Tecnológico de Monterrey

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TEC.NANO

CONFERENCIA INTERNACIONAL DE NANOTECNOLOGIA 2019

Carbon - MEMS

2019
International Meeting
Theme: Advances and Challenges

Health for the Billions

Theme: Affordable Technologies

21st-23rd October
Monterrey
MEXICO

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Tec.Nano *is an international conference jointly organized by the undergraduate and graduate programs in Nanotechnology as well as the Research office of the School of Engineering and Sciences of Tecnologico de Monterrey. The 2019 edition of Tec.Nano has two plenary sessions by Dr. Marc Madou and Dr. Satadal Saha. It hosts the 5th session of Carbon-MEMS, the 2nd session of Health for the Billions, and parallel sessions addressing different topics in Nanotechnology. It has also some workshops, and a poster session.*

The Carbon-MEMS series of Meetings started in 2014 under the leadership of our colleague and friend Prof. Marc Madou. This year, we have sessions on Fabrication and Applications of Carbon- MEMS. We have also an extensive session on Microfluidic Devices, addressing both Lab-on-a- Chip and CD-Microfluidics topics. Although many of the works are not strictly connected to Carbon, there are already activities aimed to the incorporation of Carbon Sensors or Actuators to the Microfluidic Devices. Tec.Nano 2019 hosts also the session Health for the Billions presenting different efforts in the development of affordable health-care technologies for a broader mass of the population. Tec.Nano 2019 offers introductory workshops in Lab-on-a-Chip and Lab-on-a-Disc low-cost prototyping, Electrospinning, Preparation of Liposomes and Cancer Nanotechnology. The last part of the event is a Poster session with some awards for the best works.

I expect this international event will help to consolidate the international research network on Carbon-MEMS and Microfluidic Devices, serve as a seed of a strong new research network committed to the creation of more affordable health-care technologies, and very important, provide students inspiration to embrace the exciting world of Nanotechnology.

Sincerely,

General Chair, Tec.Nano 2019
Sergio O. Martinez

SCHEDULE

Monday 21st Oct

8:30 – Registration

9:30 – 10:15 **Opening Session**

Sergio Martínez
Ricardo Ramírez

10:15 – 10:30 Coffee Break

10:30 – 12:00 **Plenary Lectures**

Marc Madou — Graphene in Carbon-MEMS
Satadal Saha — Health for the Billions

Location: Pabellón Carreta

Carbon MEMS - Advances and Challenges

13:30 – 15:45 **C-MEMS Fabrication**
***Chairs:** Rodrigo Martínez-Duarte, Marc Madou

Rodrigo Martínez* — Novel Ways to Fabricate Carbonaceous Materials from Renewable Resources
Monsur Islam — Interesting Methods Towards Fabrication of Multi-dimensional Carbonaceous Cellular Materials
Babak Rezaei — Complex 3D Carbon Structures Generated by Stereolithography Printing Technology as Free-standing Electrodes in Electrochemistry
Surabhi Nimbalkar — Preliminary Characterization of Glassy Carbon and Graphene based Metamaterial
Arnoldo Salazar — Sub-10nm Nanogap Fabrication from Carbon Suspended Wires

15:45 - 16:00 Coffee Break

16:00 – 18:00 **CMEMS Applications 1**
***Chairs:** Sam Kassegne, Marc Madou

Sam Kassegne* — Why Carbon is a Compelling Material for Multi-Modal Neural Probes for Long-Term Electrical Stimulation, High-Resolution Recording and Neurochemical Detection
Shashank Vasudevan — Leaky Optical Neural Probe for Optical Stimulation and Real Time Electrochemical Detection of Dopamine Exocytosis from Optogenetically Modified Human Neural Stem Cells
Afia Asif — Pyrolytic Carbon Nanograss for Enhanced Neurogenesis and Dopaminergic Differentiation of Human midbrain Neural Stem Cells
Sunny Holmberg — Graphitized Carbon Nanofibers for Electrochemical Sensing
Long Nguyen Quang — Pyrolytic carbon resonator and its applications

Location: Pabellón Carreta

SCHEDULE

Tuesday 22nd Oct

8:30 – 10:30	**CMEMS Applications 2** ***Chairs**: Stephan Keller, Israel de León
Stephan Keller*	Biomaterial Microsystems for Electrochemical Monitoring of Cells and Oral Drug Delivery
Israel de León	Large and Ultrafast Nonlinear Response of ENZ-loaded Metamaterials
Tiefu Li	Reducing Intrinsic Energy Dissipation in Single-Crystal Diamond Mechanical Resonators
Gaurav Chauhan	Nano-spaced Gold on Glassy Carbon Substrate
10:15 – 10:30	Coffee Break
10:30 – 13:30	**Microfluidic Devices** ***Chairs**: Sergio Martínez, Dario Mäger
Dario Mäger*	Electrified-Lab-on-Disc for Immunoassays
Mehdi Aeinehvand	Advances in CD-Microfluidics at Tec de Monterrey
Laura Oropeza	Carbon-MEMS Hydro-Electrokinetic Platforms for Manipulation of Bioparticles and Droplets
Oscar Pilloni	3D Positioning of Spherical Microparticles Suspended inside a Confined Microvolume using Dielectrophoretic Forces Induced by a C-MEMS Microelectrode Array
Víctor Pérez	Use of Correction Factors in Modelling iDEP-based Particle Trapping
Roberto Gallo	Exosome Classification by Size using Insulator-based Dielectrophoresis
Masoud Madadelahi	Double Emulsion Generation using Centrifugal Microfluidic Platforms
Location:	Pabellón Carreta

Health for the Billions - Affordable Technologies

15:00 – 18:00	**Health for the Billions – Affordable Technologies** ***Chairs:** Sergio Martínez, Satadal Saha, Marc Madou
Sergio Martínez*	Summary of Previous Event
Satadal Saha*	Advances in Affordable Technologies in JSV Innovations
Marc Madou*	Microbe Identification and Antibiotic Resistance Testing in under Two-Hours
Martínez-Madou group	The CD-Microfluidics Platform for Water Monitoring in EPOC (SM, GC, MA, BJ, MJ)
Alán Aguirre	Photochemical ROS Modulation for Enhanced Wound Healing and Tissue Bonding
Rodrigo Martínez	Perspectives on Selected DEP Platforms for Selective Bioparticle Manipulation in Sample Preparation
Dora Medina	Triborheological Study of Biomaterials
Álvarez-Trujillo group	Cost-effective Bioprinting & Tumor-on-Chip Technologies for the Democratization of Cancer-Research
Marc Madou	Closing Remarks
Location:	Pabellón Carreta

SCHEDULE

Tuesday 22nd Oct

Parallel Session 1

9:00 – 10:30 **Microfluidics and Lab on a Chip**
Chairs: Víctor Pérez, Roberto Gallo

Ricardo García	Microfluidic Generation of Lipid-stabilized Droplets as Artificial Cell Models
Ana Cristina Corona	Origami CD Fabrication Protocol
José Eric Ortiz	A Reactor-on-a-Chip for Cost-effective Synthesis of Gold Nanoparticles
Fabián Romero	Automation of a Peptide-microarray-based Immunoassay on a Disc by a Wireless Electrolysis Pump

Location: Bi-214

Parallel Session 2

11:00 – 13:00 **Nanotechnologies in Life Sciences**
Chairs: Gaurav Chauhan, José Guillermo González Valdez

Rolando Rodriguez	G4-PAMAM Dendrimer-HIV Peptide Complexes using Three-Dimensional Models of HIV-1 GP120 Glycoprotein
Clara Ríos	miR31 and AuNP´s in Colon Cancer
David Medina	Biogenic Metallic Nanoparticles. A nanometric trojan horse approach.
Ivonne González	Gelatin-Methacryloyl Hydrogels Enriched with Viral Nano-Meshes Functionalized with Epidermal Gr-Factor
Jorge Tavares	A Versatile GelMA Bio-ink Engineered with Plant Nanoviral Meshes
Saeed Beigi	Centrifugal-spun wool fibrous structure: a novel 3D-scaffold for tissue engineering

Location: Bi-214

Parallel Session 3

10:30 – 13:00 **Advanced Nanomaterials and Nanophotonics**
Chairs: Israel de León, Fernando Rodríguez, Alan Aguirre

Alejandro Lujambio	Fabrication of Carbon-based Supercapacitors through Electrospinning of Partially Mixed Solutions
Paloma Vilchis	Characterization of PVA based CNT Nanofibers for Electrochemical Sensing
Diego Crespo	Galvanostatic Electrodeposition of Silver Nanoparticles: Nucleation and Growth Studies
Saeed Beigi	Centrifugal-spun Wool fibrous structure: A novel 3D-Scaffold for Tissue Engineering
Chinmay Tiwari	3D-printing Packed-bed Photoreactors for Higher Efficiency Chemical Synthesis and Water Treatment
Osamu Katagiri	Electrospinning Oxygen-less Polymers to Fabricate Carbon-based Nanostructures
Apurv Chaitanya	Diffraction assisted circular dichroism in 2D plasmonic metasurface
Zeinab Jafari	High-Q Nanobeam Cavity on Silicon Nitride Platform
Alma Paola	Cobalt Nanohybrids for Optimization of Electrodes for Solar-driven Hydrogen Generation

Location: Biblio-TEC Auditorio

SCHEDULE

Tuesday 22nd Oct

Workshops

14:30 – 17:30

W1. **LOC Devices Prototyping**
Number of Participants: 8
Organizer and Instructor: Roberto Gallo (rgallo@tec.mx)
Instructor: Alejandro Lujambio (alejandrolujang@gmail.com)
Location: Microfluidics Lab, CETEC Ground Floor

W2. **CD-Microfluidic Devices Prototyping**
Number of Participants: 8
Organizer and Instructor: Mehdi Aeinehvand (m.aeinehvand@tec.mx)
Location: Microfluidics Lab, CETEC Ground Floor

W3. **Cancer Nanotechnology: Cellular Nanovesicle Recovery from Cancer Cell Lines**
Number of Participants: 25
Organizer: José González (jose_gonzalez@itesm.mx),
Instructors: Javier Donoso (jadonosoq@gmail.com), Sergio Ayala (antonioayalamar@gmail.com)
Location: Enzimology Lab, Biotec 2nd Floor

W4. **Preparation of Liposomes**
Number of Participants: 10
Organizer and Instructor: Daniel Guajardo
Location: Bioprocesses Lab, Biotec 1st floor

W5. **Electrospinning Technology**
Number of Participants: 10
Organizer and Instructor: Daniel Guajardo, Katya Huesca
Location: Bioprocesses Lab, Biotec 1st floor

SCHEDULE

Wednesday 23rd Oct

Poster Session & Closing Ceremony

8:45 – 11:30 **Poster Session**

Presenter	Title	Code
Alan Alberto Guevara	Research for the chemical synthesis of BSA nanoparticles	**WPS-01**
Sveidy Vaca	Study of the Effect of Different Ni Thickness on the Diffusion of C-MEMS Based on Electrospun SU-8 and CNT	**WPS-02**
Jesus Eduardo Contreras Naranjo	Rapid Determination of Dopamine at Electrochemically Activated Commercially Screen-Printed Carbon Electrodes Integrated with a 3D-printed Microfluidic Platform	**WPS-03**
Sarai Torres Torres Delgado	Electrified Lab-on-a-Disc	**WPS-04**
Jorge Cruz-Angeles	Nano co-amorphous solid dispersion of simvastatin – nifedipine for the treatment of cardiovascular diseases Main Area: Nanobiotechnology and Nanomedicine	**WPS-05**
Ana Murrieta	Microstructure of Polycrystalline Solids: A Brief Review from Methods in X-Ray Line Profile Analysis	**WPS-06**
Fausto Abril	Modern Raman Spectroscopy Advances for Biomedical Applications	**WPS-07**
Estefania Luna	Caracterización de los Mecanismos de Citotoxicidad Mitocondriales de Óxido de Grafeno en Células Ventriculares Hipertróficas	**WPS-08**
Sandra Lara	Electroactive and non-electroactive molecule in-vitro detection using glassy carbon microelectrode arrays	**WPS-9**
Shirley Mora	Green synthesis of silver nanoparticles using microalgae acclimated to high CO2	**WPS-10**
Rodrigo Cue Sampedro	Research on Structural and Optical Properties of Superlattice Tin/CrN Nanocoatings on glass via PVD sputtering	**WPS-11**
Omar Nuñez Cuacuas	Fabrication and Preliminary Characterization of Glassy carbon on Flexible substrate interdigitated supercapacitor	**WPS-12**
Long Nguyen Quang	Fabrication of pyrolytic carbon microneedles by de-focused maskless lithography	**WPS-13**
Wendy Ortega	Preparation of electrospun fibers of Poly(L-lactide-co-D,L-lactide) with Na2Ti6O13, Ca3(PO4)2 and ZrO2 as a bioactive mesh.	**WPS-14**
Héctor Eduardo Flores Hernández	Surface modification of PLGA loaded resveratrol nanoparticles for the improved delivery of resveratrol in H9c2 cells induced by Ang II to hypertrophy	**WPS-15**

11:30 – 12:30 **Closing Ceremony**

Location: Pabellón Carreta

15:00 – 19:00 **Cultural visit MARCO Museum and Fundidora Park**

Meeting Point: Pabellón Carreta, 15:00 hrs

Proceedings

Proceedings papers from Tec.Nano 2019 in the journal Materials Today: Proceedings (ISSN: 2214-7853)

Do not miss this opportunity to highlight your research by submitting your presented paper in the Tec.Nano2019 conference for publishing in the journal Materials Today: Proceedings. Work presented during either an oral session or poster session is eligible for submission; however, preparation of full papers is optional. These will go through a full peer-review and successful submissions will be published on-line, and optionally as hard copies.

The deadline for submission is January 1, 2020. Provided that the manuscript is acceptable to Elsevier, the Proceedings will be published within 3 (three) months later. See the following Guidelines for the Preparation of Manuscripts.

