EVENT BOOKLET

Oxford Instruments Virtual Symposium

Quantum Technology, Semiconductors and Power Generation

June 8-10, 2021

Oral Presentations

Poster Presentations

Event Agenda

Day 1, June 8: Quantum Technology

Time			Presentation
1-2 pm (BST)	2-3 pm (CEST)	8-9 am (US EDT)	Digital Quantum Computing Dr. Matt Hutchings, SeeQC
2-3 pm (BST)	3-4 pm (CEST)	9-10 am (US EDT)	Quantum Imaging with Entangled Photons and EMCCD Cameras Dr. Hugo Defienne, University of Glasgow, UK
3:15-4 pm (BST)	4:15-5 pm (CEST)	10:15-11 am (US EDT)	Surface Engineering for High Performance Quantum Devices Dr. Russ Renzas, Oxford Instruments
4-5 pm (BST)	5-6 pm (CEST)	11am-12 pm (US EDT)	Superconducting Quantum Circuits for Quantum Technologies Prof. Martin Weides, University of Glasgow, UK
5-6 pm (BST)	6-7 pm (CEST)	12-1 pm (US EDT)	Diamond Nanofabrication for Quantum Photonics and Nanomechanics Dr. Paul Barclay, University of Calgary

Day 2, June 9: Semiconductors

Time			Presentation
1-2 pm (BST)	2-3 pm (CEST)	8-9 am (US EDT)	AFM Solutions in Semiconductor Device Fabrication and Development Dr. Ted Limpoco, Oxford Instruments
2-3 pm (BST)	3-4 pm (CEST)	9-10 am (US EDT)	All you ever wanted to know about plasma etch processing for InP devices Dr. Mark Dineen, Oxford Instruments
3:15-4 pm (BST)	4:15-5 pm (CEST)	10:15-11 am (US EDT)	From SEM to TEM, Qualitive and Quantitative Compositional Analysis of Semiconductor Devices Dr. Sam Marks, Oxford Instruments
4-5 pm (BST)	5-6 pm (CEST)	11am-12 pm (US EDT)	Flexible, high performance plasma etch solutions for MEMs device manufacture Dr. Zhong Ren, Oxford Instruments

Day 3, June 10: Batteries and Power Generation

Time			Presentation
1-2 pm (BST)	2-3 pm (CEST)	8-9 am (US EDT)	Correlative Microscopy Applied on Solar-Energy Materials and Devices Dr. Daniel Abou-Ras, Helmholtz-Zentrum Berlin
2-3 pm (BST)	3-4 pm (CEST)	9-10 am (US EDT)	Structural Elucidation of Anionic O-Redox Cathodes for Li-ion Batteries Dr. Gregory Rees, University of Oxford
3:15-4 pm (BST)	4:15-5 pm (CEST)	10:15-11 am (US EDT)	Applying Benchtop NMR to the Development and Quality Control of Battery Materials Dr. James Sagar, Oxford Instruments
4-5 pm (BST)	5-6 pm (CEST)	11am-12 pm (US EDT)	Atomic Layer Etch and Deposition, advanced plasma processing solutions to enable next generation Power device performance Dr. Mark Dineen, Oxford Instruments
5-6 pm (BST)	6-7 pm (CEST)	12-1 pm (US EDT)	Safer Batteries with AZtecBattery Alexandra Stavropoulou, Oxford Instruments
6-7 pm (BST)	7-8 pm (CEST)	1-2 pm (US EDT)	Energizing Research in Battery Performance with Advanced Atomic Force Microscopy (AFM) Dr. Nate Kirchhofer, Oxford Instruments

Oral Presentations

Digital Quantum Computing

Dr. Matt Hutchings, SeeQC

June 8: 1-2pm BST | 2-3pm CEST | 8-9am US EDT

SeeQC is developing the first digital quantum computing platform for global businesses. SeeQC combines classical and quantum technologies to address the efficiency, stability and cost issues endemic to quantum computing systems. The company applies classical and quantum technology through digital readout and control technology and through a unique chip-scale architecture. SeeQC's quantum system provides the energy- and cost-efficiency, speed and digital control required to make quantum computing useful and bring the first commercially-scalable, problem-specific quantum computing applications to market.

