Rencontres Jeunes du C'Nano Nord-Ouest

EN LIGNE

13 mai 2022

Programme & Abstracts

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Horaire : 14h – 17h
Format : visioconférence

PROGRAMME

14h00 – Accueil et présentation du C'Nano par Fabienne GAUFFRE (CNRS – ISCR & animatrice du bureau C'Nano Nord-Ouest)

14h15 – Conférence de Laurent CARIO (CNRS – IMN)

- *"Mottronics a novel microelectronics based on Mott insulators"*

14h40 – Présentations des doctorant.e.s

- **Thibaud AUMOND,** (Université de Poitiers – IC2MP)
  "How do the zeolite active sites impact the synthesis and quality of Zeolite-Templated Carbons ?"

- **Guillaume DUBOIS, (**Université de Rennes 1– ISCR**)**
  "Synthesis of nanostructured molybdenum Nitride and carbide catalysts using Metal Cluster Compounds as Precursors:Application to the Heterogeneous catalysis?"

- **Youssef EL MOUSSAOUI,** (Nantes Université – IMN)
  "Physico-chemical characterization of hydropatite nanoparticles from tricalcium phosphate food additive?"

15h15 – Présentation des travaux du lauréat du Prix C'Nano Nord OUEST, Clément GOUBAULT (CNRS – ISCR)

- "The ouzo effect for the elaboration of hybrid nanocapsules (Hybridosomes®): application to encapsulation by nanoprecipitation and to radiotherapy"

15h35 – 15h50 : PAUSE

15h50 – Conférence de Fabien ALIBART (CNRS – IEMN)

- *"Transitors électrochimiques organiques dendritiques pour l'ingénierie neuromorphique 3D"*

16h20 – Présentations des doctorant.e.s

Dimitri HENNIQUAU, (CNRS – IEMN)

- *"Design of a functional interface for connecting artificial and living neurons"*

Chakrya-Anna CHHUON, (Axorus – IEMN)

- *"Design and manufacture of flexible implantable and energy autonomous neuroelectronic devices"*

Wijden KHELIFI, (Université de Lille – IEMN)

- *"Characterization of electron transport inside inAs/GaSb quantum nanostructures using four probe scanning tunnelling microscopy"*

16h50 – Clôture par Jean-Luc DUVAIL (Nantes Université – IMN & animateur du bureau C'Nano Nord-Ouest)

Abstracts disponibles ci-dessous

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13 mai 2022

Abstract de Laurent CARIO

(CNRS -IMN)

Rencontres Jeunes du C'Nano Nord-Ouest
EN LIGNE
13 mai 2022

First Name, Family Name: Laurent, CARIO
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City: Nantes

MOTTRONICS A NOVEL MICROELECTRONICS BASED ON MOTT INSULATORS MOTTRONICS A NOVEL

L. Cario, D. Babich, C. Adda, J. Tranchant, M.- P. Besland, B. Corraze, and E .Janod

Abstract

Mott insulators represent a broad class of quantum materials that should be metallic according to conventional band theory, but are insulating due to on-site electron-electron repulsions. In such systems, electronic doping or external pressure may drive insulator to metal transitions (IMT) and lead to remarkable properties such as High Tc superconductivity or magnetoresistance. For this reason, during the last decades, filling or bandwidth control IMT in Mott insulators (i.e. the Mott transition) have been the subject of intense research and led to astonishing academic results. In comparison, the use of these IMT in real applications remains quite scarce and this may be ascribed to a simple reason: pressure or doping are not external parameters that are easily controllable in real devices. But recently a new exciting way to destabilize the Mott insulating state was reported that consists in applying an electric field. This so called Electric Mott Transition whose main signature is a volatile or a non-volatile resistive switching is much more promising in terms of applications as the voltage pulse is the most common tuning parameter used in microelectronic devices. The Electric Mott Transition may therefore open the door to a new electronic based on Mott insulators, namely the Mottronics.