GUIDELINES

- The manuscripts have to be submitted in the English language, together with the complete table of contents, photographs, figures, legends, drawings, front matters, maps and other illustrative material to be included into it.
- Each paper in a Proceedings issue shall consist of a minimum of Three (3) pages and a maximum of Ten (10) pages.
- Files should be in MS Word format only and should be formatted for direct printing, using the CRC (Camera ready Copy) MS Word template provided. Figures and tables should be embedded and not supplied separately.
- The «MS Word Template» will be delivered from the conference organizer.
- Do not make any changes to the structure of the template as this can lead to production errors.

More information is available here: www.tec-nano.com/proceedings/

Graphene in Carbon-MEMS

Dr. Marc Madou [1,2,3,4,5]

[1]Chancellor's Professor Mechanical & Aerospace Engineering and Biomedical Engineering University of California
[2]Honorary Visiting Professor at IIT Kharagpur, India
[3]Visiting Professor UNIST, South-Korea (World Class University Scholar, WCU)
[4]Icon Professor University of Malaya
[5]Star Professor Monterrey Tecnológico, Mexico

Precise control of the polymer precursor chains and the exact polymer atomic composition, before and during pyrolysis, enables one to control the resulting carbon microstructure from glassy carbon to graphitic carbon and even to turbostratic graphene.

We will show how the presence of turbostratic graphene in C-MEMS reveals itself in the mechanical properties, electrochemical behavior and electronic conductivity of various C-MEMS structures. The focus of the talk will be on the electrochemical behavior of far-field electrospun carbon fiber mats. The potential use of these sensor mats for wearables is illustrated by some recent Cence, Inc. work.

Health for the Billions

Dr. Satadal Saha[1,2,3]

[1]Founder & Mentor, JSV Innovations Private Limited
[2]Visiting Professor, School of Medical Science & Technology, IIT Kharagpur
[3]Project Director, Dr B C Roy Super-specialty Hospital, IIT Kharagpur

Almost 50% of the global population, 3.74 billion, live in a state of inadequate access to basic primary care and outside the umbrella of public health measures. Lack of healthcare and health education lead to accumulation of disease, resulting in loss of societal productivity and forced seeking of high-cost secondary and tertiary healthcare. 100 million people choose between food and medicine everyday around the world. In India alone, 39 million falls below poverty line every year due to healthcare-related expenses.

Governments across the world are trying to address the problem. But given the extreme shortage of doctors and other health workers, absence of theragnostic technologies that work optimally in resource-poor environment, paucity of resources, wide and varying geographies, supply-chain constraints government efforts are both too little and not very effective. There is now realization among stakeholders that digital healthcare delivery is the only way forward. It is now our responsibility to come forward and lift the people out of this morass; everyone has a role to play – basic sciences, engineering, medical, economists and sociologists.

In India, our team have been working on a model for last four (4) years. This was conceptualized after thorough evaluation of others' efforts in India between 2013 & 2015 and understanding the 'gaps' that did not allow the models to scale and sustain economically.

Our model involves structured training of rural youth (middle school dropouts) as 'Health Workers' in a government accredited system; enabling them with innovative software and affordable 'Extreme-point-of-care' diagnostic technologies; encouraging them in an enterprise model and connecting them with formal doctors at distant locations. They deliver primary care to the local rural population including home care, undertake public health measures and function as the 'Health hub' for the community. This is supported by both state and central governments and is in line with the 'National Digital Health Policy 2017' of Government of India.

Prof. (Dr.) Saha's talk revolves round sharing the experience of implementing such a large-scale project in India.

Carbon-MEMS 2019

Advances and Challenges

Novel ways to fabricate carbonaceous materials from renewable resources

Rodrigo Martinez-Duarte*

Multiscale Manufacturing Laboratory, Department of Mechanical Engineering
Clemson University, USA

In this talk I will present innovative ways to manufacture carbonaceous materials from renewable resources. These processes are based on the shaping of different organic polymers followed by heat treatment at high temperatures in an inert atmosphere. Besides using renewable resources, the goal is to gain control of the material structure across several length scales. To this end, we are pursuing three different techniques: 1) Robocasting, or 3D printing, of composite pastes, 2) Origami folding of films, and 3) the manipulation of microbial factories to deposit cellulose nanofibers on specific locations. I will present our latest results in the shaping of complex geometries using these techniques and how carbon-based materials can be derived through heat treatment. The talk will end with a discussion on how these techniques can be merged towards the bottom-up fabrication of carbonaceous cellular materials with structure control over several dimensional scales.

*corresponding author webpage: www.multiscalemanufacturing.net

Interesting methods towards fabrication of multi-dimensional carbonaceous cellular materials

Monsur Islam*, Dario Mäger and Jan G. Korvink

Institute for Microstructure Technology, Karlsruhe Institute of Technology, Karlsruhe, Germany

Cellular carbon material possesses interesting properties including low density, high surface area, high chemical inertness, high oxidation resistance, adjustable electrical conductivity, strong mechanical properties, and excellent biocompatibility. This makes cellular carbon materials useful for a wide range of applications i. e. from thermal insulation to scaffolds for cell culturing [1]. The current state-of-the-art for synthesizing cellular carbon materials includes direct foaming and templating method. However, structuring these cellular materials mostly depends on the use of molds. Here we focus on methods for the fabrication of 3D architectures of cellular carbonaceous materials at different length scales. One approach is to fabricate 3D shapes of cellular carbon from a 2D edible rice paper precursor. The main constituent of rice paper is starch which goes through rapid dehydration during initial stage of pyrolysis. This yield into a 3D foam like structure, which transforms into a 3D carbon foam upon further heat treatment (Figure 1a, b). Carbonization of 2D geometries of such rice paper result in the formation of 3D shapes of carbon foam. Another approach is using stereolithography to fabricate epoxy micro-lattice structures as precursor. Controlled pyrolysis of the 3D printed epoxy results in fabrication of carbon micro-lattices (Figure 1c, d). Shrinkage during the pyrolysis yields obtainment of the lattice dimension much below than the limits of the used stereolithography process. The smallest micro-lattice width obtained in the process is ~100 µm. We explore different properties of these carbon cellular structures depending on their microstructures and geometries of the 3D architectures, which will lead them to different applications.

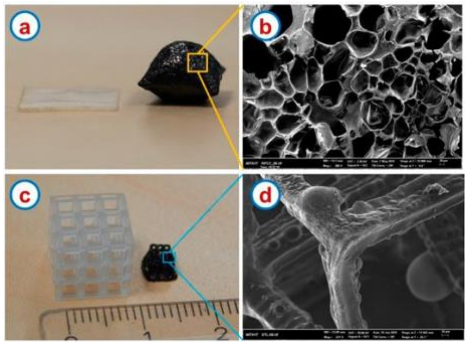

Figure 1: (a) 3D carbon foam from 2D rice paper; (b) Foam like microstructure of the rice paper derived carbon; (c) Fabrication of stereo-lithographically printed micro-lattices before and after carbonization; (d) microstructure of the carbon microlattices.

References:
[1] Inagaki, M., Qiu, J., and Guo, Q., 2015, “Carbon Foam: Preparation and Application,” Carbon N. Y., 87(C), pp. 128–152.

*corresponding author: monsur.islam@kit.edu

Complex 3D Carbon Structures Generated by Stereolithography Printing Technology as Free-standing Electrodes in Electrochemistry

Babak Rezaei,[1,*] Jesper Yue Pan [1] and Stephan Sylvest Keller[1]

[1]DTU Nanolab, 2800 Kgs. Lyngby, Denmark

Thanks to their excellent physicochemical characteristics such as thermal stability, electrical conductivity, and tailorable surface chemistry, carbon-based materials have attracted great attention for numerous applications ranging from micro-electromechanical systems (MEMS) to electrochemistry. In particular, to serve as an electrode in various electrochemical applications, patterning and three-dimensional (3D) aspect of carbon materials would result in increased electroactive surface area, higher chemical surface functionality, lower resistivity, higher sensitivity and miniaturizability [1]. Although several manufacturing methods have been employed to generate 3D carbon microelectrodes such as multi-steps UV photolithography, e-beam and two-photon lithography, the expensive fabrication of devices, long and complicated procedures and very low throughput would seriously restrict their applications at larger scale [2].

In this study, a simple and straightforward approach was employed based on the combination of stereolithography (SLA) printing technology and pyrolysis process to generate 3D carbon electrodes with specified and controllable complex architectures. For this purpose, a series of commercially available resins, SLA-printed architectures and pyrolysis conditions were assessed and optimized to obtain monotonic shape preserved and reproducible free-standing carbon electrodes with desired microstructure for electrochemical applications. From the experiments it was found that a 3 steps pyrolysis process (gradual carbonization treatment) of a commercial acrylate-based resin (FormLabs High Temperature resin) with mesh structure and high specific surface area (as is shown in Fig. 1a) could generate 3D carbon microelectrodes with more reliable and reproducible electrochemical results than direct ramping to the final temperature. Different characterization methods like SEM, Raman spectroscopy, XPS and XRD were employed to assess the influence of different pyrolysis conditions on the microstructure of the 3D carbon materials (Fig. 1b & c). Based on the Raman results it was concluded that the 3D pyrolyzed carbon microelectrodes had more graphitic content and less microstructural disorder than pyrolyzed SU-8 photopolymer at the same pyrolysis condition. The electrochemical activity, stability and reliability of the electrodes were confirmed through CV and EIS evaluations. The results showed that the pyrolysis conditions significantly influence the electrochemical behavior whereas the final pyrolysis temperature (in the range of 900 °C to 1100 °C) had small influence on electrochemical performance (Fig. 1d). Altogether, due to their reliable, stable and reproducible electrochemical behavior, special macro- and micro-structural properties, and scalability, we believe that the proposed pyrolyzed 3D carbon materials are really promising for a broad area of research and applications.

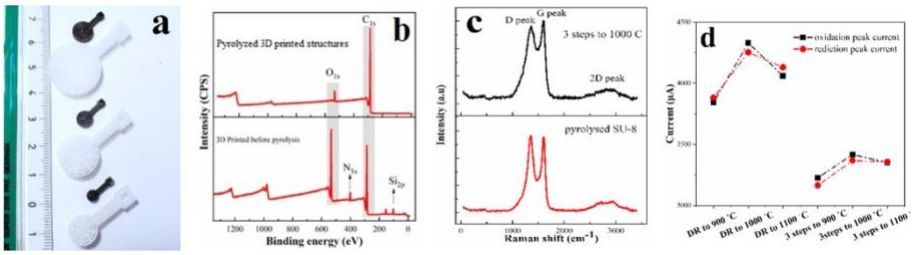

Figure 1: 3D printed structures with different surface areas before and after pyrolysis, (b) XPS and (c) Raman spectra and (d) CV-derived results of the different electrodes.

References: (1) S. Hemanth, et al., Carbon, 121 (2017) 226; (2) J. Bauer, et al., Nature Materials, 15(2016) 438.

*Corresponding author: barez@dtu.dk

Preliminary Characterization of Glassy Carbon and Graphene based Metamaterial

Surabhi Nimbalkar*[1] and Sam Kassegne[1]

[1]MEMS Research Lab, Department of Mechanical Engineering College of Engineering, 5500 Campanile Drive, San Diego State University, San Diego, CA, USA 92182

Graphene is the gold-standard for electrical conductivity along with its high mechanical strength and excellent thermal conductivity. On the other hand, GC has exceptional chemical inertness, good electrical properties, high electrochemically stability (gold-standard for electrochemistry), purely capacitive charge injection, and fast surface electrokinetics coupled with lithography patternability. Therefore, to leverage the unique strength of these 'gold-standard' materials in electrode technology, we introduce a new material system that brings the best qualities of these materials in a single format joined through strong covalent bonds. In this preliminary study, we investigate fabrication methodology, transfer on flexible substrate, bonding between the two allotropes of carbon through FTIR (Fourier transform Infrared) spectroscopy, surface morphology through SEM (Scanning electron microscopy) and topography by AFM (atomic force microscopy), and application of metamaterial-based microelectrodes for neural signal recording i.e. electrocorticography (ECoG).

*corresponding author: snimbalkar@sdsu.edu

Fabrication of sub-10 nm nanogap electrodes on suspended glassy carbon nanofibers

Arnoldo Salazar[1], Samira Hosseini[1], Margarita Sanchez-Domínguez[2], Marc. J. Madou[1,3], Alejandro Montesinos-Castellanos[1], Sergio O. Martinez-Chapa[1]

[1]School of Engineering and Sciences, Tecnológico de Monterrey, Eugenio Garza Sada 2501, Monterrey, NL 64849, México
[2]Centro de Investigación en Materiales Avanzados, S. C. (CIMAV), Unidad MonterreyParque de Investigación e Innovación Tecnológica, Apodaca, NL 66628, México
[3]Department of Mechanical and Aerospace Engineering, University of California Irvine, Engineering Gateway 4200, Irvine, CA, 92697, USA

Glassy carbon nanofibers (GCNFs) are promising candidates for the fabrication of nanoscale devices for biosensing and microelectronics applications. Particularly, carbon electrodes with sub-10 nm separations (nanogaps), represent an attractive platform for probing the electrical characteristics of molecules. Previously, we found that the nanogap size was dependent on the length of the GCNF, where in order to obtain nanogap electrodes separated less than 10 nm, fibers shorter than ~2 µm were required. In this work, in order to obtain sub-10 nm nanogaps, without the need of controlling the length of the fibers, we employed a fabrication strategy where the GCNFs were gradually thinned down by continuously monitoring the changes in the electrical resistance of the fiber and adjusting the applied voltage accordingly. To further reduce the nanogap size, we studied the mechanism behind the thinning and eventual breakdown of the suspended GCNFs by controlling the environmental conditions and pressure during the experiment. Following this approach, which includes performing the experiments in a high-vacuum chamber after a series of carbon dioxide (CO2) purging cycles, nanogaps of the order of 10 nm were produced in suspended GCNFs, independently of the length of the fiber. Furthermore, the electrodes showed excellent stability, with no apparent change in their shape or nanogap widening after being stored at room temperature for approximately 6 months.

