First Short-Term Scientific Mission Workshop on Innovative and Advanced Epitaxy

Organized by European Network for Innovative and Advanced Epitaxy (OPERA), COST Action CA-20116

18 April 2024 (online workshop)

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The COST Action CA-20116, European Network for Innovative and Advanced Epitaxy (OPERA), is supporting Short-Term Scientific Missions (STSM) to give the opportunity to Researchers or Innovators to carry out specific scientific tasks in a host organization for a well-defined period of time. Since the beginning of the action in September 2021, the Cost Action OPERA has funded more than 59 Researchers/Innovators all around Europe.

On April 18, 2024, at 14:30 pm (CEST), the first online STSM workshop will take place. There 6 STSM grantees will present their experience and results.

Do not hesitate to connect to this STSM workshop!

Link to the meeting by Teams:

https://teams.microsoft.com/l/meetup-join/19%3ameeting_YmQwYzkwYjQtOTI2ZS00MDg4LWEwZWEtNTUwM2E4ZGRmYjk3%40thread.v2/0?context=%7b%22Tid%22%3a%226afea85d-c323-4270-b69d-a4fb3927c254%22%2c%22Oid%22%3a%225aee3742-8c4b-483d-b9d8-e20290244937%22%7d

The STSM Team and OPERA COST Chair

STSM team members: Sergio Fernández Garrido (STSM Leader), Zoran Jovanović (STSM Vice-Leader), Noelle Cogneau (Action Chair), Tamara Potlog (Action Vice-Chair), Yamina André (Grant Holder Scientific Representative), Laurence Mechin (Grant Awarding Coordinator), Paula Ferreira (Science Communication Coordinator), Gavin Bell (WG1 Leader), Nini Pryds (WG2 Leader), Susana Cardoso (WG3 Leader), Lucian Pintilie, Gertjan Koster, Lucia Sorba, Marta Sawicka and Brian Rodriguez.

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Program, Thursday 18 April 2024

(CEST times)

14:30	Opening
14:40	Speaker: Raffaele Giani
	Title: Fabrication of GeSn Avalanche Photodiodes
14:55	Speaker: Stefano Vichi
	Title: Molecular Beam Epitaxy of NbN/GaN
15:10	Speaker: Anna Sacchi
	Title: Towards the Epitaxial Growth of a κ-Ga_2O_3 Single Domain
15:25	Speaker: Andrea Ardenghi
	Title: Point Defect Control in B-Ga_2O_3 Thin Films Grown via Molecular Beam Epitaxy
15:40	Speaker: Alaa Mohammed Idris Bakhit
	Title: Epitaxial Growth of Hexagonal boron–nitrogen–carbon (h-BNC) Monolayer on Different Substrate Materials
15:55	Speaker: Emma van der Minne
	Title: Magnetic Enhanced Faradaic Efficiency for the Oxygen Evolution Reaction on Epitaxial Thin Film Model Catalysts
16:10	Closing remarks

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Abstracts

Title: Fabrication of GeSn Avalanche Photodiodes

Authors: Raffaele Giani[1], Lorenzo Finazzi[1], Alberto Tosi[1], Giovanni Isella[1], Teren Liu[2], Omar Concepción Díaz[2] and Dan Buca[2]

STSM home institution: [1]Politecnico di Milano (Italy)

STSM host institution: Forschungszentrum Jülich (Germany)

Summary: The mid-infrared (MIR) region of the light spectrum is interesting for chemical species sensing with applications, for example, in environment and food safety applications. To work in this region an interesting and promising material, because can be integrated in silicon photonics, is germanium-tin. Due to the presence of tin, a semimetal of the group IV, the resulting alloy can be a direct bandgap semiconductor, making it possible to work in the MIR with a group IV alloy. Germanium-tin-based photodetectors have a high dark current, which is the main source of noise in these devices, so we have designed an avalanche structure to increase the generated photocurrent, obtaining a better signal-to-noise ratio. During my presentation, I will discuss the challenges of the epitaxy of these alloys and then I will discuss the fabrication of the GeSn Avalanche Photodiodes (APDs) and the first results obtained from these devices.

