperature*
   *InGaN Quantum Wells with Increased Internal Efficiency*

   *Spectroscopy of Excitons in a Single ZnO/(Zn,Mg)O Quantum Well*
THURSDAY POSTER SESSION (ThP1 – ThP60)

1. E.O. Melezhik, J.V. Gumenjuk-Sichevska, F.F. Sizov
   *Modeling of Electron Mobility in Semi-metallic Hg$_{1-x}$Cd$_x$Te Quantum Wells at T = 77 K: Application to THz Detection*

   *Correlations of axial and lateral emission of coupled quantum dot – micropillar cavity system in cQED regime*

   *Tunneling Magnetoresistance of (Ga,Mn)As / GaAs Esaki Diodes*

4. M. Krajewski, K. Gołasa, D. Wasik, W.S. Lin, H.M. Lin
   *Influence of Iron Nanowires Oxidation on Their Semiconducting Properties*

5. B. Sawicki, E. Tomaszewicz, M. Piątkowska, T. Groń, H. Duda, K. Górny
   *Correlation between the band-gap energy and the electrical conductivity in MPr$_2$W$_2$O$_{10}$ tungstates (where M = Cd, Co, Mn)*

   *Layer by Layer Fabrication of Sub-Micron Light Trapping Structures for Dye-Sensitized Solar Cells*

7. K. Ptaszyński, B.R. Bułka
   *Dynamics and logic operations in two coupled triple quantum dot charge qubits*

8. I.P. Koziarskyi, E.V. Maistruk, D.P. Koziarskyi
   *The Thickness of the CZTS(Se, Te) Films*

9. T.P. Surkova, V.I. Maksimov, M. Godlewski
   *Imperfect structure state and superstructures formed in Zn$_{0.95}$Fe$_{0.05}$Se DMS cubic crystal*

10. V.V. Brus, I.G. Orletsyk, E.V. Maistruk, D.P. Koziarskyi, P.D. Maryanchuk
    *Physical properties of Cu$_2$SnS$_3$ thin films, prepared by the spray pyrolysis method*

    *Enhancing the transition oscillator strength in type II quantum wells for application in interband cascade lasers*

    *Anomalous pressure hysteresis due to intercluster interaction in the new high-pressure chalcopyrite phase*

13. P. Kopyciński, S. Prucnal, K. Pyszniak, W. Skorupa, J. Żuk
    *Influence of Ion Implantation and Annealing Parameters on Synthesis of InAs Nanostructures in SiO$_2$/Si Matrices*
*Exciton spin polarization relaxation in InAs/InP quantum dashes under optical-phonon-mediated resonant excitation*

15. V. Krápek, Z. Édes, P. Klenovský, T. Šikola
*Plasmon-enhanced photoluminescence of spatially extended quantum emitters*

16. D.V. Savchenko, E.N. Kalabukhova
*The ESR study of conduction electrons in heavily nitrogen doped 6H SiC crystals*

*Spin conductance of nanowires with double coupled quantum dots*

18. A.I. Mostovyi, M.M. Solovan, V.V. Brus, P.D. Maryanchuk
*Optical properties thin films of Cu$_2$ZnSnSe$_4$*

*Transport properties of the two-dimensional electron gas in modulation doped CdTe quantum well structures*

*Magnetic, kinetic, optical properties and band parameters of crystals Cu$_2$ZnSnSe$_2$Te$_2$*

*Temperature damping of ESR and FMR for nanocomposites Co/Al$_2$O$_3$ in the superparamagnetic and ferromagnetic states*

*Thermally evaporated HgTe layers as planar ohmic contacts for CdTe and CdMnTe quantum wells*

23. A.A. Golovatenko, M.A. Semina, A.V. Rodina, T.V. Shubina
*Density of states and photoluminescence spectra in the dense arrays of CdSe/ZnSe quantum dots with Gaussian potential profile*

24. B.K. Kuśmierz
*Search for Jack ground states of two-body hamiltonians*

25. T. Groń, E. Filipiak, M. Piz, Z. Kukula, S. Pawlus
*Dielectric permittivity of Nb$_6$V$_3$Sb$_3$O$_{25}$*

*Current-voltage characteristics of n-TiN/n- Hg$_{1-x}$Cd$_x$Me$_2$Se heterojunctions*

27. M. Brzezińska, P. Potasz, A. Wójc
*Exact diagonalization studies of topologically non-trivial flat bands with interactions*

28. P. Strak
*Accurate band gap model based on density functional theory with half occupation technique correction for application to nitrides quantum heterostructures*
29. M. Inglot, V.K. Dugaev, J. Barnaś
   *Thermoelectricity and thermospin induced by the temperature gradient in ballistic graphene*

30. T. Palutkiewicz, M. Wołoszyn, B.J. Spisak
   *Influence of the gate voltage and geometrical parameters on the transport characteristics of core-multishell nanowires*

   *Time dependent current through a quantum dot-ring nanostructure*

   *Optical properties of GaN nanowires grown by plasma assisted molecular beam epitaxy on Si(111) substrates with amorphous Al2O3 buffers*

33. K.P. Korona, D.A. Ziółkowska, P.A. Dróżdż, M. Michalska, L. Lipinska
   *Diffusion and conductivity in lithium titanium oxide*

34. J. Pers, M. Grodzicki, A. Ciszewski
   *Morphology of thin films containing Ni-Ga intermetallic compounds formed on GaN(0001)*

35. M. Gawelczyk, P. Machnikowski
   *Spin dynamics and magneto-optical response in charge-neutral tunnel-coupled quantum wells*

   *Low-temperature cathodoluminescence investigations of GaN nanowires with AlxGa1-xN insets*