Why Carbon is a Compelling Material for Multi-Modal Neural Probes for Long-Term Electrical Stimulation, High-Resolution Recording and Neurochemical Detection

Sam Kassegne[1,2*], Surabhi Nimbalkar[1,2], Omar Nunez Cuacuas[1,2]

[1] MEMS Research Lab, Department of Mechanical Engineering College of Engineering, 5500 Campanile Drive, San Diego State University, San Diego, CA, USA 92182
[2] NSF-ERC Center for Neurotechnology (CNT)

Over the past several years, carbon has emerged as a competitive material of choice for the micro and nanofabrication of a variety of micro devices with applications varying from biochemical sensors to micro capacitors, batteries, and neural probes. Its unique tunable mechanical and electronic properties enabled by the availability of a range of possible hybridized bonds (sp2 and sp3) make it a versatile material. Further, discovery of newer carbon forms and allotropes such as patternable glassy carbon (excellent electrochemistry), graphene (excellent conductivity and strength), Q-carbon (excellent hardness) and compressed glassy carbon (excellent strength) continue to position carbon as competitive in increasing number of application areas. In the meantime, research progress in devices that interface with the human body particularly with the central and peripheral nervous systems continues, with two key application areas, i.e., (i) BCI (cortical, intracortical, and spinal neuroprosthetics) and (ii) bioelectronics (treating chronic conditions through electrical stimulation of vagus nerves) driving a search for materials of excellent electrical and electrochemical characteristics. Against this background, carbon's excellent conductivity, robust electrochemical activity as well as homogenous microstructure offer a very compelling in-vivo platform for multi-modal neural interfaces for extended period of implantation.

In the meantime, the recent introduction of neural probes consisting of glassy carbon (GC) microelectrodes microfabricated through carbon MEMS (C-MEMS) technology and transferred to flexible polymer substrates has opened up significant opportunities in wearable and implantable carbon devices. This trend will continue as more evidence supporting the superior performance of GC microstructures in applications requiring extended electrical, electrochemical, and mechanical stability under chronic in vivo conditions emerge. In this talk, therefore, we report a portfolio of new class of carbon-based neural probes that consist of homogeneous glassy carbon (GC) microelectrodes, interconnect and bump pads with superior electrochemical properties, in-vivo performance and long-term stability under electrical stimulation. These electrodes have purely capacitive behavior with exceptionally high charge storage capacity (CSC) and are capable of sustaining more than 3.5 billion cycles of bi-phasic pulses at charge density of 0.25 mC/cm2. Extensive in-vivo and in-vitro tests confirmed: (i) high SNR (>16) recordings, (ii)

highest reported CSC for non-coated neural probe (61.4± 6.9 mC/cm2), (iii) high-resolution dopamine and serotonin detection (10 nM level - one of the lowest reported so far), (iv) recording of both electrical and electrochemical signals, and (v) no failure after 3.5 billion cycles of pulses. Supported by characterizations and computational modeling results, the talk will demonstrate (i) the reason behind long-term corrosion problems in thin-film metal microelectrodes and the promise of homogenous electrode material such as GC and (ii) the microenvironment and response of tissues to long-term electrical stimulations.

Leaky Optical Neural Probe for Optical Stimulation and Real Time Electrochemical Detection of Dopamine Exocytosis from Optogenetically Modified Human Neural Stem Cells

Shashank Vasudevan[1], Marta Baracchini[1], Janko Kajtez[1], Arto Heiskanen[1], Stephan S Keller[2], Jenny Emneus[1], *

[1] DTU Bioengineering, Technical University of Denmark, Lyngby, Denmark
[2] DTU Nanolab, Technical University of Denmark, Lyngby, Denmark

Parkinson's disease (PD) is characterized by the degeneration of dopaminergic neurons in the midbrain. The most effective therapy for the treatment of PD is administration of levodopa. However, it leads to the development of motor complications. Continuous delivery of dopamine has been shown to reduce the risks associated with chronic motor complications [1]. This work presents the fabrication and characterization of a microfabricated implantable leaky optical neural probe to fulfil three functions: i) it acts as a cell culture substrate for application in cell replacement therapy (CRT). ii) the leaky waveguide on the probe enables optical stimulation of neural stem cell derived optogenetic neurons differentiated on the probe. iii) pyrolytic carbon electrodes allow electrochemical detection of dopamine exocytosis and modulation of its continuous supply in the striatum for application in Parkinson's disease (PD) therapy. The neural probes are optimized for a mouse brain (4 mm long, 50 µm thick and 200 µm wide). The width is necessary for differentiating a large number of stem cells for application in CRT. Electrodes with micro-pillars are patterned in SU-8 and pyrolyzed to obtain the working (WE) and counter electrodes (CE) while gold is used as a pseudo reference electrode (RE) for electrochemical measurements. Pyrolytic carbon is used as cell substrate as it supports differentiation of neural stem cells into dopaminergic neurons [2]. A SU-8 waveguide was designed along the probe edge to encapsulate the cells during implantation and enable optogenetic stimulation of a large population of neurons in the immediate vicinity of the waveguide without the need to increase input optical power.

The probes are fabricated using a combination of front and backside silicon etching. The backside etch defines the probe thickness while the front side etch releases the probe and defines the groove for the placement of an optical fiber for coupling light into the waveguide. Figure 1a shows the probe shank containing the pyrolytic carbon electrodes surrounded by the leaky waveguide. The micro-pillars act as anchor points for the adhesion of stem cells. The design of a leaky waveguide was optimized using COMSOL. Figure 1b shows light leak pattern from the fabricated waveguide. The intensity of light leaking from the waveguide is measured to be 10 mWmm-2 (laser pulsed at 2 ms) which is sufficient for the stimulation of the optogenetically modified cells. The ability of the electrodes to detect different concentrations of dopamine (Figure 1c) demonstrate the suitability of the probes for optogenetic stimulation and electrochemical detection of dopamine. Furthermore, optogenetic human neural stem cells differentiated on the probes show excellent viability (Figure 1d). Experiments are currently in progress to evaluate dopamine exocytosis from optical stimulation of neurons.

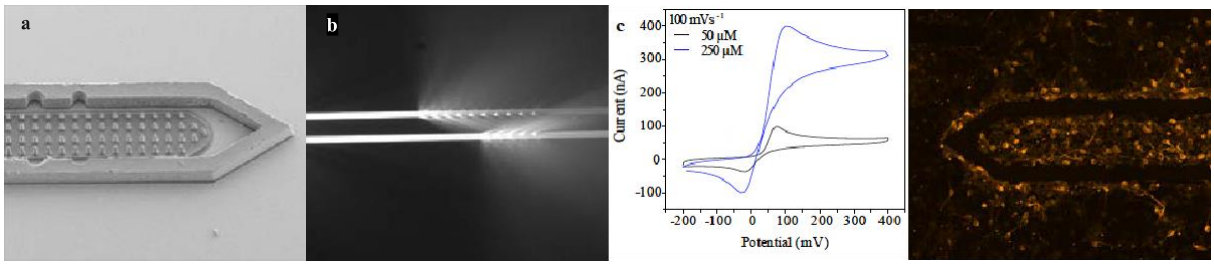

Figure 1: (a) SEM image of probe tip showing leaky SU-8 encapsulation waveguide and pyrolytic carbon WE. (b) Fabricated leaky waveguide coated with fluorescent nano-beads revealing the pattern of light leak (c) Comparison of CVs acquired at 100 mVs-1 in dopamine solution at two different concentrations (50 µM and 250 µM). (d) Immunocytochemistry of differentiated neurons on the probe (B-III tubulin).
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*corresponding author: jemn@dtu.edu

Pyrolytic Carbon Nanograss for Enhanced Neurogenesis and Dopaminergic Differentiation of Human midbrain Neural Stem Cells

Afia Asif, [1] Silvia Gracía-López, [3] Arto Heiskanen, [1] Alberto Martínez-Serrano, [3] Stephan S. Keller, [2] Marta Pereira, [3] and Jenny Emnéus [*1]

[1] Department of Biotechnology and Biomedicine (DTU Bioengineering), Technical University of Denmark, Copenhagen, Kgs. Lyngby 2800, Denmark
[2] National Centre for Nano Fabrication and Characterization (DTU Nanolab), Technical University of Denmark, Copenhagen, Kgs. Lyngby 2800, Denmark
[3] Center of Molecular Biology Severo Ochoa, University of Autonoma de Madrid, Madrid, Calle Nicolás Cabrera 28049, Spain

Stem cells are undifferentiated cells endowed with the properties of self-renewal and ability to develop into multiple specialized cells on demand. Sophisticated nano/microstructures have been employed as one way towards better understanding of cell to cell signaling mechanisms. Such topographies and biomaterials have the ability to influence cell migration, proliferation, gene expression, and tailored differentiation towards desired phenotypes (1). Pyrolytic carbon has been used as a tissue engineering scaffold in biosensing and life science applications due to its ability to be patterned as well as its multifunctional nature conductivity, biocompatibility and mechanical support (2,3).
This work presents fabrication and characterization of pyrolytic carbon nanograss (CNG) structures and investigates the role of Nano topography and material on the biology of human neural stem cells (hNSCs). The overall aim of the experimental study is to identify if pyrolytic CNG is a promising engineered nanomaterial for use as a future platform in CRT and implants for PD treatment. For this purpose, four different types of CNGs were fabricated using a simple one-step photolithography process, reactive ion etching and pyrolysis for carbonization. The analysis of hNSCs differentiation was achieved by quantifying morphological parameters such as cell area, elongation, and circularity. In-depth cellular studies of immunocytochemistry (ICC) characterization of specific biomarkers were performed on CNG to investigate neurogenesis and the generation of dopaminergic neurons (DAn) as compared to on tissue culture plastic (TCP) control and flat carbon (FC) surfaces, both in the presence and the absence of poly-L-lysine (PLL) as the biocoating to evaluate the effect on cell adhesion and differentiation. The results show that in the presence of the PLL, the CNGs enhanced hNSCs neurogenesis up to 2.3 folds and DAn differentiation up to 3.5 folds. Moreover, CNGs without any PLL coating, are not only supporting cell survival but also lead to significantly enhanced neurogenesis, promoting the hNSCs to acquire dopaminergic phenotype compared to PLL coated TCP and FC substrates.

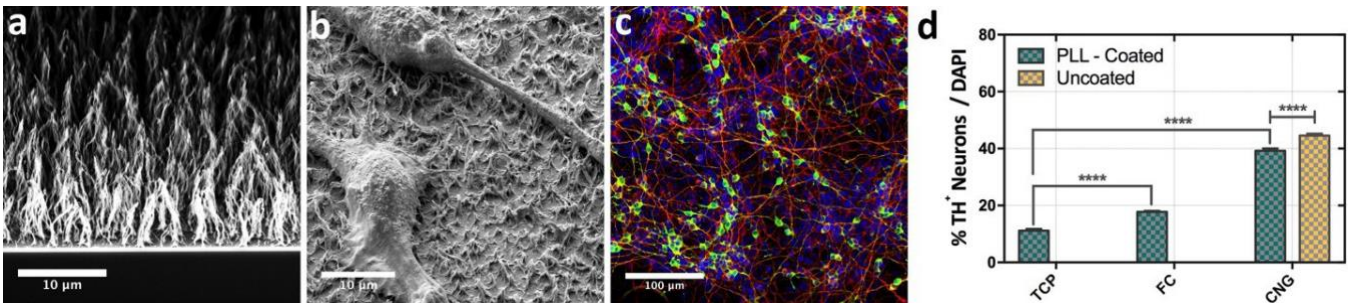

Figure 1: Scanning electron microscopic images of: a) fabricated CNG (tilted view), b) hNSCs differentiated for 10 days on CNG. Fluorescent micrograph of: c) hNSCs differentiated for 10 days on CNG, representing biomarkers b - III tubulin, Tyrosine Hydroxylase, and DAPI. d) DAn generation comparison on CNG vs TCP and FC controls in presence and absence of PLL biocoating. Error bars represent s.e.m, n=3.

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*corresponding author: jemn@dtu.dk

Graphitized Carbon Nanofibers for Electrochemical Sensing

Sunshine Holmberg[1,2]

[1] School of Engineering and Sciences, Tecnológico de Monterrey, Av. Eugenio Garza Sada 2501 Sur, 64849, Monterrey, NL, Mexico.
[2] Department of Mechanical and Aerospace Engineering, University of California, Irvine, CA, USA.

Carbon's microstructure to property relationship has long been popular focus of many studies over the years. Despite the plethora of studies in this field, tuning the microstructure carbon, both its morphology and atomic configuration, to express desired properties of carbon has remained a great challenge. A recent advance in a stress-induced methodology for graphitizing carbon electrodes has shown great promise in altering the resultant carbon's atomic structure while leaving its morphology intact. Here, we show how this methodology can be used to produce a powerful carbon paper sensing platform, which demonstrates enhanced electrochemical sensitivity while providing microfluidic properties exhibited in paper microfluidic systems. These unique properties allow this carbon paper to simultaneously as function an enzyme-free sensor and microfluidic platform. This type of carbon paper sensing platform holds tremendous potential in various biomedical fields such as wearable technologies.

Pyrolytic carbon resonator and its applications

Long Quang Nguyen[*,1], Peter Emil Larsen[2,3], Anja Boisen[2,3] and Stephan Sylvest Keller[1]

[1]DTU Nanolab, Technical University of Denmark, 2800 Kgs. Lyngby, Denmark
[2]DTU HealthTech, Technical University of Denmark, 2800 Kgs. Lyngby, Denmark
[3]DNRF and Villum Fonden Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics, IDUN, Technical University of Denmark, 2800 Kongens Lyngby, Denmark

In the last few decades, silicon has been the most widely used material in the Integrated Circuit (IC) industry, especially in Micro Electromechanical Systems (MEMS) due to its excellent mechanical and electronic properties. However, due to some limitations of silicon in both fabrication and for applications, new materials with the potential to replace silicon have gathered a lot of attention all over the world. Recently, carbon-based materials such as graphite [1], graphene [2], carbon nanotube (CNT) [3] and glassy carbon [4] have been studied. Pyrolytic carbon which is similar to glassy carbon is one of those carbon-based materials. It is obtained by pyrolysis of polymer precursors at high temperature in inert atmosphere [5] and has shown many advantages for MEMS devices. Therefore, the aim of this work was the fabrication and characterization of resonant MEMS sensors using pyrolytic carbon as the sensor's material and the use of the fabricated sensors for bio or chemical applications.