This presentation will review the Electric Mott Transition and the new functionalities that are enabled by this property. The first part will be devoted to the experimental evidences of the Electric Mott Transition and of the concomitant resistive switching observed when Mott insulators are subjected to Electric pulses. A second part will review the numerous theoretical studies that have been carried out to unveil the mechanism at the origin of the system destabilization under electric field. The last part will give an overview of the new functionalities enabled by the Electric Mott Transition that may be used to build up new type of devices for data storage, or artificial intelligence.

Keywords (4-5) : Mott Insulator, Resistive Switching, Non-Volatile Memories, Neuromorphic applications

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Abstract de Thibaud Aumond

(Université de Poitiers-IC2MP)

Rencontres Jeunes du C'Nano Nord-Ouest
EN LIGNE
13 mai 2022

First Name, Family Name: Thibaud, AUMOND
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Supervisor(s): Yannick Pouilloux, Alexander Sachse
City: Poitiers

HOW DO THE ZEOLITE ACTIVE SITES IMPACT THE SYNTHESIS AND QUALITY OF ZEOLITE-TEMPLATED CARBONS?

Abstract

Zeolite-Templated Carbons (ZTCs) are a well-established category of microporous carbons featuring defined textural proprieties and reveal very interesting in a number of fields including (electro)catalysis and adsorption due to their unique electronic properties in combination with very high porous volume and homogeneous micropore size distribution. They develop within the micropores of a zeolite and can be described as a negative copy of it. In this communication, we present for the first time the impact of the active sites concentration on the quality of the final ZTCs by using five FAU zeolites with Si/Al ratios between 2.6 and 40.

Different behaviors on the formation of ZTCs are highlighted as a function of the synthesis temperatures (Fig. 1). Using 790 °C leads to a similar amount of carbon within the zeolite (SPD) for each active site content. When the synthesis temperature is decreased to 690 °C and 740 °C, the quantity of carbon is decreased proportionally with the amount of active sites indicating an important depending on the active sites concentration. On the other hand, when the synthesis temperature raises 840 °C, the SPD increases by decreasing the active sites concentration which can be explained by the filling of mesopores. Using this temperature, carbon filling is completely independent of the active site amount of the template zeolite and only depends on the textural properties of these latter. These results with Raman, N_2 physisorption, Electronic microscopy, EPR show that the zeolite is more than a template but plays a crucial role on the final structural and chemical qualities of ZTCs.

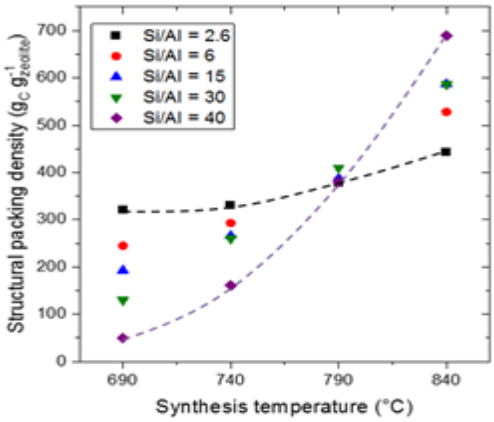

Fig. 1. *Structural Packing Density as a function of synthesis temperature for different active sites concentration.*

Keywords (4-5): Zeolite-Templated Carbons, microporous carbons, ordered carbons, zeolite, active sites

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Abstract de Guillaume DUBOIS

(Université de Rennes - ISCR)

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13 mai 2022

First Name, Family Name: Guillaume, DUBOIS
Title: PhD student 1st
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Supervisor(s) : Franck Tessier, Fabien Grasset and Stéphane Cordier
City : Rennes

SYNTHESIS OF NANOSTRUSCTURED MOLYBDEMUM NITRIDE AND CARBIDE CATALYSTS USING METAL CLUSTER COMPOUNDS AS PRECURSORS: APPLICATION TO THE HETEROGENEOUS CATALYSIS

Abstract

Transition metal carbides and nitrides show interesting properties in heterogeneous catalysis1,2 to catalyse the Hydrogen Evolution Reaction (HER) 3,4 and the Water Gas Shift reaction.5 When synthesized by the urea route,6 Mo2C shows an electrocatalytic activity superior to that of other catalysts (Mo2N and MoB) in acidic and basic aqueous media, although still inferior to that of platinum.7 Nevertheless, the use of Mo2C carbide would be an alternative to platinum that would make the technology more economically viable.