The company is one of the first companies to have built a superconductor multi-layer commercial chip foundry and through this experience has the infrastructure in place for design, testing and manufacturing of quantum-ready superconductors. SeeQC is a spin-out of Hypres, the world's leading developer of superconductor electronics. SeeQC's team of executives and scientists have deep expertise and experience in commercial superconductive computing solutions and quantum computing. Seeqc is based in Elmsford, NY with design and test facilities in the UK and EU.

1. Boto, Agedi N., et al. "Quantum interferometric optical lithography: exploiting entanglement to beat the diffraction limit." Physical Review Letters 85.13 (2000): 2733.
2. Brida, Giorgio, Marco Genovese, and I. Ruo Berchera. "Experimental realization of sub-shot-noise quantum imaging." Nature Photonics 4.4 (2010): 227-230.
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6. Moreau, Paul-Antoine, et al. "Realization of the purely spatial Einstein-Podolsky-Rosen paradox in full-field images of spontaneous parametric down-conversion." Physical Review A 86.1 (2012): 010101.
7. Edgar, Matthew P., et al. "Imaging high-dimensional spatial entanglement with a camera." Nature communications 3.1 (2012): 1-6.

Quantum Imaging with Entangled Photons and EMCCD Cameras

Dr. Hugo Defienne, University of Glasgow

June 8: 2-3pm BST | 3-4pm CEST | 9-10am US EDT

Quantum imaging harnesses quantum properties of light and their interaction with the environment to go beyond the limits of classical imaging or to implement unique imaging modalities. In conventional quantum imaging systems, a non-classical state of light illuminates an object from which an image is formed on a set of photodetectors. In this respect, sources of entangled photon pairs are very prolific. Over the last decades, they have been used to achieve super-resolution [1] and sub-shot-noise imaging [2], as well as to develop new imaging approaches such as ghost imaging [3], quantum illumination [4] and quantum holography [5].

However, most of these experimental schemes require to measure intensity correlations between many spatial positions in parallel, a task that is much more delicate than forming an image by photon accumulation. Originally, this was performed using raster-scanning single-pixel single-photon detectors, but this process is very photon inefficient and time-consuming. In recent years, these systems were substituted by single-photon sensitive cameras, such as electron multiplied charge coupled devices (EMCCDs), to achieve faster quantum imaging with photon pairs and move this field closer to practical applications [6,7].

In this presentation, I will review photon-pair-based quantum imaging experiments that were developed and implemented with EMCCD cameras, including those manufactured by Andor. In particular, I will clarify what is the type of image information that is measured and exploited in these systems, and describe what are the drawbacks and advantages of EMCCD technology to achieve such a task. Finally, I will discuss the potential of other single-photon camera technologies for photon-pair-based quantum imaging, including single-photon avalanche diode cameras (SPAD) and EMCCD cameras from other companies (Nuvu), and compare them to the results obtained with the Andor model.

Surface Engineering for High Performance Quantum Devices

Dr. Russ Renzas, Oxford Instruments Plasma Technology

June 8: 3:15-4pm BST | 4:15-5pm CEST | 10:15-11am US EDT

Next-generation quantum computers and quantum sensors require better materials and processes to reduce losses associated with substrate-metal, metal-vacuum, and substrate-vacuum interfaces in superconducting systems, as well as to reduce losses due to roughness in diamond and photonic systems. Low-loss superconducting nitrides deposited by PE-ALD offer improved performance for resonators and qubits, while high quality RIE and ALE etches achieve low roughness and reduce losses at substrate-vacuum interfaces. We will also discuss the importance of these techniques for low roughness diamond and photonic etches, superconducting 3D integration, and single photon detectors.