For MEMS resonators, the measurement principle is that an external stimulus changes the resonant behavior of the sensor and the measurand is calculated from this change. The resonance frequency of the resonator is a function of both geometry of the sensor structure and mechanical properties of the sensor material. Based on the resonance frequency (f) and quality factor (Q) changes, the resonators can be used for detecting added mass, material properties, temperature, etc. Recently, polymer resonators have been studied due to the advantages of polymer structure such as fast and simple fabrication. With the development of C-MEMS technology, polymer structures can be transformed into carbon. With this, the advantages of polymers structures can be combined with the advantages of carbon materials.

In this work, by combining the resonator sensors with pyrolytic carbon, we present several advantages of pyrolytic carbon resonators such as: (i) the possibility of tailoring carbon properties by modifying the pyrolysis process, potentially allowing to tailor the performance of the resonators; (ii) heat sensitivity with biocompatible carbon materials; (iii) carbon is a conductive material which is promising for integrated readout and actuation; and (iv) the possibility of combining many types of sensors in one chip due to the advantages of polymer fabrication. Based on these advantages, we developed several version of pyrolytic carbon resonators and used them for bio or chemical applications.

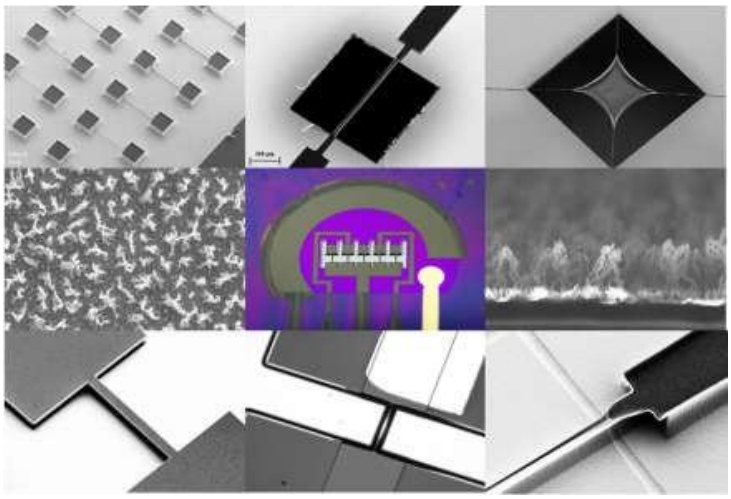

Figure 1: Pyrolytic carbon resonators and its applications.

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Biomaterial Microsystems for Electrochemical Monitoring of Cells and Oral Drug Delivery

Claudia Caviglia[1], Suhith Hemanth[1], Yasmin M. Hassan[1], Jesper Y. Pan[1], Emil Ludvigsen[1], Babak Rezaei[1], Nina Pedersen[1], Zarmeena Abid[1,2], Ritika S. Petersen[1,2], Anja Boisen[2] and Stephan S. Keller[*1]

[1]DTU Nanolab, Kgs. Lyngby, 2800, Denmark
[2]The Danish National Research Foundation and Villum Foundation's Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nano mechanics (IDUN), Kgs. Lyngby, 2800, Denmark

Fabrication of high aspect ratio three-dimensional (3D) microstructures with well-defined geometry is challenging, in particular for applications where the materials have to be biocompatible or even biodegradable. Here, we will present the latest results on the fabrication of pyrolytic carbon microelectrodes serving as intelligent cell scaffolds and of biodegradable microcontainers for oral drug delivery.

3D pyrolytic carbon microelectrodes: In bio electrochemical applications, cells are typically incubated on 2D electrodes. The major limitation of this approach is that planar electrode geometry poorly mimics the natural environment of the cells. 3D scaffolds have been developed to provide a more realistic environment for the cells but these structures usually lack integrated sensor functionality to perform in situ measurement in the 3D cell culture. Here, we address these limitations and demonstrate the in situ electrochemical analysis of the alkaline phosphatase (ALP) activity in a 3D bone tissue model with integrated electrochemical sensing using 3D pyrolytic carbon microelectrodes. For this purpose, a novel approach for patterning of multi- layered 3D electrodes was developed [1] and 3D culturing of Saos-2 osteosarcoma cells in gelatin hydrogels was established. The use of 3D electrodes resulted in approximately 2 fold increase of the electrochemical signals compared to 2D configurations. Furthermore, we present our latest fabrication of 3D electrodes combining additive manufacturing and traditional photolithography, and in direct writing of conductive carbon by laser pyrolysis.

Biodegradable drug delivery systems: In the past years, microfabricated containers were introduced as new concept for oral drug delivery. These containers are able to protect drug from degradation during transit of the gastro-intestinal tract, potentially enable one-directional drug release at the site of absorption and could thereby enhance the bioavailability of drugs. Here, we demonstrate the fabrication of biodegradable microcontainers with a novel method called hot punching [2]. The poly(caprolactone) (PCL) microcontainers were loaded with drug and coated with a polymer lid using spray coating. In vivo

evaluation of the microfabricated drug delivery devices showed an increased bioavailability compared to traditional dosage forms.

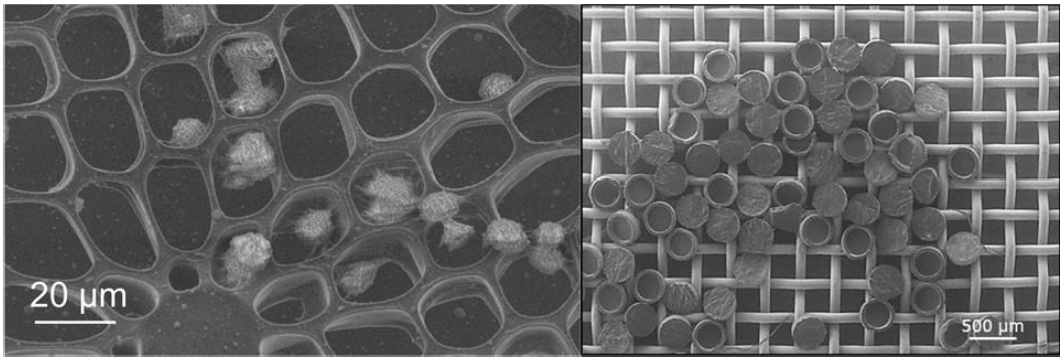

Figure 1: Left: Saos-2 cells on 3D carbon scaffold; right: PCL microcontainers for oral drug delivery

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*corresponding author: suke@dtu.dk

Large and ultrafast nonlinear response of ENZ-loaded metamaterials

Israel de León*

*School of Engineering and Sciences, Tecnológico de Monterrey, Monterrey, NL, Mexico

A key requirement for the development of modern integrated photonic devices is the ability to enable efficient nonlinear optical phenomena at the nanoscale. Promising materials to meet this requirement are plasmonic metamaterials, [1] and materials with vanishing permittivity, commonly known as epsilon-near-zero (ENZ) materials [2-4]. In this talk I discuss our recent work on the nonlinear optical response of ENZ materials and metamaterials [2,5]. We focus in particular to the case of indium-tin oxide, a transparent metal that exhibits ENZ properties at near infrared wavelengths. We show that the nonlinear response of this ENZ material can be engineered through carefully designed plasmonic two-dimensional metamaterials, allowing us to enhance significantly the strength of its nonlinear optical response and to tailor its bandwidth with great flexibility. The results discussed here suggest that plasmonic metamaterials loaded with ENZ media hold promise for developing metamaterial-based optical devices with efficient nonlinear functionality.

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Website: https://sites.google.com/itesm.mx/ideleon/home

Complex 3D Carbon Structures Generated by Stereolithography Printing Technology as Free-standing Electrodes in Electrochemistry

Tiefu Li[1,2,3]

[1] Institute of Microelectronics, Tsinghua University, Beijing 100084, China
[2] Beijing Computational Science Research Center, Beijing 100193, China
[3] National Institute for Materials Sciences, Namiki 1-1, Tsukuba, Ibaraki 305-0044, Japan

The reduction of the energy dissipation induced by defects is essential to achieve the ultrahigh-quality-factor mechanical resonators for the applications of quantum platform and high-sensitivity microelectromechanical (MEMS) and nanoelectromechanical system (NEMS) sensors. Single-crystal diamond (SCD) is the ideal material for high-quality-factor mechanical resonators due to its outstanding mechanical properties and intrinsic low-energy dissipation. To achieve mechanical resonators with extreme properties as well as high reliability, it is desirable to develop all-SCD mechanical resonators. By using a smart-cut method and atomic layer etching to remove the defects within the resonators, we achieve the SCD-on-SCD mechanical resonators with ultrahigh quality factors of over one million at room temperature. The quality factors are one or more orders of magnitude higher than those of the state-of-the-art MEMS cantilevers based on polycrystalline diamond, single-crystal silicon, and other crystal materials. The diamond MEMS resonators would be highly promising for sensor application as well as for the scheme for coupling with quantum centers in diamond.

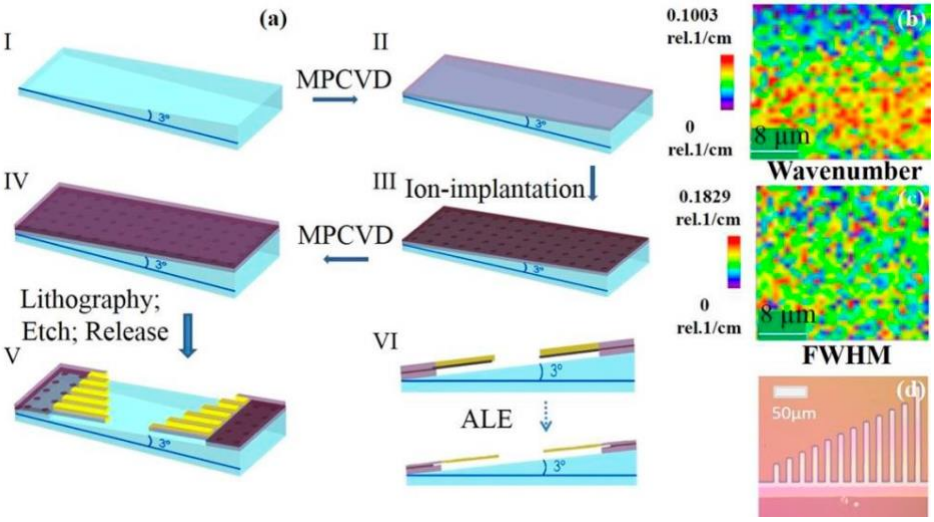

Figure 1: (a) The schematic diagram of the fabrication process of SCD cantilevers. The 2D Raman mappings of the homoepitaxial diamond film with spatial distribution of (b) wave number and (c) FWHM. (d) Optical image of the SCD cantilevers after the ALE treatment.

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*corresponding author: litf@tsinghua.edu.cn, meiyong.liao@nims.go.jp

Nano-spaced Gold on Glassy Carbon Substrate

Gaurav Chauhan[1], Marc Madou[1,2*] and Sergio O. Martinez-Chapa[1*]

[1] School of Engineering and Sciences, Tecnológico de Monterrey, Av. Eugenio Garza Sada 2501 Sur, 64849, Monterrey, NL, Mexico
[2] Department of Mechanical and Aerospace Engineering, University of California, Irvine, CA, USA

This approach involves the synthesis of gold nanoparticles (GNPs) within the carbonizing photoresist (SU8) to achieve GNPs trapped glassy carbon (GNPs-GC) substrates. Surface size distribution and interparticle separation of GNPs is primarily controlled by changing the metal precursor concentration. Chemical stability and fabrication control are achieved by selecting sodium tetrachloroaurate over a more conventional tetrachlorauric acid (HAuCl4) as the gold precursor. Seeding of gold nuclei's in a photo crosslinking polymer is a classical representation of simultaneous homogeneous and heterogeneous nucleation. GNPs growth during the carbonization process is tracked and explained using pertinent mechanisms. With the nanoparticle spacing ranging from 260nm to 50nm, GNPs-GC thin films are employed as interfaces for fibroblast cell adhesion. GNPs act as potential anchor points for cell adhesion and their nanoscale arrangement regulates the structural behavior of the cells. GNPs density- dependent fibronectin physisorption significantly improves cell adhesion and proliferation. Intraparticle spacing around 160nm offers ideal bio interface for fibroblast attachment and spreading. Fabrication of 3D GNPs composite carbon microelectromechanical systems (C-MEMS) is achieved as a demonstration of the studied GNPs-GC synthesis mechanism. Sub-micron patterning of GNPs-GC combined with its bio functional nature presents vast opportunities in the field of bioelectronics, bio photonics and lab/organ- on-a-chip technology.

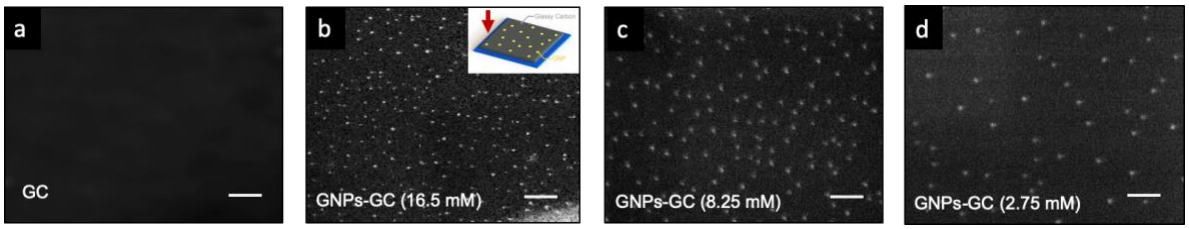

Figure 1. (a-d) High definition backscattered electron emission image of the GNPs presents on the surface of GNPs-GC (constant film thickness 1µm, 2.25cm2 surface area and exposure at 165mj/cm2) with different NaAuCl4 concentrations. Image J software is used to analyze these SEM images, scale bar = 200nm.