37. M. Bieniek, P. Potasz, A. Wójc
   *Magnetic field in topological insulator quantum dots*

38. M.V. Rakhlin, S.V. Sorokin, I.V. Sedova, A.A. Usikova, S.V. Gronin, K.G. Belyaev, S.V. Ivanov, A.A. Toropov
   *Micro-Photoluminescence Studies of CdSe/ZnSe Quantum Dot Structures with and without Sub-monolayer CdTe Stressor*

   *Photoelectrical properties of p-CdZnTe/i-CdTe/n-CdTe diodes with PbTe nanoinclusions*

40. A. Łusakowski, W. Szuszkiewicz
   *Ab initio studies of magnetic anisotropy energy in highly Co-doped ZnO*

   *Magnetic and structural properties of MBE grown wurtzite (Ga,Mn)As shells in a radial quantum well nanowire heterostructures*

42. M. Pilat, K. Golasa, M. Grzeszczyk, A. Babiński
   *Raman Spectroscopy of Guanajuatite – Natural Topological Insulator*

43. S.P. Łepkowski, W. Bardyszewski, D. Rodak
   *Topological Quantum Phase Transition in InN/GaN Quantum Wells under Hydrostatic Pressure*
Mechanisms of excitonic emission in ultrathin CdSe layers embedded in ZnSe

45. L.Yu. Kharkhalis, K.E. Glukhov, M. Sznajder
Electron-deformational Phase Transitions in a TlGaSe2 Layered Crystal

46. B.A. Orlowski, A. Reszka, E. Guziewicz, B.J. Kowalski
Rare Earth 4f electrons in semiconductors valence band

47. E. Guziewicz, R. Ratajczak, D. Snigurenko, M. Stachowicz, T.A. Krajewski, A. Stonert, A. Turos
Structural, optical and electrical properties of ZnO single crystals and epitaxial films implanted with Er and Yb

48. K. Ubych, P. Kaźmierczak, K. Golaśa, M. Grzeszczyk, W. Strupiński, A. Babiński, A. Wysmolek
Optical properties of graphene-MoS2 heterostructure

49. K.A. Kluczyk, W.A. Jacak
Surface plasmon resonance in metallic nano-particles

High quality factor microcavities with CdSe/(CdMg)Se quantum wells

51. M.Ś. Świderski, M.Z. Zieliński
Perturbative treatment of electric field in semiconductor quantum dots

52. M. Król, R. Mirek, K. Lekenta, K. Nogajewski, M. Koperski, P. Kossacki, A. Babiński, M. Potemski, J. Szczytko, B. Piętka
Optical cavities for WSe2 monolayers

53. J. Andrzejewski
Electronic Structure Calculations of InP-Based Coupled Quantum Dot – Quantum Well Structures

54. W.J. Pasek, M.P. Nowak, B. Szafran
Spin Exchange Energy For A Pair Of Valence Band Holes In Artificial Molecules

55. M. Marchwiany, M. Popielska, A. Niegowski, J.A. Majewski
Accurate exact-exchange Kohn-Sham real space formalism

56. A. Siklitckaia, J.A. Majewski
Ab initio molecular dynamics studies of CO2 and CH4 adsorption at CaCO3 (10-14) surface

57. A. Szumska, A. Warchulski, J.A. Majewski
Looking for graphene like material for thermoelectric applications

Ferromagnetic resonance study of magnetic anisotropy in Ge1-xMnxTe layers on KCl (001) substrate

Manipulation of carrier concentration in GaN:Si-based metal-oxide-semiconductor structures
60. K. E. Oksuz, S. Sen, U. Sen

*Raman scattering and dielectric investigations of B₂O₃ doped Ba(Ti₁₋ₓZrx)O₃ ceramics*
Spins in Colloidal Nanocrystals

D. R. Yakovlev

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In this lecture spin related phenomena in colloidal nanocrystals (NCs) will be presented, including spin structure of neutral and charged excitons (trions) and spin dynamics of the excitons and carriers. Introduction to the optical properties of the colloidal nanocrystals will be given in their comparison with epitaxially grown quantum dots. Various types of colloidal nanocrystals will be considered: core only, core-shell [1-2], dot-in-rod [4-5], platelets [3] based on II-VI semiconductors, mainly CdSe/CdS. Specifics of the exciton energy structure and its influence on the recombination dynamics at different temperatures and strong magnetic fields will be considered with illustrating by experimental results.

Main part of the lecture will be devoted to spin physics in colloidal nanocrystals. Here we report on experimental and theoretical studies of the trion and exciton spin dynamics in core/thick-shell CdSe/CdS NCs. We have shown recently that photo-excitation of core/shell CdSe/CdS nanocrystals (NCs), which shell thickness exceeds 4 nm, leads to a single electron charging of NCs [1,2]. Time-resolved photoluminescence measurements were performed at low temperatures and in high magnetic fields up to 15 Tesla. From the decay of the photoluminescence intensity the trion radiative time of 8 ns was measured. It is independent of the magnetic field reflecting the fact that the trion ground state is always optically bright (i.e. allowed in electric-dipole approximation). This is in strong contrast to the exciton states in NCs which dynamics is controlled by a competition of the bright and dark states, which can be mixed either by magnetic fields or thermally.

Spin relaxation time of excitons is shorter than a nanosecond and are limited by time-resolution of the used setup. While for the trions it is very long up to 60 ns and it decreases by about two orders of magnitude down to 1 ns in strong magnetic field of 15 Tesla.

Theoretical description of the polarization dynamics is complicated by the fact that we study an ensemble of CdSe/CdS nanocrystals with random orientation of their hexagonal axes to the magnetic field direction. The trion Zeeman splitting is controlled solely by the hole g-factor, which is strongly anisotropic: it is maximal for NCs oriented along magnetic field and zero for NCs oriented perpendicular to the field. However, the magnetic field mixing of the hole states, which accelerates spin relaxation in trion, is most efficient for the perpendicular orientation. The developed model approach accounts for all these conditions.