Herein we report the synthesis of Mo2C and Mo5N6 from an original route using transition metal cluster-based precursors.5 The resulting carbides and nitrides are characterized by using several complementary techniques (XRD, SBET measurement, SEM, etc...). This innovative mode of synthesis affords nanostructured compounds that are evaluated as catalysts for the HER reaction and the WGS reaction.

References:

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4. Jiang, R. et al. Electroch. Act. **261**, 578–587 (2018).
5. Guy, K. et al. Chem. Mater. **32**, 6026–6034 (2020).
6. Giordano, C. et al. Chem. Mater. **21**, 5136–5144 (2009).
7. Ma, L. et al. Mater. Chem. A **3**, 8361–8368 (2015).

Keywords (4-5) : Clusters, Carbide, Nitride, HER reaction, WGS reaction.

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Abstract de Youssef EL MOUSSAOUI

(Nantes Université - IMN)

Rencontres Jeunes du C'Nano Nord-Ouest
EN LIGNE
13 mai 2022

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Title: PhD Student
Employer, Laboratory: Nantes Université, Institut des Matériaux de Nantes, Nanostructures)
Supervisor(s): Bernard Humbert, Marie-Hélène Ropers, Sophie Quillard, Hélène Terrisse
City: Nantes

PHYSICO-CHEMICAL CHARACTERIZATION OF HYDROXYAPATITE NANOPARTICLES FROM TRICALCIUM PHOSPHATE FOOD ADDITIVE

Abstract
Tricalcium phosphate (TCP) is a commercially available product involved in numerous industrial applications such as in the food industry where it is used as a food additive (labelled E341). Since it was found in the United States that TCP food additive was composed of nanoparticles, the question of the presence of such nanoparticles in European products became of interest to address consumer safety concerns. Here a physico-chemical investigation of three different TCP samples used in France and complying with European regulations is proposed.
X-Ray diffraction, Raman Spectroscopy, ^{31}P NMR as well as infrared spectroscopy revealed the main phase in the TCP samples to be hydroxyapatite (HA). The Ca/P molar ratio obtained by ICP-AES, which is characteristic of calcium phosphate compounds, is close to the 1.67 HA reference value. BET analysis of the N_2 adsorption-desorption isotherms provided specific surface values consistent with the definition of nanomaterials. Transmission electron microscopy gave the morphology and overall size of the HA nanoparticles. The measure of solubility in different pH conditions highlighted the persistency of HA nanoparticles until pH 3. Granulometry and zetametry showed the agglomeration tendency of this compound and its negatively charged surface in its stability range (pH>5).

Keywords (4-5) : Hydroxyapatite, Nanoparticles, Food Additive, Characterization

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Abstract de Clément GOUBAULT

(CNRS - ISCR)