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gchauhan@tec.mx

Electrified-Lab-on-Disc for immunoassays – or how to organize research across the Atlantic

Mohammad Mahdi Aeinehvand[2], Fabian Soto[2], Sarai Torres[1], Laura Weber[1], Martín Jiménez[2], Jan Korvink[1], Sergio O. Martínez-Chapa[2], Marc Madou[2] and Dario Mager[*1]

1 Institute of Microstructure Technology, Karlsruhe Institute of Technology, Germany
2 Tecnológico de Monterrey, Monterrey, 64849, Mexico

About 3 years ago a group from the Tecnológico de Monterrey (Tec) and a group from Karlsruhe Institute of Technology (KIT) started to collaborate in the areas of carbon fabrication and microfluidic diagnostic. In this presentation we would like to show the results achieved in this long-distance collaboration that led to two publications in high impact international journals about using electrified-Lab-on-a-Disc (eLoaD) [1] and the pyrolysis of 3D printed nano structures [2]. Due to the scope of the conference and the interactions needed to achieve the paper we are going to focus on the on the eLoaD paper [1].
For the paper three expertise were combined to obtain the novel results. On the KIT side the peptide array group designed a immunoassay chip and a fluidic protocol that made possible to integrate it into the concept of centrifugal microfluidics. The Monterrey team joint with their broad knowledge on LoaD design with advanced valving concepts, while a second group at KIT that had developed an electrified Lab-on-a- Disc system was integrated to pave the way for a later full automation of the process.
Besides the pure scientific results, a focus of the talk will also be on the boundary conditions of the research like the funding situation for the collaboration and the time frame in which it did take place. The idea of the presentation is besides conveying a scientific result also to show the advantages and challenges of such a long-distance collaboration. Which is not only valuable on the scientific side, as the two papers prove, but is also very rewarding on the human and cultural level.

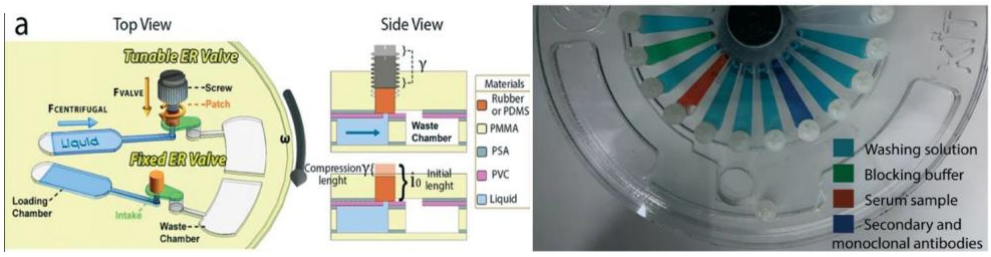

Figure 1: a) Concept of the implemented elastic reversible (ER) valves, both with a fixed and a tunable pressure. b) show the implementation of various tunable ER valves on the disc with the fluids involved in the experiment. (Images reprinted from (1))
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*corresponding author: dario.mager@kit.edu

Advances in CD-Microfluidics at Tec de Monterrey

M.Mahdi Aeinehvand*, Marc J. Madou* and Sergio Omar Martinez-Chapa*

School of Engineering and Sciences, Tecnológico de Monterrey, Monterrey, Mexico

CD microfluidic group at Tec de Monterrey started its activity in October 2016 by introducing a point of need CD fabrication technology using only a portable cutter plotter [1]. The technique allowed for the fabrication of CD microfluidic prototypes made of thin plastic films and double-sided adhesive. As an early prototype for proof of concept, we design a fluidic CD for automated blood typing assay from finger prick. To further enhance the flexibility of the technology to enable the automation of more complex assays, we invented a mechanical valve (M-valve) that could be engraved during disc manufacture itself by the cutter plotter. We then designed two microfluidic cartridges with a series of M-valves for the automation of immunoassay and chromatography fluidic protocols. Once the CD fabrication protocol was established, with help of our collaborator at San Jose Hospital we decided to tackle a health issue relevant to Mexican community. Víctor Lara research group has recently corelated the level sTREM-1 biomarker in neonatal patient blood serum to the stage of sepsis e.g., early stages and septic shock at late stages [2]. In this regard, we investigated the use of CD microfluidic technology for enabling rapid and automated sTREM-1 immunoassay at point-of-care (POC) [3]. We implemented an aluminum layer on the disc to develop a new active valving mechanism to automate the immunoassay fluidic steps as well as to protect the photosensitive reagents from exposure to the ambient light. To reduce the assay incubation periods, we developed the magneto-balloon mixing technique for reciprocating sample and reagents in the bioreaction chamber. The automated lab-on-a-disc system with a mobile phone camera allowed for the prediction of septic shock in 75 minutes, while the same sTREM-1 immunoassay in a conventional lab required 5 hours. Many viral infections present similar symptoms such as fever, diarrhea, fatigue, muscle aches and coughing, and therefore doctors usually prescribe the analysis of several biomarkers in a patient body fluidic. To comply with this requirement, in collaboration with Dario Mäger group at KIT, we designed a new microfluidic CD for the automation of immunoassay based on peptide microarray technology which enables the analysis of several biomarkers from single sample [4]. To automate the bioassay with peptide microarrays, we developed a reversible valve that enabled step-by-step incubation of a sample and eleven reagents in a bioreaction chamber. The disc was equipped with micro balloons [5], for an efficient incubation of solutions and washing of the peptide microarray. The automated CD with integrated peptide microarray allowed for the detection of five different biomarkers from a single serum sample. Another ongoing activities of CD microfluidic group at the Tec de Monterrey includes the development of an origami CD fabrication protocol for low mass manufacturing and rapid prototyping of CDs, investigating the effect of centrifugal force on the direction of CaCo-2 cell growth, rapid cancer drug testing, and mechanical characterization of thin film biomaterials on a spinning disc.

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*corresponding authors: m.aeinehvand@tec.mx, mmadou@uci.edu, smart@tec.mx

Carbon-MEMS Hydro-Electro kinetic Platforms for Manipulation of Bioparticles and Droplets

Laura Oropeza Ramos*

Facultad de Ingeniería, Universidad Nacional Autónoma de México, CDMX, 04510 México

The development of miniaturization science and technology has propelled a plethora of possible applications. These devices allow the integration of miniaturized components that realize biochemical process as well as biomedical diagnostics. Furthermore, this technology represents the possibility to improve the sensitivity, specificity and the response time, which are some of the key components in BIO (biological, biomedical and biochemical) analysis (1).
In particular, the coincidence in scales it is important to achieve efficient transfers of momentum and energy in the fluids and micro-entities motion control. Most of these entities that are of biological interest, like ADN, proteins and cells, and/or the compartmentalization of these entities inside micro droplets to miniaturize even more a bioreactor, have a characteristic scale of nano and micrometers. In the other side, the electrokinetics is especially effective in this domain due to the dominant surface/volume forces ratio (2).
In this talk I will present the developments on micro-platforms for droplets and bio-particles manipulation achieved in the BioMEMS and Lab on a Chip Laboratory at the Engineering School of the National University of Mexico, UNAM in the last four years, including our more recent results on Carbon-MEMS fabrication devices.

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*corresponding author: loropeza@unam.mx

3D Positioning of Spherical Microparticles Suspended inside a Confined Microvolume using Dielectrophoretic Forces induced by a C-MEMS Microelectrode Array

Oscar Pilloni[1], Laura Oropeza-Ramos[*2]

[1]Instituto de Ingeniería, Universidad Nacional Autónoma de México, C.P. 04510, CDMX, México.
[2]Facultad de Ingeniería, Universidad Nacional Autónoma de México, C.P. 04510, CDMX, México.

Microparticle manipulation enables the ability to move target particles into specific positions where they can be aggregated in bigger structures, tested for specific purposes or inspected to better understand their nature. Micromanipulation can be achieved by mechanical, optical and electrokinetic means. While there are advantages and drawbacks for each strategy, electrokinetics remains as a very versatile micromanipulation technique because of its easy miniaturization and integration in MEMS devices. Particularly, dielectrophoresis phenomena is useful for the manipulation of microparticles that do not exhibit an electric charge, such as bioparticles. On the other hand, an emerging technology known as carbon- based MEMS (C-MEMS) has become popular because it allows the fabrication of microstructures that possess the advantageous properties of carbon, a straightforward fabrication procedure and allow an accessible approach to produce high aspect ratio features.
We present the results of an on-going work that aims to combine C-MEMS technology with dielectrophoretic micromanipulation to build a micro device that allows the precise positioning of target bioparticles suspended inside a microvolume. The microvolume is physically delimited by an array of carbon microelectrodes that combines planar and extruded features. The microelectrodes were designed to be individually addressable, which allows for individual selection of electric potential and array configurations to exert a dielectrophoretic force onto a target microparticle, inducing movement in any selected direction inside the microvolume, enabling 3D positioning of the microparticle inside it.
While we show that 3D micromanipulation inside a microvolume is achievable with this approach, more work is needed to further increase the precision and automatization of the envisioned micro device.

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*corresponding author: loropeza@unam.mx loropeza@unam.mx

Lab on a Chip- Microfluidic Devices

The use of correction factors in modelling iDEP-based particle trapping

Braulio Cardenas-Benitez,[1] Binny Jind,[1] Roberto C. Gallo-Villanueva,[1] Blanca H. Lapizco-Encinas,[2] Sergio O. Martinez-Chapa,[1] and Víctor H. Pérez-González*[1]

[1]Tecnológico de Monterrey, Escuela de Ingeniería y Ciencias, Ave. Eugenio Garza Sada 2501, Monterrey, N.L., México, 64849
[2]Microscale Bioseparations Laboratory, Rochester Institute of Technology, Rochester, New York 14623, United States

Dielectrophoresis (DEP), the force acting on a polarizable particle due to a non-uniform electric field, has become a widely used technique to manipulate samples in microfluidics [1]. The non-uniform electric field, necessary for DEP to take place, can be generated either using embedded electrodes or insulating structures within the microfluidic device. The insulator-based approach is known as insulator-based dielectrophoresis (iDEP) and has many attractive advantages over the electrode-based approach (e.g., lower fabrication cost, time and complexity). iDEP has been extensively used to trap, separate, transport, and characterize a wide range of particles [2]. From these, particle trapping is by far the most explored application of iDEP in the literature. Computational models have been developed to either explain or predict experimental outcomes. However, a correction factor has been proven to be necessary for the model to provide an accurate description or prediction [3]. This correction factor c takes values in the range $1 < c < \sim 600$. This indicates a mismatch between the experimental outcome and the predicted response of the iDEP-based microfluidic device that can be almost as significant as three orders of magnitude. In this work we aim to unveil the meaning of this correction factor, providing, in this way, a new perspective on analysis of the interrelation between electrokinetic phenomena involved in iDEP-based microfluidics.

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Exosome Classification by Size using Insulator-based Dielectrophoresis

Sergio Ayala-Mar, Victor H. Perez-Gonzalez, Marco A. Mata-Gómez, Roberto C. Gallo-Villanueva and José González-Valdez

Tecnológico de Monterrey, Escuela de Ingeniería y Ciencias, Ave. Eugenio Garza Sada 2501, Monterrey, N.L., México, 64849

Exosomes are a recently described subpopulation of extracellular vesicles that have gained interest due to their many potential biomedical applications. Nonetheless, exosome isolation remains a challenge that requires innovative strategies to overcome several hurdles. In this work, exosomes were separated employing insulator-based dielectrophoresis in a microfluidic device. Because of a size distribution within an exosome population, our device was able to separate an exosome sample with an average particle size of 100 nm in two fractions with an average particle size of 40 nm and 80 nm, respectively. In this way, our device was able to simultaneously isolate and separate exosomes by size in less than a minute. These results are ominous, as the separation of exosomes by size opens the door to further study the physiological role of these vesicles and to find them the most suitable applications.

Double Emulsion Generation Using Centrifugal Microfluidic Platforms

Masoud Madadelahi[1], Marc J Madou[1,2], Yeganeh Dorri Nokoorani[3], Amir Shamloo[3], and Sergio O Martinez-Chapa[*1]

[1] School of Engineering and Science, Tecnológico de Monterrey, Mexico
[2] Department of Mechanical and Aerospace Engineering, University of California Irvine, USA
[3] Department of Mechanical Engineering, Sharif University of Technology, Iran

We introduce a new method of double emulsion generation on centrifugal microfluidic platforms or Lab-On-a-Discs (LODs). Double emulsions are applicable for different biological and chemical purposes like cell encapsulation and digital gene amplification. There are some researches related to single emulsion generation on a disc; Schuler et al. (2016) used a system of droplet generation for doing digital gene amplification on a centrifugal microfluidic device. We broadened this concept to multiple emulsion generation on a disc. In this way, after numerical simulations, an LOD device is designed, including stratified fluids in a way that the generated droplets can pass through different fluids with specific densities. This device is fabricated using four layers of acrylic plate and three layers of adhesives. At the first step, single emulsions are generated within this device, and the important parameters like water droplets' size and generation time of droplets are measured in three rotational frequencies of 10HZ, 15HZ and 20HZ. It is concluded that the best concentration of Span-80 as the surfactant for the stability of droplets, is 0.5% (w/w). In the next step, using the presented method, water droplets (water-phase1) are passed through an oil reservoir and then immediately entered into another water-phase fluid (water-phase2). In this way, water-in-oil-in-water emulsions are captured in the centrifugal microfluidic platform. For the evaluation of the significant differences between samples, one-way Analysis of Variance (ANOVA) is utilized, followed by Tukey's Honestly Significant Difference (HSD) post hoc test and $p<.05$ is considered as the statistically significant criteria. It is concluded that in general, the higher rotational frequency, the smaller droplets due to the higher centrifugal force detaching smaller columns of water-phase1 fluid. The statistical investigation confirmed that between the examined frequencies, the frequency of 20HZ makes significantly smaller droplets in comparison with frequencies of 10 and 15HZ ($p<.05$). Nevertheless, no evidence of a significant difference between frequencies of 10 and 15HZ was observed ($p>.05$). Furthermore, according to the standard errors, it was found that the higher the rotational frequency, the less uniform the droplets are. This is due to the instability of water-phase1 fluid at high rotational speeds. The reason is low viscosity of this fluid, which causes the detachment of non-uniform volumes of the dispersed phase liquid. It was also concluded that by increasing the rotational speed, the time needed to generate droplets significantly decreases ($p<0.05$) in a way that increasing the rotational frequency from 10HZ to 20HZ, leads to time decreasing from 0.22s to 0.02s for producing each double emulsion droplet. In addition to experimentally analyzed data, many other parameters including droplets velocity and trajectory are calculated by numerical simulations to characterize this method as much as possible. It is seen that both density and viscosity play important roles in this method. In the next steps, we are going to use this method for generating microspheres which are applicable in a wide variety of disciplines such as drug-delivery, single cell encapsulation and digital PCR.