Growth and properties of semiconductor nanowires

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Nanowires are one-dimensional crystals with a tailored diameter between few and few tens of nanometer. Thanks to this special morphology and the small dimensions, they have been proposed as advanced building blocks for a manifold of applications ranging from chemical or biological sensors to energy harvesting. Among the different materials that have been synthetized in the form of nanowires are compound semiconductors. This has allowed for the first time the defect-free integration of III-V semiconductors on the silicon platform. The perspectives are numerous, ranging from the integration of the functionality of III-Vs (high mobility, bright optical emission…) with the CMOS technology.

In this seminar I will present the state of the art of nanowire growth, with a special emphasis in the growth of ultra-pure III-As nanowires by molecular beam epitaxy [1,2]. I will discuss the growth mechanisms as well as the issues allowing the growth of III-V nanowires on silicon. I will continue by expanding the possibilities of this technique for creating other kinds of heterostructures on the nanowires themselves. These will include prismatic quantum wells, quantum dots and crystal phase heterostructures [3-6]. The optical properties of the quantum heterostructures are characterized by micro-photoluminescence and cathodoluminescence at temperatures down to 4.2K.

Finally, the application of nanowires for next generation solar cells and the possible contribution to the generation of solar fuels will be discussed [7,8].

Atom Probe Tomography and Semiconductor Nanostructures: Principles, Applications, and Correlative Approaches.

Lorenzo Rigutti

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I – Principles and Applications of Atom Probe Tomography. Laser-assisted Atom Probe Tomography (La-APT) is a technique based on the field-evaporation of ions from the surface of a sharp tip [1]. This process is triggered by a femtosecond laser pulse and the evaporated ion is detected by a time-of-flight and position sensitive detector (Fig. (1)). This allows for a controlled erosion of the specimen tip and for a 3D reconstruction of the elemental composition of the evaporated volume. In this part of the lecture, I will introduce the principles of the technique, the protocols of sample preparation, and some selected results of its application to semiconductor nanostructures. A part of the lecture will be dedicated to some limitations of the technique, such as possible reconstruction artefacts and compositional biases: while the atom prober must take them into account, they also may teach us a lot about surface physics in high electric field [2].

II – Combining Atom Probe with other techniques. Atom Probe can be combined with other experimental techniques, such as Transmission Electron Microscopy (TEM) and Micro-Photoluminescence Spectroscopy (µPL) applied to semiconductor quantum wells, quantum dots and nanowires. This can be done with different degrees of accuracy: (i) comparative experiments, in which different parts of the same macroscopic samples are analyzed with different techniques [3] (Fig. (2)), (ii) correlative experiments, in which the same nanoscale object is analyzed by different techniques [4] and finally, a perspective on (iii) coupled, in-situ experiments, in which APT and µPL could be performed within a single experimental setup. For each of these approaches, I will explain through state of the art examples the information that could be retrieved from the system under study.

Figure (1) Laser-assisted field ion evaporation and detection. Figure (2) (Left) density plot of AlGaAs alloy composition: the red arrow points to a quantum dot whose electronic states (right) can be calculated directly based on the atom probe measurement [3].

The Quantum Hall Effect Revisited

Duncan K. Maude 1, Benjamin A. Piot1, Wilfried Desrat2, Laurent B. Rigal1 and Paulina Plochocka1

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In a perpendicular magnetic field, the Hall resistance of a two dimensional electron gas (2DEG) of carrier density $n_s$, exhibits quantized plateaux $\rho_{xy} = h/\nu e^2$ in the vicinity of integer Landau level filling factors $\nu = n_s/(eB/h)$. Simultaneously, the resistivity $\rho_{xx}$ exhibits a zero resistance state. This can be understood as follows: A magnetic field quantizes the density of states (DOS) into Landau levels of degeneracy $eB/h$ per spin and energy $E_n = (n + 1/2)\hbar \omega_c$ where $\omega_c = eB/m^*$ is the cyclotron frequency and $n = 0, 1, 2, ..$ is the orbital quantum number. As the carrier density $n_s$ is fixed, the position of the Fermi level is an oscillatory function of magnetic field. Whenever the Fermi level lies in a gap in the DOS, we have $\rho_{xx} \approx \sigma_{xx} \propto \text{DOS}(E_F) \rightarrow 0$. For example, at even filling factors the Fermi level lies in the cyclotron gap while for odd filling factors $E_F$ lies in the spin Zeeman gap ($E_z = g\mu_B B$).

In this talk I will show that, while this single particle picture provides an extremely useful description of the integer QHE, it actual misses most, if not all of the physics. In GaAs/AlGaAs, the most widely studied system today, the small value of the Landé g-factor $\simeq -0.44$ means that the Coulomb interaction dominates over the single particle Zeeman energy. Moreover, in reality the Fermi level jumps between Landau levels and so never actually “lies in the gap”. Disorder has to be invoked, which broadens the Landau levels, and the Fermi level is “in the gap” whenever it lies in the localized states present in the tails of the Landau levels. In a perfect sample without disorder the QHE would not exist. Magnetotransport measurements reveal that the opening of the spin gap with increasing magnetic field is controlled by the competition between the exchange energy gain, and the energy cost of flipping spin due to the disorder broadening of the Landau levels. This can be seen as a magnetic field induced Stoner transition (Quantum Hall ferromagnet) since the single particle Zeeman energy plays no role. On the other hand, circular polarization resolved optical absorption measurements show that the quantum Hall ferromagnet at filling factor $\nu = 1$ is remarkably fragile; the spin polarization of the system collapses rapidly with a small change in filling factor or increases in temperature. Finally, I will demonstrate that the phase diagram for the breakdown of the QHE, namely the magnetic field width $B_c$ of the $\rho_{xx} = 0$ state versus temperature resembles that of a HTc superconductor and gives information on the Landau level line shape and FWHM.