Superconducting Quantum Circuits for Quantum Technologies

Prof. Martin Weides, University of Glasgow

June 8: 4-5pm BST | 5-6PM CEST | 11-12pm US EDT

Quantum technologies based on on-classically interacting qubit states allow experimental realizations ranging from fundamental tests to quantum simulation & computing achieving a quantum advantage. Today, realising the second quantum revolution appears feasible, with superconducting quantum circuits having matured over the past years to one of the leading platforms with an unprecedented variety of implementation and application schemes. For instance, analogue quantum simulators can now tackle problems that are hard to solve. No sophisticated error-correction schemes are needed, making them very useful in particular for the study of universal effects such as hard-to-model open quantum systems. Their implementation with superconducting circuits seems ideal, due to their tailored functionality and broad toolbox, including qubits, bosonic modes, a range of coupling elements and additional drive tones.

In this talk, an introduction to the field will be given, including a view on technological challenges such as quantum circuit materials and processing, and exemplary quantum simulation applications such as the dynamics in ultra-strongly coupled systems or multi-state Landau Zener transitions.

Diamond Nanofabrication for Quantum Photonics and Nanomechanics

Dr. Paul Barclay, University of Calgary

June 8: 5-6pm BST | 6-7pm CEST | 12-1pm US EDT

Diamond has emerged as a key material for quantum photonic devices that have applications in quantum sensing, communications, and computing. Its ability to host high quality spin qubits, combined with its exceptional optical and mechanical properties make it an ideal platform for creating quantum photonic and nanomechanical devices.

However, realizing suspended devices from high quality bulk diamond material is challenging. Over the past five years we have developed “quasi-isotropic” etching process for creating suspended/undercut devices from single crystal diamond. This has allowed us to develop a platform for realizing diamond optomechanical devices: mechanical resonators at GHz frequencies that can be controlled with light and can be coupled to diamond qubits. In this presentation I will discuss our fabrication successes and challenges, and highlight recent progress in creating state-of-the-art diamond devices.

AFM Solutions in Semiconductor Device Fabrication and Development

Dr. Ted Limpoco, Oxford Instruments Asylum Research

June 9: 1-2pm BST | 2-3pm CEST | 8-9am US EDT

Continuous downscaling of semiconductor technology nodes imposes ever more stringent requirements on metrology and failure analysis tools. In this talk, we will cover how atomic force microscopes (AFMs) can be used in process control, defects identification, and in the research and development of new materials. We will demonstrate how AFMs’ unmatched sub-nanometer resolution and wide variety of electrical measurement modes make it an essential characterization tool in present and future devices.

All you ever wanted to know about plasma etch processing for InP devices

Dr. Mark Dineen, Oxford Instruments Plasma Technology

June 9: 2-3pm BST | 2-3pm CEST | 8-9am US EDT

Indium phosphide (InP), the direct bandgap semiconductor, has multiple uses in optical and electrical devices. For a good quality final product, the InP dry etch step must repeatedly give the desired etched structures.

For many devices, the low surface damage and the surface quality of the sidewalls and base are particularly important.

In this presentation, you will learn about InP etching processes and the process conditions which will affect the final etch product focusing on sidewall and surface quality, with device examples.

From SEM to TEM, Qualitive and Quantitative Compositional Analysis of Semiconductor Devices

Dr. Sam Marks, Oxford Instruments NanoAnalysis

June 9: 3:15-4pm BST | 4:15-5pm CEST | 10:15-11am US EDT

In this presentation we will explore how energy dispersive spectroscopy (EDS) can be utilized to solve some of the common problems that arise when analyzing semiconductor devices.

Looking at SEM, FIB-SEM and TEM, we will discuss best practice and how to optimize EDS results across the different electron microscope platforms.

Significant emphasis will be on improving the spatial resolution of EDS maps in the SEM, where we will discuss the benefits of performing low accelerating voltage SEM to make nanoscale SEM EDS analysis routine. Additionally, we will explore the benefits of STEM-SEM as an alternative to TEM, performing sub 10 nm EDS at 30kV to reduce the TEM workload.