Rencontres Jeunes du C'Nano Nord-Ouest

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13 mai 2022

First Name, Family Name: Clément, GOUBAULT
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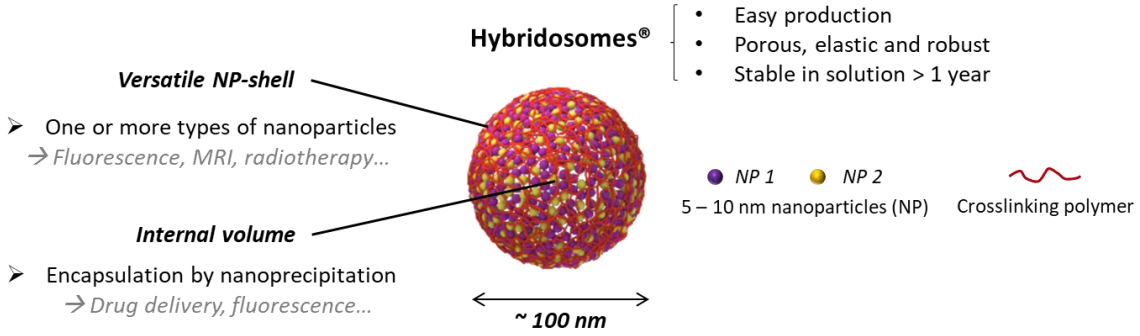
Employer, Laboratory: CNRS, Institut des Sciences Chimiques de Rennes
Supervisor(s): Fabienne Gauffre & Soizic Chevance
City: Rennes

THE OUZO EFFECT FOR THE ELABORATION OF HYBRID NANOCAPSULES (HYBRIDOSOMES): APPLICATION TO ENCAPSULATION BY NANOPRECIPITAION AND TO RADIOTHERAPY

Abstract

The ouzo effect is a phenomenon of spontaneous emulsification in a "water/miscible solvent/hydrophobic compound" system, leading to the formation of droplets of controlled size and low polydispersity. For several years, our group has been using a process based on the ouzo effect to prepare hydrophilic nanocapsules composed of inorganic nanoparticles and polymer: Hybridosomes®. This simple approach leads to nanocapsules whose properties can be modulated according to the assembled nanoparticles (iron oxide, gold, quantum dots...). The objective of this PhD was to understand the physico-chemical mechanisms involved in the formation of hybridosomes® as well as to explore their applications, more precisely encapsulation and radiotherapy. The first part of this work was devoted to the study of the ouzo system allowing the preparation of nanocapsules, with a particular focus on the stabilization of ouzo droplets with nanoparticles **[1]**. Then, we evaluated our strategy for the encapsulation of hydrophobic compounds by nanoprecipitation, with very good encapsulation performances and *in vitro* and *in vivo* release **[2]**. Finally, we successfully used gold-iron oxide hybridosomes® for the enhancement of glioblastoma radiotherapy in a murine model **[3]**. Very interestingly, one mouse showed an exceptionally long survival when treated with hybridosomes® coupled with irradiation. Hybridosomes® are therefore a very promising tool for combined therapies thanks to their properties, arising both from their encapsulation ability and their nanoparticle shell.



1. C. Goubault *et al.* Journal of Colloid and Interface Science, 2021, 603, 572-581
2. C. Goubault *et al.* Journal of Controlled Release, 2020, 324, 430-439
3. C. Goubault *et al.* Nanomedicine: Nanotechnology, Biology, and Medicine, 2022, 40, 102499

Keywords: Ouzo Effect ; Nanoparticles ; Nanoprecipitation ; Encapsulation ; Radiotherapy

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Abstract de FABIEN ALIBART

(CNRS-IEMN)

Rencontres Jeunes du C'Nano Nord-Ouest

EN LIGNE

13 mai 2022

First Name, Family Name: Fabien, ALIBART
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NEUROMORPHIC COMPUTING: A BRIDGE ARTIFICIAL NEUTRAL NETWORKS AND BIO-COMPUTING

Abstract

While our understanding of the brain have made huge progresses, we are still inefficient in interfacing biological systems with electronics, both in terms of energy and integration potential. Pushed by the need to use conventional computers for building complex systems dedicated to brain interface applications, we have mostly capitalized on technologies and architectures inherits from microelectronic that are intrinsically not adapted to interface living systems. In this talk, I will present how the neuromorphic computing paradigm can offer new perspectives for interfacing living systems. In particular, I will present how the different technologies and computing concepts of neuromorphic engineering can be deployed in the back-end and front-end of a neuronal sensing architecture.