The fractional QHE arises due to gaps in the DOS induced by electron-electron interactions. The composite Fermion model of Jain provides remarkable physical insight, naturally explaining for example the existence of spin reversed fractional states. Nuclear magnetic resonance (NMR) measurements give direct access to the local electronic spin polarization. The NMR signal is Knight shifted due to the contact hyperfine interaction in an analogous way to the Overhauser shift seen in ESR measurements. In QHE samples, the small number of nuclei in contact with the 2DEG makes classical NMR extremely difficult. We have developed resistively detected nuclear magnetic resonance (RDNMR) which relies on the sensitivity of the 2DEG resistivity to the nuclear magnetic field $B_N$. As an example, I will show that RDNMR is a powerful tool to probe the spin polarization of both integer and fractional quantum Hall states.
Interaction of a quantum system with its environment: from linewidth of optical transitions to decoherence of qubits

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During the first course on quantum physics one learns only about pure states (“wavefunctions” in the case of a single electron) of small systems. The same holds most often for the second course on more advanced quantum mechanics. This creates an impression that small quantum systems (for example electrons in quantum dots) are typically in pure quantum states. This is not the case: unless special care is devoted to preparation of the system, its state is typically a mixed one, described by a density matrix, not by a state vector. This is due to the fact that pure states can be used to describe only closed (i.e. uncoupled from the rest of the world) systems, while it is extremely hard to keep any system (even a single electron) truly closed. All the realistic quantum systems are open to some degree, and interaction with their environment (which leads to decoherence of pure quantum states) is always relevant for their description. This is an especially salient point when dealing with small quantum systems (e.g. qubits) embedded in a solid-state environment.

In this tutorial I will introduce the basic notions of quantum mechanical description of open quantum systems. I will start with a density matrix of a two-level system (e.g. a spin of a localized electron, or ground and excited state of a quantum dot), and then discuss Rabi oscillations due to external periodic driving, the appearance of Fermi Golden Rule for transition probability due to the openness of the system, spontaneous radiative recombination due to coupling to vacuum fluctuations, Bloch equations (and conditions under which they can be used), and energy relaxation and dephasing due to classical noise. While doing this I hope to explain concepts such as motional narrowing and dephasing due to a quasi-static bath. Examples from experiments on solid state based qubits (mostly quantum dots) will be used for illustration. If time permits, I plan to finish by explaining how a qubit might be turned into a spectrometer of the environmental noise.
Mechanics, electronic transport and optics of two-dimensional atomic crystals

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Vanderbilt University, Nashville TN, USA

Two-dimensional atomic crystals (2DACs) are materials that are only one or few atoms thick. Graphene, a two-dimensional form of carbon, was the first such material to be discovered. Now, almost ten years later, hundreds of metallic, semiconducting, ferroelectric, and topological insulator 2DACs such as monolayer boron nitride, monolayer molybdenum disulfide (MoS2), and phosphorene are known. The best conductors of heat and electricity, the strongest materials ever measured, and the likeliest candidate for high-temperature superconductivity belong to the family of 2DACs. Potential applications of these materials range from ultrathin membranes and coatings to transparent screens and electronic components. In this talk, we explore some aspects of physics of 2DACs we particular emphasis on phenomena related to electron wavefunction confinement and electron-electron interactions.

First, we touch upon mechanics of graphene and other 2DACs. We will discuss the experimental approaches designed to bend, stretch, cut, and fold atom-thick sheets that are 2DACs. Very high strength of carbon-carbon bonds in graphene will be shown to lead to extraordinary in-plane stiffness and breaking strength of that material. We will also discuss the modification of effective mechanical constants of 2DACs due to out-of-plane crumpling.

Second, we discuss electrical transport in 2DACs focusing on experimental approaches to reduce carrier scattering and increase carrier mobility. Different symmetries of clean low-scattering 2DACs will be shown to lead to topological phases seen in transport experiments. In particular, we cover minimum conductivity, weak localization, and Quantum Hall effects in graphene and spin/valley Hall effect in monolayer molybdenum disulfide (MoS2).

Finally, we review optical properties of 2DACs. Strong interaction between electrons resulting from miniscule thickness of 2DACs will be shown to lead to formation of tightly bound electron-hole pairs or excitons. These excitons, in turn, strongly modify optical response and optoelectronics of 2DACs.
Development of GaN based devices and future prospects

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Historically, research on GaN as a luminescent material started in the late 50s. Professor Grimmeiss and his group submitted a patent for a GaN luminescent system in 1960. In 1971, Professor Pankove developed the first GaN-based blue LEDs, which were of the metal-insulator-semiconductor (MIS) type LED. Following his success, many research groups unsuccessfully tried to commercialize Pankove-type LEDs in the 70s. Polish research group greatly contributed in understanding the thermodynamic properties of GaN, especially how difficult it is to grow GaN from solution.

In the 80s, the accumulation of several breakthroughs, such as the growth of high-quality crystals on a foreign substrate, p-type conduction by Mg doping followed by a special treatment, and the growth of InGaN layers led to the commercialization of GaN-based blue LEDs. It is worth explaining how blue LEDs have changed our lives. Portable games machines such as Game Boys and cellular or smart phones are very familiar items, especially to young people. Until the end of the 90s, all the displays of portable games machines and cellular phones were monochrome. Therefore, it should be emphasized that the younger generation can now enjoy full-color portable games and cellular or smart phones because of the emergence of blue LEDs. At the same time, some people are concerned about the increase in cellular phone or smart phone addiction.