Flexible, high performance plasma etch solutions for MEMs device manufacture

Dr. Zhong Ren, Oxford Instruments Plasma Technology

June 9: 4-5pm BST | 5-6pm CEST | 11am - 12pm US EDT

MEMS devices are having an increasing impact on our everyday lives with a wide variety of end applications from accelerometers to bio sensors. In this presentation you will learn about two different etch solutions used to etch deep Si features: Bosch and Cryo plasma etching. The benefits of each solution will be discussed.

Correlative Microscopy Applied on Solar-Energy Materials and Devices

Dr. Daniel Abou-Ras, Helmholtz-Zentrum Berlin

June 10: 1-2pm BST | 2-3pm CEST | 8-9am US EDT

This presentation will provide insight into the application of energy-dispersive X-ray spectroscopy (EDS) and electron backscatter diffraction on materials and devices for solar-energy conversion. It will be shown how EDS at low beam energies and currents can be applied to beam-sensitive materials and how using the LayerProbe feature, thicknesses as well as compositions of individual layers in thin-film stacks can be determined in a nondestructive manner. A particular focus will be set on the combination of various techniques on identical specimen areas for a correlative microscopy approach, involving techniques in scanning electron and scanning probe microscopy, as well as Raman microspectroscopy.

Structural Elucidation of Anionic O-Redox Cathodes for Li-ion Batteries

Dr. Gregory Rees, University of Oxford

June 10: 2-3pm BST | 3-4pm CEST | 9-10am US EDT

Li-rich cathode materials are potential candidates for next-generation Li-ion batteries. They have increased energy density due to storing charge at high voltages through the oxidation of oxide ions in the cathode material. However, oxidation of O2– triggers irreversible structural rearrangements in the bulk and an associated loss of the high voltage plateau, which is replaced by a lower discharge voltage, and a loss of O2 accompanied by densification at the surface.

Here we show that for Li-rich NMC ($Li_{1.2}NiO._{13}CoO._{13}Mn_{0.5}4O_2$), molecular O_2 trapped in the bulk is responsible for the voltage hysteresis. ^{17}O magic angle spinning (MAS) nuclear magnetic resonance (NMR) and resonant inelastic X-ray scattering (RIXS) suggest that molecular O_2, rather than O_2^{2-}, forms within the particles on the oxidation of O_2– at 4.6 V versus Li^+/Li on charge. These O_2 molecules are reduced back to O^{2-} on discharge, but at the lower voltage of 3.75 V. We will quantify the amount of bulk O_2 using NMR relaxometry and compare this to the theoretical O-redox charge capacity, minus the amount of O_2 loss from the surface. The implication is that O_2, trapped in the bulk and lost from the surface, can explain O-redox.

Finally, we will discuss the role of benchtop NMR spectroscopy in monitoring electrolyte degradation for Li-rich cathodes. New ^{1}H and ^{19}F species are observed over cycling along with appreciable changes in the observed relaxometry,and fluctuations in the measured diffusion coefficients, these are attributed to electrolyte degradation.

Applying Benchtop NMR to the Development and Quality Control of Battery Materials

Dr. James Sagar, Oxford Instruments Magnetic Resonance

June 10: 3:15-4pm BST | 4:15-5pm CEST | 10:15-11am US EDT

Improving the performance and reliability of next generation batteries relies on optimizing the current carrying electrolyte solutions inside them. Using benchtop NMR spectroscopy can lead to significant insights into batteries, from raw materials checking, right through the R&D cycle, to quality control in manufacturing. Benchtop NMR allows us to quantify key components in new formulations including salts and additives, quickly detect contaminants in electrolyte production, understand electrolyte breakdown process that cause battery failure and measure key performance criteria such as conductivity, diffusion and transference. These key applications will be discussed in the context of a number of recent case studies.

Atomic Layer Etch & Deposition: advanced plasma processing solutions to enable next generation GaN Power device performance

Dr. Mark Dineen, Oxford Instruments Plasma Technology

June 10: 4-5pm BST | 5-6pm CEST | 11am-12pm US EDT

New GaN power electronics are being developed for power conversion and delivery. In electric transportation such as electric and hybrid electric vehicles (EV and HEV), these devices are becoming increasingly important and device cost and efficiencies are critical for their success.