Title: MBE Growth of NbN/GaN

Authors: Stefano Vichi[1] and Krzysztof Gołyga[2]

STSM home institution: [1]University of Milano-Bicocca (Italy)

STSM host institution: [2]Institute of High-Pressure Physics Polish Academy of Sciences (Poland)

Summary: The growth of high quality NbN layers is fundamental to build superconducting qubits with good performances, and in particular the possibility to grow epitaxial NbN layers on GaN by MBE is one of the most appealing solutions. However, due to the low vapor pressure of Nb, a special equipment (electron beam evaporator) is required, which adds complexity to the system. Here I will show the results obtained during the early stages of growth optimization of NbN layers on GaN substrates and in particular the effect of e-beam parameters on surface morphology. I will compare the results with previously grown sample to determine the influence of e-beam working conditions.

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Title: Towards the Epitaxial Growth of a κ-Ga_2O_3 Single Domain

Authors: Anna Sacchi[1], F. Mezzadri[1,3], A. Ardenghi[2], O. Bierwagen[2], J. Lähnemann[2], H. Tornatzky[2], M. R. Wagner[2,4], H. Nishinaka,[5] R. Fornari[1,3] and P. Mazzolini[1,3]

STSM home institution: [1]University of Parma (Italy)

STSM host institution: [2]Paul-Drude-Institut für Festkörperelektronik, Leibniz Institut im Forschungverbund, Berlin (Germany)

Other institutions involved: [3]IMEM-CNR, Parma (Italy), [4]Technische Universität Berlin, Institute of Solid State Physics, (Germany), and [5]Faculty of Electrical Engineering and Electronics, Kyoto Institute of Technology (Japan)

Summary: κ-Ga_2O_3 is one of the metastable polymorphs of Ga_2O_3. It possesses an orthorhombic unit cell and, when grown on conventional substrates, such as c-plane sapphire, develops vertically-oriented rotational domains that are mediating its in-plane transport. The obtainment of a (001) κ-Ga_2O_3 single domain layer has been so far only demonstrated by mist chemical vapour deposition on (001) ε-$GaFeO_3$ substrates that are sharing the same orthorhombic symmetry and similar lattice parameters. In this work we investigate the growth with molecular beam epitaxy of (001) κ-Ga_2O_3 epitaxial layers on (001) ε-$GaFeO_3$ substrates. The extensive work performed on the optimization of the surface of the substrate and of the growth parameters as well as the characterization of the κ-Ga_2O_3 epi-layers will be shown, pointing out the main issues related to the MBE growth technique that prevented the obtainment of a single domain layer.

Title: Point Defect Control in B-Ga_2O_3 Thin Films Grown via Molecular Beam Epitaxy

Authors: Andrea Ardenghi[1], O. Bierwagen,[1] B. M. Janzen[3], D. Cierpinsky[3], A. Falkenstein[4], J. Kler[4], M. Martin[4], K. Mizohata[2], K. Nordlund[2], F. Tuomisto[2], M. Wagner[1] and [5]P. Mazzolini

STSM home institution: [1]Paul-Drude-Institut für Festkörperelektronik, Leibniz Institut im Forschungverbund, Berlin (Germany)

STSM host institution: [2]Department of Physics and Helsinki Institute of Physics, University of Helsinki, Helsinki (Finland)

Other institutions involved: [3]Technische Universität Berlin, Institute of Solid-State Physics, Berlin (Germany), [4]Institute of Physical Chemistry, RWTH Aachen University (Germany), and [5]University of Parma, Department of Mathematical, Physical and Computer Sciences, 43124 Parma (Italy)

Summary: Gallium oxide (Ga_2O_3) in its most thermodynamically stable monoclinic β-phase has gathered increasing interest due to his ultra-wide bandgap (≈ 4.8 eV), availability from the bulk growth and the possibility to tune its electrical conductivity.