The turning point came in 1996. In combination with phosphors, blue LEDs came to be used as a white light source and also used in general lighting. For general lighting, I would like to explain how InGaN LEDs can contribute to improving the electricity situation and saving energy, especially in Japan. Many people remember the great earthquake of east Japan and the meltdown of the nuclear power plants in 2011. Currently, none of the 48 nuclear electricity generators in Japan are in operation. Before 2011, about 30% of Japan’s electricity was generated by nuclear reactors. Thus, we have to find a way to adopt the loss of 30% of Japan’s electricity generating capacity. A research company in Japan has predicted that by 2020 more than 70% of general lighting systems will have been replaced with LED lighting, by which we can reduce Japan’s total electricity consumption by about 7%. More importantly, we can develop and supply compact lighting systems to the younger generation, especially children in remote areas without access to electricity. Using an LED lighting system with a solar cell panel and a battery, children can read books and study at night.

In this presentation, I would like to outline the history of the development and future prospects of nitride-based light-emitting devices, especially devices using the visible long-wavelength and UV regions. Also, applications to power devices will be discussed.
Challenges and new concepts of semiconductor light emitters

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The switch to high efficiency lighting is enabling to tap a huge reservoir of energy, but it requires light emitting diodes (LEDs) to reach efficiencies higher than the dominant fluorescents lamps, to have a lower cost of ownership. Beyond efficiency, major demands on LEDs are full visible spectrum coverage and low cost. To achieve this, LEDs have to perform at the physical limits of electricity-to-light conversion efficiency, requiring mastering of the intrinsic electrical and optical properties of the materials, and of the electromagnetic properties of the device structure. Today’s LEDs operate in the blue range with both 90%+ internal quantum efficiency (IQE) and light extraction efficiency (LEE). The progress in the past decade has been remarkable, in particular on LEE, with solutions based on geometrical optics or wave optics to overcome the issue of total internal reflection at the semiconductor-air interface. IQE, however, is still not at the desired level: the 90%+ performance is only obtained in the blue/violet spectral range at relatively low carrier injection. The required operation at high current densities, a prerequisite to lower lamp costs, leads to nonlinear phenomena which diminish the IQE. Many measurements point to an Auger non radiative recombination mechanism as the main cause of droop. The “green gap” of high efficiency performance in the green-yellow spectral range presents major hurdles, related to crystal growth conditions and defect formation at high In contents. Increasing strain with In contents also induces fundamental limitations related to large internal electric fields in c-plane grown LEDs. While the bulk of LEDs produced today are based on the progress of c plane QW LEDs grown on sapphire substrates, a concept originating in the mid-nineties, it is desirable to explore other avenues to reach performance beyond that materials system. I will introduce some of the paths under study: designing better LED structures leading to diminished carrier densities at high current injection, avoiding c-plane limitations by new substrates (semipolar and non polar GaN), using new concepts of active materials (quantum wires, QWRs, quantum dots, QDs), relying on lasers as alternatives to LEDs, switching to large Si substrates, ...
High-performance interband cascade lasers for the 3-7 µm wavelength range

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A multitude of absorption lines of important gases is located in the infrared region between 3 µm and 6 µm, making it very interesting for tunable diode laser spectroscopy (TDLS). However, the realization of semiconductor lasers that operate cw at room temperature (RT) in this region has been quite challenging. Extending the emission of diode lasers beyond 3 µm is difficult due to the strong increase of Auger recombination and loss of carrier confinement. Quantum cascade lasers on the other hand perform very well above 4 µm, but the available conduction band offsets limit their emission on the short wavelength side. In recent years however, several breakthroughs have allowed the demonstration of good laser performance in the 3-6 µm region [1]. The most significant development in this regard is the interband cascade laser (ICL). This device combines features from diode and quantum cascade lasers and has shown good performance (including cw operation at RT) in the 3-5.5 µm range after major design optimizations [2]. In my talk, I’ll discuss recent developments of GaSb- and InAs-based ICLs. These include the demonstration of ICLs with very low threshold current densities [3], distributed feedback lasers with output powers larger than 20 mW and operation up to 80°C (see fig. 1a), single mode emission at 5.2 µm (see fig. 1b) for sensing applications [4], distributed feedback lasers based on lateral metal gratings [5] and emission at room temperature at wavelengths up to 7 µm [6].

Fig. 1: a) Output power characteristic of a 3.5 µm ICL-DFB at different temperatures
b) Output power characteristic and emission spectrum of an ICL-DFB emitting at 5.2 µm

Quantum Hall effect in graphene: Breakdown, disorder and energy loss rates

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The quantum Hall effect in epitaxial graphene can show remarkable behavior, with a quantum Hall plateau which extends from 1 to 20 T and even up to 50T in extreme cases (Fig. 1), [1], as well as showing remarkably high breakdown current densities of up to 40A/m²[1]. We will report how the breakdown currents depend on temperature and magnetic field and show behavior suggestive of a phase transition between the quantum Hall and dissipative states of the 2D electron gas. The behaviour becomes progressively more dramatic as the system approaches the Dirac point and we have analysed both the quantum and classical Hall effect from 1.5 up to 300K. The carrier density derived from the low-field Hall coefficients for a two-carrier system shows a quadratic increase as a function of temperature (Fig. 1c), which can be well modelled by intrinsic excitation combined with disorder-induced electron-hole puddles [2] where the potential variation is found to be about 12 meV. In the quantum Hall state we observe a resistivity which shows both variable range hopping [3] (VRH), and thermally activated conduction. By fitting the longitudinal conductivity at low temperatures we directly probe the density of states at the Fermi energy and at higher temperatures, the thermal activation regime probes the position of the Fermi energy and the overall behavior gives the total width of the Landau levels which is in remarkable agreement with the zero field result.