In this presentation, Dr. Mark Dineen talks about the best ALE and ALD solutions for GaN HEMT devices. We'll demonstrate how to achieve the ultra accurate etch depth control and high film quality needed to provide the best GaN device performance.

Safer Batteries with AZtecBattery

Alexandra Stavropoulou, Oxford Instruments NanoAnalysis

June 10: 5-6pm BST | 6-7pm CEST | 12-1pm US EDT

Batteries are used in a wide range of portables devices (consumer electronics, portable devices such as power tools, etc.), taken for granted in our daily life. Li-ion batteries have been a key enabling technology for consumer electronics over the past decade and are also a vital component for the further development and adoption of Electric Vehicles (EVs).

However, raw material cleanliness of precursor powders is key to battery performance and reliability. The presence of impurities and contaminants in the material used in the production of Li-ion batteries can significantly undermine battery performance, or, in a worst-case scenario, have catastrophic impacts by causing major failure (fires/explosions), compromising thus battery safety and reliability. As such, monitoring of the quality and cleanliness of materials throughout the production process is essential if contaminants are to be found and their sources controlled.

Energizing Research in Battery Performance with Advanced Atomic Force Microscopy (AFM)

Dr. Nate Kirchhofer, Oxford Instruments Asylum Research

June 10: 6-7pm BST | 7-8pm CEST | 1-2pm US EDT

Beginning with a brief introduction to the basics of batteries and their engineering goals, examples will then be presented on how an Atomic Force Microscope (AFM) can be used for advanced operando and in-situ measurements that aid in battery optimization. Details will be presented on how to implement the environmental and electrochemical control that are critical for conducting operando battery research, while real examples will be presented that show how the AFM already contributes to improving different battery components such as the anode, cathode, separator, solid electrolyte interphase (SEI), electrolyte, and more. In this talk, expect to walk away with: (1) Practical considerations for achieving in-situ and operando imaging on electroactive materials, (2) how the state-of-the-art Asylum AFMs enable advanced electrochemical measurements on battery materials without sacrificing imaging resolution, (3) benefits of blueDrive photothermal excitation for electrochemical AFM, and (4) recent case studies of in-situ and operando measurements on the cathode, anode, separator, and more. Learn more at http://afm.oxinst.com/battery

Poster Presentations

Know your full potential: Minimizing crosstalk in Kelvin probe force microscopy experiments on device cross sections

Amelie Axt[1,2], Ilka M. Hermes[1], Victor W. Bergmann[1] and Stefan A. L. Weber
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Quantitative surface potential measurements are crucial to understand electronic processes on functional nanostructures in solar cells. Here, Kelvin probe force microscopy (KPFM) on device cross sections has become a popular method to map the potential distribution across the functional layers of solar cell devices. Cross sectional KPFM can both visualize and quantify effects such as an unbalanced charge transport [1] or slow migration of ions and charge trapping [2]. To provide quantitative and local information, the KPFM methods have to be free of cross talk from topography and electrostatic interactions with adjacent layers. In particular in thin film solar cells with active layers thinner than one micrometer, the proper choice of KPFM method is crucial. Here we study the influence of the KPFM method on the measured potential distribution as well as on crosstalk on a model electrode geometry. We directly compare the lateral resolution and the measured contact potential difference for different Amplitude Modulation (AM) and Frequency Modulation (FM) KPFM methods in air. We then suggest a "best practice" for quantitative measurements on nanoscale device cross sections to understand the limiting factors of the solar cell performance.

References: A.Axt et. al. Beilstein J. Nanotechnol. 2018, 9, 1809–1819.doi:10.3762/bjnano.9.172

Comparison of NASICON $Na_3Fe_2(PO_4)_3$ and $Na_3Fe_{1.8}Mn_{0.2}(PO_4)_3$ cathode materials for Na-ion batteries – comprehensive analysis of operation mechanism

Katarzyna Walczak[1*], Andrzej Kulka[1], Rafał Idczak[2], Robert Konieczny[2], Camelia Borca[3], Janina Molenda.