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*corresponding author: smart@tec.mx

Health
for the Billions

Affordable Technologies

Summary of previous event & Advances in Affordable Technologies “Health Care for the Billions”

Sergio O. Martínez*

*School of Engineering and Sciences, Tecnológico de Monterrey, Monterrey, Mexico

During March 2019, we organized a workshop in Mexico City with the participation of 25 researchers from the School of Engineering and Sciences and the School of Medicine of Tecnológico de Monterrey. Considering the pioneering work Dr. Satadal Saha was doing in India envisioning a new model to provide basic health care to rural communities, we invited him to give a plenary talk in our event. After individual presentations from the attendants in both available technologies and needs of the health sector, we defined as set of topics that matched novelty, needs and skills in our group. Among these topics, we have CD-Microfluidics for the extreme point of care, biosensors for systems medicine, tissue bioengineering and Organ on a Chip. A particular idea suggested by Dr. Saha at a higher abstraction level was discarded at the beginning but took relevance at the end of the meeting. Dr. Saha called his idea "Health for a Billion". This idea was not only a framework for the rest of the ideas but served as the inspiration for this new workshop. A slight change was introduced considering there is in fact a billion people in India but several billion people in the rest of the world demanding more affordable technologies. Health for the Billions is intended to promote the creation of quite interdisciplinary groups aimed to develop inexpensive technologies for the health care. Some advances in this direction will be presented in this meeting.

Training-Technology-Entrepreneurship: is this the right combination?

Satadal Saha[1,2,3]

[1]Founder & Mentor, JSV Innovations Private Limited
[2]Visiting Professor, School of Medical Science & Technology, IIT Kharagpur
[3]Project Director, Dr B C Roy Super-specialty Hospital, IIT Kharagpur

Almost 50% of the global population, 3.74 billion, live in a state of inadequate access to basic primary care and outside the umbrella of public health measures. Lack of healthcare and health education lead to accumulation of disease, resulting in loss of societal productivity and forced seeking of high-cost secondary and tertiary healthcare. 100 million people choose between food and medicine everyday around the world. In India alone, 39 million fall below poverty line every year due to healthcare-related expenses.

Governments across the world are trying to address the problem. But given the extreme shortage of doctors and other health workers, absence of theranostic technologies that work optimally in resource-poor environment, paucity of resources, wide and varying geographies, supply-chain constraints government efforts are both too little and not very effective. There is now realization among stakeholders that digital healthcare delivery is the only way forward. It is now our responsibility to come forward and lift the people out of this morass; everyone has a role to play – basic sciences, engineering, medical, economists and sociologists.

In India, our team have been working on a model for last four (4) years. This was conceptualized after thorough evaluation of others' efforts in India between 2013 & 2015 and understanding the 'gaps' that did not allow the models to scale and sustain economically.

Our model involves structured training of rural youth (middle school drop-outs) as 'Health Workers' in a government accredited system; enabling them with innovative software and affordable 'Extreme-point-of-care' diagnostic technologies; encouraging them in an enterprise model and connecting them with formal doctors at distant locations. They deliver primary care to the local rural population including home care, undertake public health measures and function as the 'Health hub' for the community. This is supported by both state and central governments and is in line with the 'National Digital Health Policy 2017' of Government of India.

Prof. (Dr.) Saha's talk revolves round sharing the experience of implementing such a large-scale project in India.

Microbe Identification and Antibiotic Resistance Testing

Marc Madou*

Chancellor's Professor Mechanical & Aerospace Engineering and Biomedical Engineering
University of California

Antibiotic resistance (AR) has become a severe, global healthcare crisis. If the current trend in AR is not averted, it is speculated that by 2050, AR could kill up to 10 million people and cost the world up to $100 trillion per year. What is causing this global crisis? According to a 2013 report by the CDC, “The use of antibiotics is the single most important factor leading to antibiotic resistance around the world. Antibiotics are among the most commonly prescribed drugs used in human medicine. However, up to 50% of antibiotics prescribed are not needed or are not optimally effective as prescribed”. Traditional clinical bacterial identification (ID) and antibiotic susceptibility testing (AST) take 24-72 hours to yield a result, forcing doctors to prescribe antibiotics using “best guess” methods. This has led to prescription of unnecessary or incorrect antibiotics, resulting in ineffective treatment while accelerating the rate of developed AR.

To combat this crisis, our team is developing an affordable, point-of-care device that decentralizes the traditional ID and AST tests, identifying bacteria in a patient sample in under 30 minutes and determining the most effective antibiotic for that patient in under 3 hours. By the time a patient leaves their doctor’s office and heads to the pharmacy, the correct antibiotic prescription is waiting for them, saving time and money for the hospital, the doctors, and you, while mitigating ineffective antibiotic treatment for future generations.

The CD-Microfluidics Platform for Water Monitoring in EPOC (Martínez-Madou's group)

Sergio Omar Martinez-Chapa*, Gaurav Chauhan, M.Mahdi Aeinehvand, Martín Francisco Jiménez, Binny Jind and Marc J. Madou*

*School of Engineering and Sciences, Tecnológico de Monterrey, Monterrey, Mexico

Heavy metal is a toxic element recognized by WHO as one the major global concerns for public health. It is ubiquitous in groundwater systems of many countries (e.g. India, Mexico, Argentina, Bangladesh, China) due to soil composition and aquifer overexploitation. Additionally, unchecked mining operations and industrial waste management has led to contamination of rivers systems, which has afflicted general public health. In the Mexican context, diverse studies correlate the high levels of Arsenic in drinking waters to chronic conditions of neurological, immunological, genotoxic, cardiac and renal nature, affecting 0.5 6 million Mexican children from under-resourced communities. In the Indian context, more than four crore people in rural India drink water contaminated by heavy metals, fluoride, arsenic, and nitrate. West Bengal is the worst-affected with 39 per cent of India's affected population living in that State. Punjab is the worst affected when it comes to heavy metal contamination with 22 lakh people dependent on metal-contaminated water. To provide opportune risk management to regulatory agencies, it is imperative to shift the paradigm in water analysis. Instead of bringing samples to the central laboratory, it is required to mobilize the monitoring tools to the source of problem. To do so, instrumentation requires to fulfill different criteria: to perform on-the-spot with a sample to answer focus while being affordable and portable. We propose a solution by harnessing the advantages of lab on a CD and electroanalysis technologies, to bring the power of water quality monitoring to the inspector. This portable lab-on-a-CD is a self-operated device that allows the swift assessment of arsenic content right next their source, reducing or even eliminating the sample storage footprint. Moreover, the lab-on-a-CD enables the recording of the test locations and transferring of the results to a databank for quality improvement outcomes. Its integration with electrochemical detection principles allows for a wide toolbox of surface sensitive techniques for detection while keeping the readout hardware simple and low-cost.

Photochemical ROS modulation for enhanced wound healing and tissue bonding

Constanza Alvarez[1,3], Alan Aguirre-Soto[1,2,3]

[1]Nanotechnology Graduate Program, School of Engineering and Science, Tecnologico de Monterrey, Monterrey, Nuevo Leon, Mexico, 64849.
[2]Department of Chemical Engineering, School of Engineering and Science, Tecnologico de Monterrey, Monterrey, Nuevo Leon, Mexico, 64849.
[3]Nanosensors and devices Research Group, School of Engineering and Science, Tecnologico de Monterrey, Monterrey, Nuevo Leon, Mexico, 64849.

Photochemical Tissue Bonding (PTB) was developed in 2001 as a new alternative method to close wounds and surgical incisions using Rose Bengal (RB) as a pigment and a source of green light. Since then, it has shown that it leads to less inflammation and scaring during the healing process in human skin. It was demonstrated that it has good cell cytocompatibility. This technique has been used for the bonding of collagenous tissue of several structures: nerves, skin, cornea, colon, etc. When collagenous tissue is bonded with this method, a water-tight seal has been achieved. Despite these advances in proving that this alternative therapy bonds collagenous tissue and provides some advantages, it is yet unclear how two tissue surfaces are bonded when the pigmented area is exposed to the light. Therefore, it still appears to be a long way to get this wound closure method to be implemented. Furthermore, the technique requires substantial amounts of visible-light radiation to bond the tissue and achieve practically relevant bonding. The clue to overcome these obstacles lies in better understanding the photochemical reactions that take place in-tissue. While a lot is known about the photochemistry and photophysics of Rose Bengal in solution and bound to amino acids, the precise reaction pathway when RB is irradiated in its nucleated and heavily aggregated state is yet elusive. In this work, we aim at providing a better understanding of how RB bonds collagenous tissue when irradiated. We discuss the different possible pathways that may lead to crosslinking of collagen fibrils in the presence and absence of cells. We present an experimental framework to investigate the structural variations in collagen crosslinking as a result of PTB. With this work we hope to contribute to the betterment of the PTB therapies so that this alternative is brought closer to implementation.

Perspectives on selected Dielectrophoresis platforms for selective Bioparticle Manipulation in Sample Preparation

Rodrigo Martinez-Duarte*

Multiscale Manufacturing Laboratory, Department of Mechanical Engineering
Clemson University, USA

Dielectrophoresis (DEP) is a well-known technique for the spatiotemporal manipulation of targeted cells and microorganisms. In this talk I will present perspectives on selected DEP platforms used for bioparticle study, separation and manipulation in the context of healthcare applications. These platforms include 1) 3D carbon-electrode DEP to increase throughput and efficiency of DEP devices; 2) integration of DEP with centrifugal microfluidics (spinDEP) towards point-of-care devices; 3) the integration of DEP with a robotic system (roboDEP) to implement automated transfer of selected particles akin to liquid handling robots; and 4) the use of light-induced DEP (LIDEP) for cell analysis.

*corresponding author webpage: www.multiscalemanufacturing.net

Triborheological Study of Biomaterials

Medina D.I.[a,b], McKinley G.H.[b]

[a] Tecnológico de Monterrey, School of Engineering and Sciences, Atizapan de Zaragoza, Estado de Mexico 52926, Mexico
[b] Hatsopoulos Microfluids Laboratory, Department of Mechanical Engineering, Massachusetts Institute of Technology, Cambridge, MA, USA

This research is concerned with the triborheological study of skin surfaces with special significance on the measurement of coefficient of friction at different angular velocities and pressures. The study includes different types of skin which in different fields and applications are used to mimic and/or replace human skin. Skin substitutes demand structural and mechanical features for optimal performance which are directly associated with the surface properties. We propose to obtain an insight into the fluid dynamics of different solid/liquid systems such as skin simulant and substitutes / fluids.
In this way we can monitor the response of coefficient of friction with levels of hydration in the skin. Also, the dependence of angular velocities and pressure over the skin with the triborheometer.

Cost-effective bioprinting & tumor-on-chip technologies for the democratization of cancer-research.

Mario Moisés Álvarez[1,2] and Grissel Trujillo-de Santiago[1,2,3]

[1] Centro de Biotecnología- FEMSA, Escuela de Ingeniería y Ciencias, Tecnologico de Monterrey, Monterrey, 64849, Mexico
[2] Departamento de Bioingeniería, Tecnologico de Monterrey, CP, Monterrey, Nuevo Leon, Mexico
[3] Departamento de Mecatrónica, Tecnologico de Monterrey, CP, Monterrey, Nuevo Leon, Mexico

Cancer continues to be a leading cause of mortality in modern societies, so improved and more reliable *in vitro* cancer models are needed to expedite fundamental cancer research and anti-cancer drug development.
We aim to democratize cancer research by developing and combining “open-source” and easy to use bioprinting of cancerous tissues and tumor-on-chip platforms (the integration of tumor culture technologies in microfluidic platforms). We pursue (a) the development of flexible, user friendly, and portable cancer-on-chip systems capable of enabling high level cancer research in practically any biology or Medicine laboratory; (b) the development of multi-material bioprinting strategies and research protocols to fabricate, culture for extended time periods, and analyze relevant cancer tissues (v.gr. bioprinting methodologies to fabricate tumorous tissue, protocols for continuous perfusion in cancer-on-chip platforms, and the methodologies to analyze the genetic expression and overall biological behavior of solid tumors grown in vitro).
Here we introduce our first functional bioprinters and cancer-on-chip platforms and discuss our results on the development of functional 3D cancer models to test pharmacological compounds.
Combined, cancer-on-chip technologies will allow us to conduct cancer research at a level of complexity and relevance that is not currently achievable by other means. Moreover, user friendly and cost-efficient bioprinting & cancer-on-chip systems will help us to intensify and democratize cancer research.

Parallel Session-1

Microfluidics and Lab on a Chip

Microfluidics and Lab on a Chip

Microfluidic generation of lipid-stabilized droplets as artificial cell models

Ricardo García-Ramírez[1], Katherine E.E. Ramsay[2], Sergio Camacho-León[1*] and Katherine S. Elvira[2*]

[1] School of Engineering and Sciences, Tecnológico de Monterrey, Nuevo Leon, 64830, Mexico
[2] Department of Chemistry, University of Victoria, British Columbia, V8P 5C2, Canada

In recent years, there has been a growing interest in the engineering of artificial biomimetic structures from the bottom-up. The design of these lipid-based constructs could potentially arise several applications, including the development of microreactors, artificial cells, simplified cell models, and drug delivery vehicles. These artificial cell models are made by encapsulated lipid membranes and can mimic relevant biological interactions within them [1]. Several microfluidic strategies for the generation of compartmentalized systems based on lipid membranes as the basic structure have been used, nevertheless droplet microfluidics has been a major tool for the generation of these structures since it allows a rapid scale-up in generation throughput, scale-down of size, and a predicable control in monodispersity [2]. The main goal of this work is to generate lipid-stabilized droplets based upon microfluidics, which facilitates the controlled and high- throughput generation of stable and monodisperse droplets using biologically relevant phospholipids. In order to determine the best conditions for the generation of droplets in a specific geometry, a numerical analysis was performed based on the current physical models for droplet generation and breakup. Based on the numerical analysis, boundary conditions were stablished for the flow rates in a flow focusing device (FFD) junction for both the continuous and disperse phases. These boundary conditions were tested in a computational fluid dynamics (CFD) simulation to validate the design and conditions in a time-dependent study. Droplets were successfully generated in such simulations, but certain flow rates were found to be a more efficient combination for droplet generation. A microfluidic device with the proposed geometry was fabricated using standard soft lithography techniques. The polydimethylsiloxane (PDMS) replicas were bonded with a glass slide covered with PDMS and sealed using a plasma cleaner. The surface chemistry of the microfluidic device was selectively patterned, enabling the production of compartmentalized lipid structures as artificial cell models in W/O/W emulsions. Finally, the proposed conditions were tested in a microfluidic device and results were compared with the simulations. It is reported the production of droplets of phosphate buffer (10 mg/mL dipalmitoyl phosphatidylcholine), squalene, and water (14% v/v glycerol) as W/O/W emulsions. These devices have shown a high potential in applications such as the gradual release of pharmaceuticals, the engineering of vesicles for drug delivery, and the design of artificial biomimetic structures. Thus, being an initial step towards the development of a fully functional artificial cell system.