Fig. 1: (a) Quantum Hall effect and resistivity for a sample with a Fermi level close to the dirac point.
(b) The hopping parameter Tₑ and the density of states at the Fermi level as a function of magnetic field,
(c) The temperature dependence of the carrier density. (d) The resistivity fitted to a combination of VRH and activated conduction.
Molecular beam epitaxy (MBE) has been well-known as a powerful technique for preparing semiconductors and heterostructures. Combining MBE with scanning tunneling microscopy (STM) and angle resolved photoemission spectroscopy (ARPES) can even push its power to an unprecedented level in material quality control. We apply MBE-STM-ARPES to topological insulators and high Tc superconductors, which have recently attracted extensive attention. We show how quantized anomalous Hall effect could be achieved by atomic-level control of band-engineered and magnetically doped topological insulators with MBE-STM-ARPES. We then show the discovery of interface enhanced high temperature superconductivity in single unit-cell FeSe films on SrTiO$_3$ using the same approach. Implications on exploring other exotic quantum phenomena such as Majorana fermions in topological insulators and on searching for new high temperature superconductors will be discussed.
Native defects retained in the crystal in the growth process can be determinant for their physical properties. In particular vacancies are in most cases electrically active, providing free charge to the system and acting as scattering centers. At room temperature and below their concentration is metastable and determined by migration energy. Irradiation with energetic particles allows controlled introduction of native defects and tuning of electronic transport properties of materials. This procedure can be used to turn the material to the charge neutrality state in the bulk and control metal to insulator transition.

In my presentation, I will review the methods of particle irradiation focusing on low temperature electron irradiation producing vacancy – interstitial (Frenkel) pairs and on swift heavy ion irradiation (in GeV range) leading to local amorphisation along particle trajectory.

In the second part of my talk, I will give the examples of use of particle irradiation for control of mean free path of carriers and for test of mechanisms of superconducting pairing mechanism.

To illustrate doping effect I will present the results of ongoing research on the tuning by energetic particle irradiation of electronic transport properties of topological insulators of two families: (1) time reversal symmetry protected Bi$_2$Te$_3$ and Bi$_2$Se$_3$ and (2) crystal symmetry protected PbSn$_{x}$Se$_{1-x}$. Two-step procedure consisting of irradiation at low temperature by 2.5 MeV electrons followed by appropriate annealing allows the reduction of the bulk conduction to the point that surface channel become dominant. This is demonstrated by the measurements of magneto resistance and of it angular dependence. Angular Resolved Photoemission Spectroscopy performed on the irradiated crystals proves the persistence of Dirac cone feature and immunity of the topologically protected states to the irradiation-induced disorder.
Fundamentals of quantum-limited spintronics with atoms on surfaces

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Spintronics use nanoscale magnetism for information technology and sensing applications. Shrinking the magnetic elements to a size where their magnetic moment becomes quantized may enable new applications that harness quantum mechanical effects. Inherent to this dream is the requirement to couple few-atom nanomagnets to the macro-world via electric leads. Recent advances in scanning tunneling microscopy make it possible to study the interaction between metallic surfaces and magnets even at this extreme scale of individual atoms.

We use low-temperature scanning tunneling microscopy to create few-atom nanostructures of our own design atom by atom. A combination of spin-polarized imaging and fast electronic spectroscopy at GHz speed allows us to access the nanosecond-fast magnetization dynamics of these nanostructures [1]. I will introduce how the interaction between the nanostructures and the metallic surface changes the nanomagnets’ spin ground states [2] and show that exchange interaction between individual atoms can be used to create a spin sensor that utilizes the quantum-mechanical mixing of spin states as sensing mechanism [3]. This effect enables non-local measurements of the spin and elucidates controlled engineering of atom-sized spintronic model systems.

Electronic Devices Based on Two-Dimensional Electron Gas (2DEG) in Nitride Polar Structures

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Wide bandgap semiconductor system of AlGaN/GaN has a number of features important in manufacturing of electronic devices: strong interatomic bonds, high electron mobility, high electron saturation drift velocity, high critical electric field, as well as thermal stability. Planar devices with 2DEG formed in polar nitride structures show excellent performance in high power, high frequency devices, as well as in power switching. However, these devices are still far from the GaN/AlGaN material system physical limits [1].

In my lecture, I will present an advantage of piezoelectric and spontaneous polarization fields in formation of 2DEG used in HEMT (High Electron Mobility Transistors) structures and also in current aperture vertical electron transistors (CAVET) which have been less investigated so far but they could get closer to material system limitations [2].

State-of-the-art devices demonstrated already have power density above 30W/mm and $f_{\text{MAX}}$ above 300GHz for RF HEMTs and switching capability of 10kA/cm² in vertical devices.

I will show achievements of our Lab, including:

- growth of HEMTs on laterally patterned SiC substrates,
- growth of HEMTs on Ammono GaN [3] bulk semiinsulating substrates with the very low dislocation density,
- Schottky diodes with 700V breakdown voltage on Ammono GaN

Role of substrates and influence of dislocations will be addressed.

Electronic devices based on planar 2DEG structures in nitrides together with vertical current transport structures will continue gradually outperform and probably replace some of the silicon-based transistors and silicon carbide counterparts in near future.

Atomically thin semiconductors light up

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Graphene is known as a prototypical two-dimensional material with unique physical properties. However, the difficulty of creating an optical band gap stimulated the search for other monolayer materials. In my talk I will show that atomically thin transition metal dichalcogenides serve as a promising new material class for opto-electronics [1,2] and quantum optics [3].