[1]AGH University of Science and Technology, Faculty of Energy and Fuels, Department of Hydrogen Energy, Krakow, Poland,[2]Institute of Experimental Physics, University of Wrocław, Wrocław, Poland, [3]Paul Scherrer Institute, Villigen, Switzerland.

In the last two decades, Li-ion batteries became the most popular energy source for portable electronics, electric vehicles as well as smart grids. The continuously growing demand for them is a reason for declining global reserves and increasing the price of lithium. Moreover, the similar trend is observed for another elements, such as cobalt or nickel, which also are used in Li-ion batteries. Taking into consideration these issues, Sodium-ion batteries are being considered as one of the possible alternative for LiBs, especially in large-scale energy storage. Furthermore, due to ecological aspects, eco-friendly cathode and anode materials for them are being quested.

In this work we present electrochemical properties of the NASICON-$Na_3Fe_{2-y}Mn_y(PO_4)_3$ (y=0, 0.1, 0.2, 0.3, 0.4) group - cathode materials for Na-ion batteries [1-2]. This group of materials is characterized not only by its high stability and good electrochemical properties, but also by the safe and eco-friendly elements. The basic studies, including powder XRD of as-synthesized samples and electrochemical charging-discharging tests of $Na|Na^+|Na_3Fe_{2-y}Mn_y(PO_4)_3$, were conducted. For selected samples: reference-$Na_3Fe_2(PO_4)_3$ and the-best-working-$Na_3Fe_{1.7}Mn_{0.3}(PO_4)_3$, the deeper analysis was employed. We concentrated mostly on the elucidation of operation mechanism, that governs the sodium transport.

Firstly, operando-XRD measurements were carried out in the voltage regime of 1.5 – 4.5 V for constructed cells based on two abovementioned samples, which showed two-phase mechanism of sodium insertion/deinsertion, in which monoclinic (C2/c) and rhombohedral (R-3c) participate. Based on operando-XRD studies, we stated that manganese stabilizes the crystal structure. Within this work we also present ex-situ XAS measurements, which provided the information about oxidation states during the cell operation. Additively, the Mossbauer spectroscopy was applied for determination of iron oxidation state in the function of temperature.

The presented analysis of structural properties of NASICON-$Na_3Fe_{2-y}Mn_y(PO_4)_3$ cathode materials is an important factor in understanding the electrochemical processes during the cell operation. This work shows that the modification of the chemical composition of the cathode materials has a major impact on electrochemical properties and allows to design eco-friendly, inexpensive NASICON-type cathodes for Na-ion batteries.

References: [1] K. Walczak, B. Gędziorowski, A. Kulka, W. Zając, M. Ziąbka, R. Idczak, V. H. Tran, J. Molenda, Exploring the Role of Manganese on Structural, Transport, and Electrochemical Properties of NASICON-$Na_3Fe_{2-y}Mn_y(PO_4)_3$– Cathode Materials for Na-Ion Batteries ACS Applied Materials and Interfaces 11 (2019) 43046–43055.

[2] R. Idczak, V.H. Tran, B. Świątek-Tran, K. Walczak, W. Zając, J. Molenda, The effects of Mn substitution on the structural and magnetic properties of the NASICON-type $Na_3Fe_{2-x}Mn_x(PO_4)_3$ solid solution, Journal of Magnetism and Magnetic Materials 491 (2019) 165602

Acknowledgement: This work was funded by the Polish Ministry of Science and Higher Education (MNiSW) based on decision number 0020/DIA/2016/45.