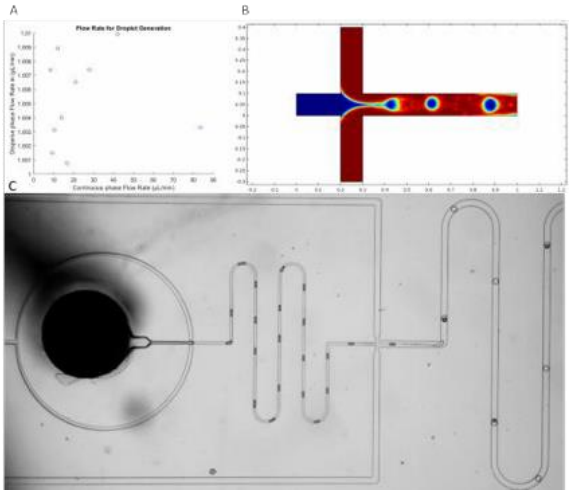

Figure 1. A) Calculated boundary conditions for the flow rates. B) CFD simulation of the boundary conditions in a FFD junction. C) Microfluidic device showing the production of W/O/W emulsions.

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*corresponding authors: kelvira@uvic.ca; sergio.camacho@tec.mx

Microfluidics and Lab on a Chip

Origami CD Fabrication Protocol

Ana Cristina Corona-Garza, Beatriz Alejandra Bosques-Palomo, Flor Helena Valencia, Marc Madou and Sergio Omar Martínez-Chapa, M. Mahdi Aeinehvand*

School of Engineering and Sciences, Nanosensors and Devices, Tecnológico de Monterrey, Monterrey, Mexico

We are presenting an origami CD microfluidic fabrication protocol for R&D purposes that is fast (one new design can be produced within thirty minutes), produces very small amounts of waste material (< 0.4 gram per disc) and requires only a computer a simple portable plotter and a laminating machine. The origami CDs are made of laminating pouches, a single widely available material. This approach obviates the need for double sided adhesive layers and therefore the tedious adhesive-plastic alignment steps [1-2]. The pouches are composed of a transparent PET and a EVA (hot-glue) layer that are weakly attached to each (see Figure 1.a). Taking advantage of this feature, we adjust the cutting-pressure of the plotter's blade, so we cut and remove either only the EVA layer (for microchannels and chambers) or the entire PET-EVA layer (for vent holes and the disc inner and outer rims). This approach is akin to the one used in origami microfluidics based on paper [3]. Because the CD layers are made of one type of material only, the disc layers are tightly integrated and fabricated in a single laminating pouch and aligned easily using origami protocols (see Figure 1.b). Once the layers are folded and aligned (origami protocol) they are passed through a laminating machine (see Figure 1.c). The resulting platform, fabricated in 15 to 30 minutes, consists of a transparent origami CD, costs less than 1 Mexican peso (about 5cents) and is as light as 3 grams (see Figure 1.d). Adjusting the blade pressure also allows for engraving lines on the laminating pouch inner surfaces of microchannels for 3D mixing. It should be noted that this origami protocol is generic and can also be used for the fabrication of lab-on-a-chip devices. Moreover, the heat during the laminating process helps with the sterilization of the chambers and channels. In general, the origami CD can be developed rapidly at different point of need locations (e.g. in remote hospitals, on ships, in space, war zones) and is very affordable, as the entire equipment used can be purchased for less than 200 USD.

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*corresponding author: m.aeinehvand@tec.mx

A Reactor-on-a-Chip for Cost-effective Synthesis of Gold Nanoparticles

J. Eric Ortiz-Castillo,[1] Matías Vázquez Piñón,[1] and Víctor H. Pérez-González[*1]

[1]Tecnológico de Monterrey, Escuela de Ingeniería y Ciencias, Ave. Eugenio Garza Sada 2501, Monterrey, N.L., México, 64849

Microfluidics studies the manipulation of fluids at the microscale [1]. Due to relevant intrinsic characteristics of microfluidic systems, such as low reagent volumes, short processing times, and high surface area to volume ratios [2], this research field has helped to find reliable and cost-effective solutions in different areas, including analytical chemistry [3], energy harvesting [4], cell separations [5], and molecular biology [6]. For the particular case of life sciences, the so-called Lap-On-A-Chip concept has revolutionized the way of processing chemical and biological analysis [7], drug discovery [8], clinical diagnosis [9], material's synthesis [10], environmental monitoring [10], among many other relevant applications [11]. For the case of synthesis of metal nanoparticles for their use in chemical catalysis [12] or molecular detection [13], the use of microreactors has several advantages, e.g., the excellent control over reagent mixing [14]. In this sense, microfluidic devices with different channel geometries have been used as microreactors, being the serpentine channel network the most widely employed design for diffusive mixing due to wide channel longitudes in small die areas. In addition, microfluidic reactors allow higher synthetic control at the molecular level [15]. In this work, a novel microreactor was designed by carrying out a finite element analysis through COMSOL Multiphysics to find the mixing velocity profile with different voltages. Then, the designed device was fabricated following the proper microfabrication techniques—such as photolithography and soft-lithography—and experimentally tested to find its velocity profile and mixing efficiency. Gold nanoparticles were then produced using the device at different mixing conditions, and the results were characterized by spectroscopic means to obtain the size distribution and morphological nature (isotropic or anisotropic nanoparticles). With this, we aim to present a green chemical approach of a microfluidic reactor for the synthesis of gold nanoparticles. We believe that this will contribute to avoid wasting reactants and optimizing the reactant mixing process by the implementation electrokinetic actuation.

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*Corresponding author: vhpg@tec.mx

Implementation of wireless-controlled electrolysis pump for automation of bioanalytical assays on Lab on a Disc

Fabian Oswaldo Romero Soto[1], MohammadMahdi Aeinehvand[1], Martin Francisco Jimenez Moreno[1], Laura Weber[2], Dario Mager[2], Marc Madou[1] and Sergio Omar Martinez-Chapa[1,*]

[1] Tecnologico de Monterrey (ITESM), Monterrey, 64849, Mexico
[2] Karlsruhe Institute of Technology, Karlsruhe, 76131, Germany

The centrifugal microfluidics platforms or “Lab-on-a-Disc” (LoaD) have proven in the last years as an instrument useful for miniaturization and multiplexing analytical assays in low costs on fabrication, consumables and equipment. The previous features, as well as user-friendly, are critical for devices dedicated to Point of care (POC) applications. This leads to ease the automation of the LoaD platforms for tests that requires multiple time-consuming steps such as immunoassays. However, the unidirectional nature of the centrifugal force to displace the liquid radially outward of the CD can complicate the footprint design for the assay. Micropumps are implemented on microfluidic discs to move liquid against the direction of centrifugal force, enabling the integration of complex sequential fluidic steps. Noroozi et al. reported the implementation of electrolysis pump on CD to create pressure to push liquid inwardly because of the accumulation of gases separated during electrolysis of water (1). To eliminate the use of bulky equipment (e.g. slip rings) to electrical supply for POC setting, an electrified Lab on a Disc (eLoaD) circuit is used to provide wireless powering to the CD. The eLoaD circuit enables data transmission via Bluetooth to control actuators, simplifying the user control and automation in the platform (2).

We developed a complete LoaD system that controls multiple electrolysis pumps wirelessly to displace various liquid volumes from different parts of the CD in determined steps of an assay. As well, we explored the use of the electrolysis pump to deliver fixed liquid volumes coming from the same chamber analogous to the “metering” feature in microfluidics platform. The electrolysis pump is able of moving volume range from 10 µL to 150 µL and flow rate from 71.2 nL/s to 431.2 nL/s while only requiring a maximum power of 25mW per pump. As application, the CD system was used for immunoassay test on peptides microarrays to detect the presence of monoclonal anti-Hemagglutinin (HA) on 50 µL of sample. The microarray used on CD had a positive response to the presence of HA, although the fluorescence intensity was lower than the control microarray done in conventional way. It is expected to improve the intensity by better implementation mixing sections on the spinning protocol. The use of wireless electrolysis pumps can ease and simplify large number of sequential fluidic steps for more complex bioanalytical assays.

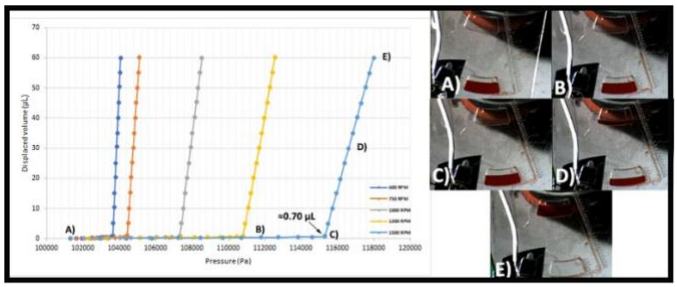

Figure 1: Displacement of 60 µL of sample volume on different rotational speed to create low flow rate for precise sample delivery. A) The sample volume is kept on the first chamber because of centrifugal pressure. B) and C) The accumulation of gases by the electrolysis pump pushes the sample through the syphon channel connected to a second chamber. D) The sample arrives to the second chamber, being the pump activated until all the liquid is displaced.

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*corresponding author: smart@itesm.mx

Parallel Session-2

Nanotechnologies in Life Sciences

G4-PAMAM dendrimer-HIV Peptide Complexes using Three-Dimensional Models of HIV-1 GP120 Glycoprotein

Rolando Alberto Rodríguez-Fonseca[1,*] Martiniano Bello Ramírez[1] , José Correo Basurto[1] and María Angeles Muñoz Fernández[2]

[1] Escuela Superior de Medicina, Instituto Politécnico Nacional, Mexico City, Mexico
[2] Hospital General Universitario Gregorio Marañón, Madrid, Spain

Peptide epitopes have been widely used to develop synthetic vaccines and immunotherapies. However, peptide epitopes may exhibit poor absorption or immunogenicity due to their low molecular weights. Conversely, fourth generation polyamidoamine (G4-PAMAM) dendrimers are non-immunogenic and relatively nontoxic synthetic nanoparticles that have been used as adjuvants and nanocarriers of proteins [1]. We hypothesized that the combination of intranasal immunization and G4-PAMAM dendrimers would be useful for enhancing the antibody responses of HIV-1 gp120 peptide epitopes. Therefore, we first used structural data, peptide epitope predictors diffusion ligand molecular dynamic simulations, calculations od energetic contributions by MMGBSA method figure 1) to identify two peptide epitopes on the CD4 binding site of HIV-1 gp120. The formation of G4-PAMAM-peptide complexes was evaluated in and validated experimentally (electrophoresis, MALDI-TOF/ms, 1H NMR and cryo-TEM). Next, the G4-PAMAM dendrimer-peptide complexes were administered intranasally to groups of female BALB/c mice. The results showed that both peptides can form complexes with G4-PAMAM dendrimers, both peptides and complexes were immunogenic at the systemic and mucosal levels (nasal and vaginal), Finally, G4-PAMAM dendrimer- peptide complexes improved IgG and IgA responses in serum and nasal washes without modify IgG and IgA responses in genital tract (figure 2), full research is published Rodríguez-Fonseca, et al 2019,

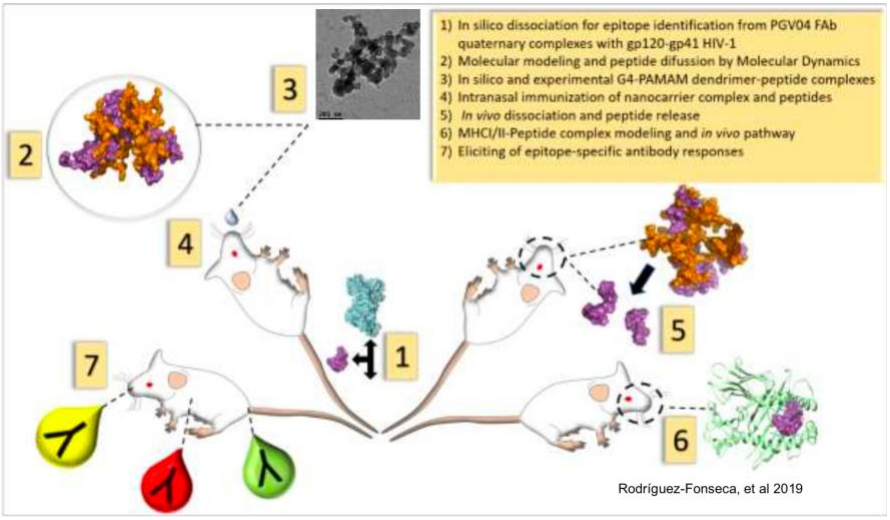

Figure 1. HIV- derived peptide epitope identification modeling of complex with G4-PAMAM dendrimer, experimental formulation, characterization and in vivo evaluation, Yellow chart shows the steps of full research.