![Schematic drawing of a MoS$_2$ monolayer](image)

Fig. 1: Schematic drawing of a MoS$_2$ monolayer


The magnitude and spatial distribution of magnetization at the mesoscopic scale (e.g., micromagnetic properties of ferromagnets) are determined by relativistic spin-orbit interaction and crystal symmetry.

In the first part of the lecture I will discuss the role of carrier contribution to the total magnetization in dilute ferromagnetic semiconductors, such as (Ga,Mn)As [1]. In particular, I will compare, within the \( k.p \) model, the time-honored Landau approach to the modern theory of orbital magnetization developed more recently by Resta and co-workers to account for effects of spin-orbit interaction [2]. The key finding here, allowing to describe experimental data [1,3], is the demonstration that the determination of Landau level energies is not needed within the modern approach. Its implementation requires the proper treatment of contributions arising from remote bands.

In the second part of the talk, in-plane uniaxial anisotropy of (Ga,Mn)As will be discussed. This anisotropy was discovered in 1998 and found to be crucial for functionalities of (Ga,Mn)As [4]. By combining \textit{ab initio} approaches with the Luttinger method of invariance with spin-orbit interaction taken into account we demonstrated that this puzzling anisotropy, whose presence contradicts the results of group theory for zinc-blende crystals, stems from a non-random distribution of Mn over cation sites setting in at the surface during the epitaxial growth [5]. Gaining the insight into the physical origin of the uniaxial anisotropy allows us to propose methods of its control, the important step to explore further novel functionalities in (Ga,Mn)As and related systems. At the same time, our model elucidates the origin of a threefold enhancement of the apparent shape magnetic anisotropy found in thin films of (Ga,Mn)As [6].

Using Nuclear Spins To Probe New Electronic States In Low Dimensional Systems

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In this talk, I will describe how nuclear spins can be used to probe electronic states in low dimensional systems. The first part will concentrate on the physics of electrons in 2 dimensions in the presence of a normal magnetic field. In this so-called “quantum Hall regime”, a sensitive nuclear magnetic resonance (NMR) technique known as “Resistively-detected-NMR” can be employed to measure the spin polarization of many-body driven electronic states. A first example of such states is the integer quantum Hall state observed when one Landau level is completely filled (filling factor $\nu =1$). In this case, exchange interactions between electrons induce a long range ferromagnetic order, while peculiar spin textures known as “Skyrmions” tend to depolarize the system. The second example I will discuss is the $\nu = 5/2$ fractional quantum Hall state, which has attracted much attention because of its predicted “non-abelian” anyonic quantum statistics, promising a new platform for topological quantum computation. I will focus in particular on the measurement scheme [1] that we have developed to probe the sought-after spin polarization of this state.

From a more general point of view, the (hyperfine) coupling between electrons and nuclei is not only related to the electron spin degree of freedom, but also to the spatial properties of the electronic wave function. For this reason, its strength, sign and symmetry are highly material dependent. I will discuss within this context our efforts to probe, via NMR, the electronic states in the topological insulator Bi$_2$Se$_3$. Our identification of the bulk spin properties [2] constitutes a first step toward NMR-based studies and manipulation of the surface states in these systems.


Topological Matter and Why You Should Be Interested

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In two dimensional topological phases of matter, processes depend on gross topology rather than detailed geometry. Thinking in 2+1 dimensions, particle world lines can be interpreted as knots or links, and the amplitude for certain processes becomes a topological invariant of that link. While sounding rather exotic, we believe that such phases of matter not only exist, but have actually been observed (or could be soon observed) in experiments. These phases of matter could provide a uniquely practical route to building a quantum computer. Experimental systems of relevance include Fractional Quantum Hall Effects, Exotic superconductors such as Strontium Ruthenate, Superfluid Helium, Semiconductor-Superconductor-Spin-Orbit systems including Quantum Wires. The physics of these systems, and how they might be used for quantum computation will be discussed.
Spin-photon interface and distant entanglement of quantum dot spins

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Entanglement plays a central role in fundamental tests of quantum mechanics as well as in the burgeoning field of quantum information processing. Particularly in the context of quantum networks and communication, some of the major challenges are the efficient generation of entanglement between stationary (spin) and propagating (photon) qubits, the transfer of information from flying to stationary qubits, and the efficient generation of entanglement between distant stationary (spin) qubits. In this talk, I will present such experimental implementations achieved in our team with semiconductor self-assembled quantum dots.

Not only are self-assembled quantum dots good single-photon emitters, but they can host an electron or a hole whose spin serves as a quantum memory, and then present spin-dependent optical selection rules leading to an efficient spin-photon quantum interface. Moreover InGaAs quantum dots grown on GaAs substrate can profit from the maturity of III-V semiconductor technology and can be embedded in semiconductor structures like photonic cavities and Schottky diodes.

I will first present the observation of quantum entanglement between a semiconductor quantum dot spin and the color of a propagating optical photon. In a second part, I will demonstrate the transfer of quantum information carried by a photonic qubit to a quantum dot spin using quantum teleportation. Such an interface between dissimilar qubits has attracted considerable interest not only as a versatile quantum-state transfer method but also as a quantum computational primitive.

I will also report on the realization of heralded quantum entanglement between two semiconductor quantum dot hole spins separated by more than five meters. The entanglement generation scheme relies on single photon interference of Raman scattered light from both dots. A single photon detection projects the system into a maximally entangled state. We developed a delayed two-photon interference scheme that allows for efficient verification of quantum correlations. Moreover the efficient spin-photon interface provided by self-assembled quantum dots allows us to reach an unprecedented rate of 2300 entangled spin pairs per second, which represents an improvement of four orders of magnitude as compared to prior experiments carried out in other systems.