After introducing the architecture of a sensing / computing hardware used to sense electrical activity in neuronal cells, I will present both the technologies and the fundamental concepts that we can exploit in the back-end and front-end of a neuromorphic sensing interface. I will introduce the neuromorphic framework and show how emerging nanotechnologies can be used to implement efficient hardware that capitalizes on bio-inspiration. Then, I will present how iono-electronic sensors and materials can be used in the front-end for neuromorphic sensing of biological signals.

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Abstract de Dimitri HENNIQUAU

(CNRS-IEMN)

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EN LIGNE
13 mai 2022

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Employer, Laboratory: CNRS, IEMN
Supervisor(s): Virginie HOEL, Christel VANBESIEN-MAILLIOT, Alexis VLANDAS
City: Lille, FRANCE

DESIGN OF A FUNCTIONAL INTERFACE FOR CONNECTING ARTIFICIAL AND LIVING NEURONS

Abstract

Neuromorphic engineering is a new field that aims to develop artificial systems capable of reproducing the brain's data processing. Thus, neuromorphic systems aim to develop more efficient and effective solutions than current data processing technologies [1]. In the same time, the enhancement of neurobiohybrid systems allows to consider the production of new neuroprostheses and the development of new therapeutic strategies to manage diseases of the aging adult. In this context, the research group Circuits Systèmes Applications des Micro-ondes (CSAM) of the Institute for Electronics, Microelectronics and Nanotechnologies (IEMN) has contributed to the generation of such neuromorphic systems by developing a toolbox constituted of artificial neurons and synapses. These artificial neurons have excellent energy efficiency and are able to emit biomimetic electrical signals [2], [3], [4]. To include neuromorphic engineering in the management of pathological neural dysfunctions, it appears necessary to interface artificial and living neurons establishing a bidirectional communication loop between these different components, which means artificial neurons stimulate living neurons, whose response stimulates other artificial neurons and vice versa. Results were achieved concerning the development of a functional interface allowing the culture of living neurons and the demonstration (using a calcium-based imaging technique) that artificial biomimetic spikes excite living neurons. It represents the first part of the bidirectional communication loop. The target is now to develop an original experimental bench connecting artificial and living neurons. This bench will allow to simultaneously stimulate a living neuron connected to an artificial neuron and record the electrical signals elicited in this living neuron, highlighting the entire bidirectional communication loop.

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3. *Brevet Neurone Artificiel, N° de priorité : FR20160053175 20160411 Inventeurs : Cappy Alain, Danneville François, Hoel Virginie, Loyez Christophe Demandeur(s) : Université de Lille 1, CNRS Licence : Axorus N° de publication : FR3050050 (A1) 2017-10-13*
4. *Hedayat, S. (2018). Conception et fabrication de neurones artificiels pour le traitement bioinspiré de l'information [These de doctorat, Lille]. https://www.theses.fr/2018LILUI039*

Keywords (4-5) : Neuromorphic, artificial neurons, Biomimetic, neuroprosthesis,

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(Axorus-IEMN)

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EN LIGNE
13 mai 2022

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Supervisor(s): Virginie Hoël, Christel Vanbesien, Alexis Vlandas, Hélène Moulet
City: Villeneuve d'Asq

DESIGN AND MANUFACTURE OF FLEXIBLE IMPLANTABLE AND ENERGY AUTONOMOUS NEUROELECTRONICS DEVICES

Abstract

Neurodegenerative diseases such as age-related macular degeneration (AMD) are increasing with the aging of the population [1]. In AMD, the photoreceptors in the center of the retina degenerate and die, which results in vision loss. The Institute of Electronics, Microelectronics and Nanotechnology (IEMN) and Axorus, a startup founded in 2019, are collaborating on a retinal implant prototype which aims at restoring the visual capacities of AMD patients. IEMN developed and patented an electronic circuit which reproduces the electrical signature of a biological neuron. Axorus has integrated this "artificial neuron" into an implant powered by light.