Possibility of application of Y1-xRxMnO3+d materials as new cathodes for SOFC

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Hexagonal rare-earth manganites gained the renewed interest of researchers, especially in terms of theirs application as oxygen storage materials for O2 via temperature swing absorption. Here we present the results of the structural, transport properties and stability studies of the materials from the Y1-xRxMnO3+d (R = Pr, Nd) group to evaluate their potential applicability as the cathodes for solid oxide fuel cells (SOFC). Special attention was paid to Y0.95Pr0.05MnO3+d material (Pr005) - symmetrical cell of Pr005|LSGM|Pr005 was assembled and tested employing electrochemical impedance spectroscopy.

References: [1] K. Cichy, K. Świerczek, K. Jarosz, A. Klimkowicz et al., Acta Materialia 205 (2021) 116544 [2] K. Cichy, K. Świerczek, Crystals 11 (2021) 510

Acknowledgment: This work was funded by the National Science Centre Poland, Grant Number 2018/31/N/ST5/02280.

Patterning of Zinc Oxide from Zinc Acetate Using Electron Beam Lithography

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Zinc oxide (ZnO) is one of the most studied materials in the nanotechnology field due to the exceptional physical and chemical properties. This n-type semiconductor thin film can be obtained using physical or chemical techniques as shown in the literature. Patterning of ZnO thin film is a key for advanced microelectronics applications to achieve a critical dimension (CD) below 15 nm. In this work, a new approach is presented to pattern zinc oxide films using electron beam lithography. Zinc acetate (Zn4O(CH3COO)6) films were exposed using a scanning electron microscope (SEM), causing decomposition of Zn4O(CH3COO)6 into ZnO, these nanostructures are obtained directly without the need for etching step. The exposure of zinc acetate using an electron beam is capable of producing sub-15 nm structures, spaced on a 40 nm pitch on silicon for future nanoelectronic devices. This poster describes the transformation process by understanding its exposure mechanism to electrons; this is confirmed by the x-ray photoelectron spectroscopy technique. Moreover, the optical and electrical properties of ZnO patterns obtained using ebeam exposure are investigated to confirm the decomposition of zinc acetate into zinc.

Electrical properties of topological atomic chains

Marcin Kurzyna, Tomasz Kwapiński

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Atomic chains as the thinnest possible electrical conductors are very interesting nanomaterials[1,2] which can find potential applications in electronics and engineering. In this presentation there are shown theoretical studies of static and time-dependent electrical properties of the topological Su-Schrieffer-Heeger (SSH) atomic chains[3] on different substrates which play a role of electron reservoirs. In this talk, there are analysed electron occupancies, currents and spectral density functions using the Green's function formalism, evolution operator technique and tight-binding Hamiltonian. It is revealed that one-dimensional topological materials show unique physical phenomena that are very hard to observe in bulk materials, like e.g. topological state migration[4]. From the practical applications point of view there is revealed that the conductance of the 1D topological system is almost insensitive to single adatoms and oscillates as a function of the sidechain length with very large periods. Next, there are analysed electron transport properties of topologically trivial and nontrivial SSH chains between unbiased leads in the presence of external time-dependent forces in the form of one-Gaussian or two-Gaussian perturbations (train impulses) and shown that such systems can play a role of an effective electron pump. Furthermore from the analysis of time dynamics of the topological end state after the quench it is divulged that the topologically trivial chain stands for much better charge pump than other normal or nontrivial chains.

References: [1] Kopciuszynski, M.; Dyniec, P.; Krawiec, M.; Łukasik, P.; Jałochowski, M.; Zdyb, R. Pb nanoribbons on the Si(553) surface. Phys. Rev. B 2013, 88, 155431. doi:10.1103/PhysRevB.88.155431. [2] Jałochowski, M.; Kwapinski, T.; Łukasik, P.; Nita, P.; Kopciuszynski, M. Correlation between morphology, electron band structure, and resistivity of Pb atomic chains on the Si(553)-Au surface. J. Phys. Condens. Matter 2016, 28, 284003. [3] Asboth, J.K.; Oroszlany, L.; Palyi, A. A Short Course on Topological Insulators; Springer: Switzerland, 2016. [4] Kurzyna, M.; Kwapinski, T. Edge-state dynamics in coupled topological chains. Phys. Rev. B 2020, 102, 195429.

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