Our results extend previous demonstrations in single trapped ions or neutral atoms, in atom ensembles and nitrogen vacancy centers to the domain of artificial atoms in semiconductor nanostructures that allow for on-chip integration of electronic and photonic elements. This work lays the groundwork for the realization of quantum repeaters and quantum networks on a chip.
Coherent Precession of an Individual 5/2 Spin

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Up to now, coherent behavior of an individual spin in a solid have been demonstrated in several two- and three-level systems utilizing i.e. single electron in quantum dot (QD) [1-3] or a nitrogen-vacancy center in diamond [4-5]. Such systems are interesting not only from the scientific point of view, but also from the point of view of future information processing devices and quantum computing. However, more complex multi-level large-spin systems have not been accessible experimentally so far. They have been considered only theoretically, showing i.e. possibility of using them as a multi-qubit systems [6]. This talk summarizes the recent progress in a direct observation of coherent dynamics of an individual Mn$^{2+}$ impurity embedded in a CdTe QD [7], having both electronic and nuclear spin equal to 5/2.

In order to probe the spin state of the single Mn$^{2+}$ impurity we performed a time-resolved measurement of the absorption of a QD containing such an ion. The QD was resonantly excited with two circularly polarized picosecond laser pulses. The energy of the photons was tuned to the transition energy of an exciton-Mn complex with arbitrary chosen spin state of the magnetic ion. The absorption was detected by using the excitation transfer to a neighboring QD and observation of the emission from this dot, similarly to the technique presented previously [8-9]. The delay between the two pulses was precisely controlled so that the second pulse could probe the evolution of the investigated system after the perturbation introduced by the first pulse.

The system under investigation was placed in a magnetic field applied in the Voigt configuration, parallel to the surface of the sample. Under such conditions the spin of the magnetic impurity starts to precess after the pump pulse, which drives it out of the relaxed state. Thus the probability of the absorption of the second pulse (of the same energy as the first one) depends on the delay between the pulses. By measuring this absorption we are able to observe in detail the occupation evolution of different spin states of the system. We also determine the spin dephasing time limited mainly by the crystal field originating from the strain of the QD material. Experimental data are well reproduced with a theoretical model.

[6]. A. Gün et al., Quantum Information Processing 12, 205 (2013).
Lanthanides doped nanocrystals - synthesis, optical properties and biomedical applications

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Introducing to medicine and biology concept of optical markers in tremendous way has changed the recent status of these two important disciplines. This was mainly due to strong development in imaging techniques which recently allow us to investigate both static as well dynamic properties of living cells, their components and their interactions with external factors. One of the alternatives for recently dominating molecular markers are inorganic quantum dots. However, even if they are much better from physico-chemical point of view, from the application point of view the high risk of their toxicity and lack of multimodality makes them still limited in use.

One of the solutions of this problem are nontoxic, inorganic fluoride nanocrystals doped with lanthanide ions. These nanocrystals can be grow as colloidal dots, rhombs, cubes or rods with sizes ranging from 3 up to 100 nm (Fig.1). They can be design as both down-shifting (Fig.1a-e) or up-converting (Fig. 1f-j) emitters being also active in NIR spectral range. In addition, these markers can be used as multimodal markers where one probe can be detected with several imaging techniques (i.e. MR, CT and optical imaging). The main disadvantage of these markers is however their low excitation cross-section making their emission rather low what became a serious problem once coming to clinical use. Thus, to make them a serious candidates for practical use, their emission, relaxation and excitation mechanisms should be understood and optimized.

This paper will present results of our work on synthesis of high quality fluoride nanocrystals doped with lanthanide ions (β- NaGdF₄:Yb, Er and β-NaGdF₄:Eu) both in hydrophobic as well hydrophilic forms containing -OH, -COOH and -NH₂ surface groups. We will discuss in details their excitation, emission and kinetic properties including the ion-ion and ion-ligands interactions. Finally, we will present results of their bio-conjugation and example of their use in optical imaging for melanoma cancer cells detection.

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Ultrafast electron kinetics in graphene

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Graphene is an ideal structure to study the efficiency of different carrier relaxation channels in a two-dimensional system: Its linear energy dispersion and the vanishing bandgap allow scattering processes, which are suppressed in conventional semiconductors (cp. Fig.1a).

Here, we present self-consistent calculations of the coupled carrier and phonon dynamics based on a second order Born-approximation [1]. This approach allows to track the way of optically excited carriers toward equilibrium - resolved in time-, momentum-, and angle - in theory and corresponding experiments (Helmholtz-Zentrum Dresden-Rossendorf; RWTH Aachen).

After optical pulse excitation, a highly anisotropic non-equilibrium carrier population (cp. Fig. 1b) is created [2]. The efficient intraband carrier-carrier scattering leads to a redistribution of carriers to energetically lower states already within the first 10 fs. Preferably, the scattering occurs along the Dirac cone conserving the anisotropy. In contrast, the phonon-induced relaxation processes bring carriers across the Dirac cone, which leads to an isotropic distribution already after 50 fs (cp. Fig. 1c-d).

The calculations also predict a significant contribution stemming from Auger processes. Inverse Auger recombination leads to a considerable carrier multiplication - in spite of the directly competing phonon-induced processes [3]. After about 100 fs, the carriers are completely thermalized resulting in a spectrally broad Fermi distribution. Unique signatures of Auger processes can be identified in pump-probe experiments on graphene in a magnetic field [4].

In summary, the presented microscopic study provides insight into the ultrafast relaxation dynamics of optically excited carriers in graphene, in particular in anisotropic relaxation and Auger processes.

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