One objective of this thesis is to develop a thin bendable silicon substrate following the shape of the eye. It has to be bendable for easy insertion, with a large implant size to provide a maximum visual field [2][3]. Our aim is to push the limits of substrate thinning and reach a thickness of 10 µm. At this thickness, the silicon should be bendable.

Another objective of this thesis work is to select an energy source able to be stored and provide enough energy to stimulate biological neurons [4][5], in the case where photovoltaic energy is not usable. The energy source will also have to be biocompatible and reach a lifetime of at least 10 years.

This will pave the way for other applications using the artificial neuron. The implant will be adapted to implantation areas with strong dimensional constraints and will be self-sufficient for unlit areas.

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4. Pozo, Garate, Araujo, et Ferreiro, « Energy Harvesting Technologies and Equivalent Electronic Structural Models - Review », Electronics, vol. 8, no 5, p. 486, avr. 2019, doi: 10.3390/electronics8050486.
5. M. A. Hannan, S. Mutashar, S. Samad, et A. Hussain, « Energy harvesting for the implantable biomedical devices: Issues and challenges », Biomed. Eng. Online, vol. 13, p. 79, juin 2014, doi: 10.1186/1475-925X-13-79.

Keywords (4-5) : Neuro-electronic implant, Silicon thinning, Microfabrication, Energy sources, B

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Abstract de Wijden KHELIFI

(Université de Lille-IEMN)

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EN LIGNE
13 mai 2022

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Employer, Laboratory: Lille University, IEMN
Supervisor(s): Ludovic Desplanque, Bruno Grandidier
City: Lille

CHARACTERIZATION OF ELECTRON TRANSPORT INSIDE INAS/GASB QUANTUM NANOSTRUCTURES USING FOUR PROBE SCANNING TUNNELING MICROSCOPY

Abstract

We investigate the electron transport properties inside broken-gap InAs/GaSb quantum well and core-shell nanostructures. The samples are grown by molecular beam epitaxy on highly mismatched GaAs and InP substrates. In-plane core/shell nanostructures are obtained using selective area epitaxy inside the nanoscale openings (100 and 200nm wide) of a SiO2 mask deposited on InP(100) substrate. Hall effect measurements on mm-scale Van der Pauw devices fabricated from the quantum well reveal a mobility of about 26000 cm² /V·s and 190 000 cm²/V·s at room temperature and 77K respectively for the two dimensional electron gas. The low sheet resistance of the quantum well at room temperature (115 Ω/□) is confirmed with "Four-probe (4P)- STM" measurements that exhibit a constant 4P-resistance while varying the distance between the equidistant probes [1] (Figure 1). Using the same set-up, the room temperature resistivity of 200nm and 100 nm wide in-plane nanostructures is found to be consistent with the deduced resistivity of the 2DEG independently from their orientation, showing an efficient passivation of the InAs surface with GaSb without impeding injection and collection of electrons with STM tips. Low temperature multiprobe STM experiments are in progress to try to evidence ballistic electron behaviour using nanometer scale probe separation.

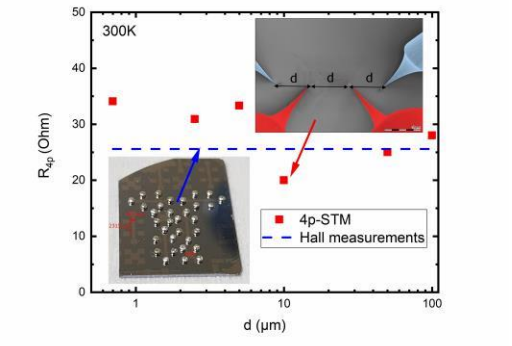

Figure 1 : Resistance versus inter-probe-distance d extracted from Hall-effect (blue) and four-probe (red) measurements for two dimensional electron gas of the InAs/GaSb heterostructure.

Keywords (4-5) : Electron transport, quantum well, In-plane nanostructures, Hall effect, Four-probe-STM, ballistic electron behaviour…