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Despite the large expectations, by now there is still a considerable difference between the theoretically predicted properties of Ga_2O_3 and the outcome performances obtained in device structures for power electronics. To this end, point defects, such as oxygen- or gallium-vacancies (VO, VGa), and/or interstitials, can play an important role. In this work homoepitaxial samples of β-Ga2O3 were grown with high crystal quality in different growth conditions (i.e. gallium and oxygen rich regimes) by molecular beam epitaxy (MBE) with the aim to engineer the overall concentration of different point defects. In this framework, various characterization techniques (e.g., X-ray diffraction, Raman, positron annihilation spectroscopy) are considered to correlate the synthesis conditions to the point defect formation.

Title: Epitaxial Growth of Hexagonal boron–nitrogen–carbon (h-BNC) Monolayer on Different Substrate Materials

Authors: Alaa Mohammed Idris Bakhit, Anna A. Makarova, J. Enrique Ortega and Frederik Schiller

STSM home institution: Materials Physics Center MPC (Spain)

STSM host institution: Russian-German Beamline at BESSY Synchrotron facility, Helmholtz-Zentrum Berlin für Materialien und Energie (Germany)

Summary: We studied the epitaxial growth and electronic properties of a hybrid h-BNC monolayer on curved crystals Ni(111), Rh(557), and Pt(331). This h-BNC monolayer is a mixture of the two-dimensional layers of hexagonal boron nitride (hBN) and graphene (Gr). The combination of hBN and Gr promises to open the ability for a semiconducting behaviour. Hybrid h-BNC was synthesized by Chemical Vapor Deposition (CVD) of trimethylborazine precursor, and the epitaxial growth was performed at various temperatures. The epitaxial growth and the electronic structure were characterized by low-energy electron diffraction (LEED), X-ray photoemission (XPS), and near-edge X-ray absorption fine structure spectroscopy (NEXAFS). The study of catalytic activity for epitaxial growth varied based on substrate material, temperature, and step density. On c-Ni and c-Pt, the BN to graphene ratio was influenced by growth temperature, while on c-Rh, the film primarily comprised hBN with minor carbon doping.

Title: Magnetic enhanced faradaic efficiency for the oxygen evolution reaction on epitaxial thin film model catalysts

Authors: Emma van der Minne, Ellen Kiens, Marcel Risch, and Chris Baeumer

STSM home institution: University of Twente (The Netherlands)

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STSM host institution: Helmholtz Center Berlin (Germany)

Summary: An important hurdle in the oxygen evolution reaction (OER) originates from differences in the magnetic state between the reactants and products, implying that magnetic order in an OER catalyst is essential[1,2]. In line with this idea, we have shown that changing the magnetic order of a epitaxial $La_{0.67}Sr_{0.33}MnO_3$ thin film OER catalyst from paramagnetic to ferromagnetic results in an activity increase[3]. However, next to this increase in activity it is hypothesized that spin filtering in these catalysts, induced by this magnetic order, can increase their faradaic efficiency for the OER[4]. Using rotating ring disk experiments we have investigated the selectivity of the OER under magnetic fields on epitaxial magnetic model catalysts and show a slight enhancement of the oxygen production in these ferromagnetic catalysts upon external magnetic field application. Understanding this effect of magnetic order on selectivity will help to unravel the mechanism of spin enhanced OER.

[1] C. Biz et al., ACS Catal, 2021, 11(22), 14249–14261
[2] X. Ren et al., Nat Commun, 2021, 12(1), 2608
[3] E. van der Minne et al., Appl. Phys. Rev., 2024, 11, 011420
[4] A. Vadakkayil et al., Nat Commun 14, 1067 (2023)