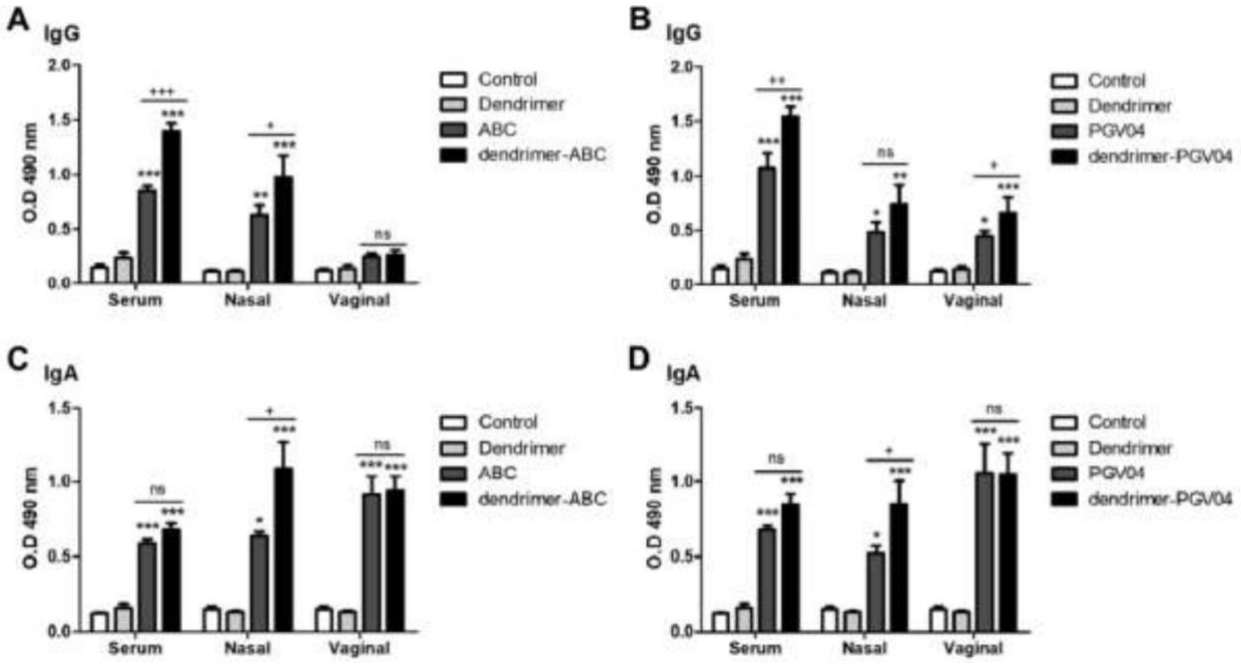

Figure 2. Anti-peptide antibody responses in serum, nasal washes and vaginal lavages of female mice: IgG (Fig. 2A and 2B), IgA (Fig. 2C and 2D). In serum, nasal washes and vaginal washes, the IgG responses were increased by G4-PAMAM dendrimer complexes. Both peptides IgG, IgA and IgM responses were higher than those in the controls. The data obtained were statistically analyzed by performing ANOVA, followed by a Tukey post hoc test. A significance level of $P < 0.05$, $P < 0.01$ or $P < 0.001$ established a significant difference between groups. * ($P < 0.05$); ** ($P \leq 0.01$) and *** ($P < 0.001$) compared to control or G4-PAMAM dendrimer individual. + ($P < 0.05$), ++ ($P < 0.01$), +++ ($P < 0.001$) or did not significantly differ (ns) compared to groups of mice immunized with G4-PAMAM dendrimer.

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*corresponding author: rrodriguezf1400@alumno.ipn.mx

miR31 and AuNP´s in Colon Cancer

Ana Cecilia Luque-Badillo,[1] Daniel Alberto Jacobo-Velázquez and Clara Patricia Ríos-Ibarra[*1]

[1]Tecnológico de Monterrey, Department of Bioengineering, Guadalajara, México. ZIP 45138

Introduction. The World Health Organization (WHO) estimates that about 84 million people die from cancer; colon cancer being one of the five with the highest incidence (1); previously, the antitumor potential of chlorogenic acid (CGA) has been reported in various cell models (2), so we decided to quantify the inhibitory effect of CGA on the miR31 oncogene, which is a microRNA (miRNA). The miRNAs are small molecules that regulate expression at the translational level; these can be released in exosomes, structures that have protein characteristics and transport miRNAs (3).

Material and methods. To increase the sensitivity of our assay we use gold nanoparticles (AuNPs) in order to have a more accurate quantification of circulating miRNAs in a culture of RKO colon cancer cells. The cells were treated with 1000 µM CGA at 24, 48 and 72 hours. After that, total RNA extraction was performed, and to perform the quantification of miR31, qPCR was used with TaqMan probes, normalizing the results with miR191 (constitutive).

Results. A 92% inhibitory effect of miR31 was observed at a concentration of 1000 µM CGA, p=4.62x10-4 using AuNPs for isolation of total miRNAs.

Discussion. CGA decreases the expression of the miR31 oncogene in an in vitro colon cancer model and the use of AuNPs increases the number of miRNAs detected, that is, it increases the detection sensitivity of our technique.

Conclusion. Based on our results, a new strategy can be proposed to develop a non-invasive molecular diagnostic tool for colon cancer.

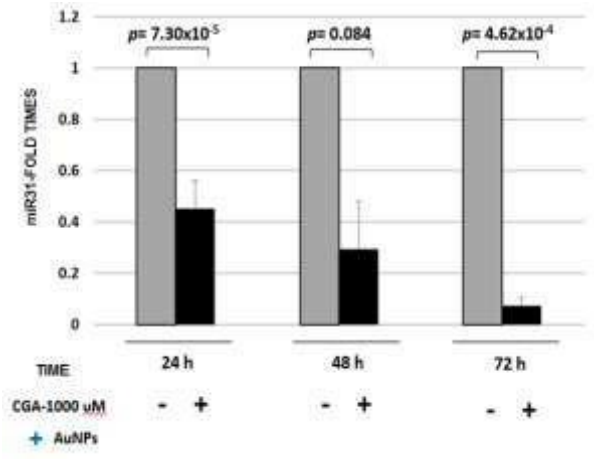

Figure 1. Quantification of miR31 isolated from RKO cells with chlorogenic acid treatment (CGA - 1000 uM), at the different times measured (24, 48 and 72 h), performing the extraction with gold nanoparticles.

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*corresponding author: clara.rios@tec.mx

Biogenic Metallic Nanoparticles. A nanometric trojan horse approach

David Medina*, Ada Vernet-Crua, María Ujué González, Lidia Martínez, Alessandro Ajo, A-Andrew D. Jones, III., Matthew Kusper, Eduardo Sotelo, Ming Gao, Luke D. Geoffrion, Grégory Guisbiers, Jorge L. Cholula-Díaz, Christelle Guillermier, Fouzia Khanom, Yves Huttel, José Miguel García-Martín and Thomas J. Webster

[1] Department of Chemical Engineering, Northeastern University, Boston, MA 02115, USA
[2] Instituto de Micro y Nanotecnología, IMN-CNM, CSIC (CEI UAM+CSIC), Madrid 28049, Spain
[3] Instituto de Ciencia de Materiales de Madrid, ICMM-CSIC, Madrid 28049, Spain
[4] Department of Chemistry and Nanotechnology, School of Engineering and Sciences, Tecnológico de Monterrey, Monterrey, N.L. 64849, Mexico
[5] Department of Physics and Astronomy, University of Arkansas at Little Rock, Little Rock, AR 72204, USA

Antimicrobial resistance to antibiotics (AMR) and cancer and two of the main concerns that the healthcare system should face nowadays. Current drugs and antibiotic treatments are becoming ineffective or have plenty of drawbacks. Therefore, new alternatives are needed. Despite the increase in the use of nanostructures in the biomedical field, traditional synthesis of such materials is subjected to several disadvantages, such as the production of toxic-by-products and harsh conditions. Green nanotechnology is presented as a suitable answer, allowing the generation of nanostructures in a quick, cost-effective and environmentally friendly approach.

Pathogenic bacteria and human cells -both cancer and healthy ones- were used for the synthesis of metallic nanoparticles similarly. Bacteria and cells are cultured in the presence of metallic salts under standard conditions until the generation of nanoparticles, that is followed using microscopy and spectrophotometric techniques. After purification, nanoparticles are used as antimicrobial and anticancer agents using colony counting unit assays and MTS assays, respectively, as well as characterized. Pathogenic bacteria are used for the synthesis of bacteriogenic metallic selenium nanoparticles that were characterized in term of size, morphology, and composition. These agents were employed as suitable agents with antimicrobial activity against the same bacteria that synthesized them, showing low cytotoxicity for human dermal fibroblasts (HDF) cells. The synthesis of metallic nanomaterials using cancer and healthy cells -HDF and HFOB- is reported. Pure metal nanoparticles –palladium or platinum- and bimetallic structures –such as gold- platinum- are readily synthesized using the cells, and after purification, they are used as anticancer agents.

Microbiological agents are successfully used as a synthetic machine for the generation of metallic nanoparticles of different compositions with biomedical properties. Therefore, they are presented as a suitable approach for the synthesis of nanomaterials in a green fashion, overcoming the limitations of traditional nanotechnology.

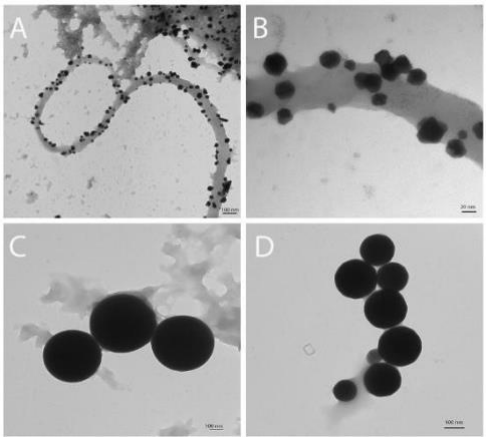

Figure 1 Metallic nanoparticles made by different microorganisms. Gold-platinum (AuPt) nanoparticles made by Melanoma cells (A, B) and selenium (Se) nanoparticles made by Staphylococcus aureus (C, D).

*corresponding author: medina.dav@husky.neu.edu

Gelatin-Methacryloyl Hydrogels Enriched with Viral Nano-Meshes Functionalized with Epidermal Growth Factor

Ivonne González-Gamboa[1], Matias José Lobo-Zegers[1,2], Andrea Monroy-Borrego[1,] Edith Velázquez-Lam[3], José Arnulfo Juárez[1], Jorge Menchaca-Arredondo[4], Pablo Lunello[5], Laura Williams[5], Fernando Ponz[3], Mario Moisés Álvarez[1]*, Grissel Trujillo-de Santiago[1,2]*

[1] Centro de Biotecnología-FEMSA, Tecnologico de Monterrey, Monterrey, 64849, Mexico.
[2] Departamento de Ingeniería Mecátrónica y Eléctrica, Tecnologico de Monterrey, Monterrey, 64849, Mexico.
[3] Centro de Biotecnología y Genómica de Plantas, Universidad Politécnica de Madrid – Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria (CBGP, UPM-INIA), Madrid, 28223, Spain.
[4] Centro de Investigación de Ciencias Físicas y Matemáticas, Facultad de Física y Matemáticas, Universidad Autónoma de Nuevo León, San Nicolás de los Garza, Mexico.
[5] Agrenvec SL, Madrid, 28760, Spain.

Modern tissue engineering techniques rely heavily in hydrogels to support cell proliferation mainly due to their high resemblance to the extracellular matrix (ECM). These can be functionalized with signaling molecules or biological factors to promote the growth and maturation of specific tissues (i.e., skin). For instance, growth factors (GFs) are naturally occurring proteins which stimulate cellular proliferation and differentiation. However, GFs translation into clinical applications is limited due to their short effective half-life, low stability, and rapid inactivation by enzymes under physiological conditions. Here we use of plant virus nanoparticles, functionalized with growth factors, as micro/nano scaffolds for cell growth within gelatin-based hydrogels.

We developed gelatin-methacryloyl (GelMA) hydrogels enriched with Turnip mosaic virus (TuMV) nano-fibers and conjugated (or not) with Epidermal Growth Factor (EGF). We cultured fibroblasts (i.e., BJs) on culture plates coated with our EGF-TuMV-GelMA (2D cell cultures). We used optical microscopy, scanning electronic microscopy, and atomic force microscopy (combined with image analysis) to analyze cell adhesion and proliferation over time in these nanostructured EGF-TuMV-GelMA hydrogels.

Enhanced cell adhesion and proliferation (>30%) was observed during the first 72h in fibroblast cell cultures conducted in nanostructured EGF-TuMV-GelMA hydrogels, as compared to those in cultures on GelMA, GelMA enriched with TuMV, and GelMA added with free (non-covalently bound) EGF (Figure 1). Moreover, the addition of TuMV nano-meshes and EGF-TuMV nano-meshes had a significant effect on the morphology (i.e., shape factor) of fibroblast cultures.

Our work illustrates a strategy to develop tailored hydrogels for controlled growth factor release applications using plant viral nano-meshes as nanostructured scaffolds. These “smart” hydrogels have potential to be used in medical scenarios such as regenerative treatments for burn injuries, post-surgery incisions, and chronic wounds.

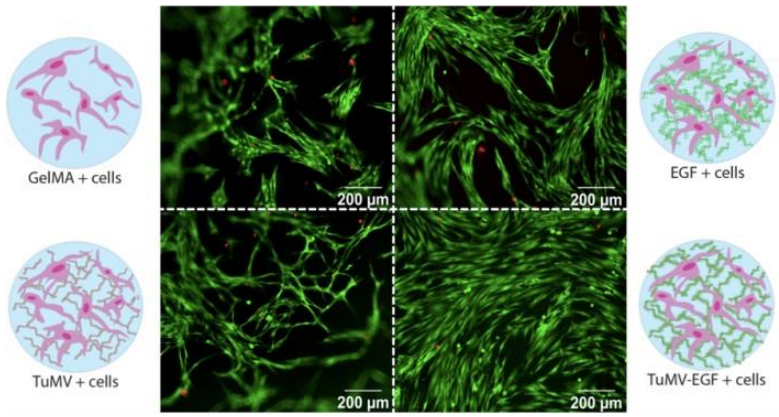

Figure 1. Cell viability on GelMA with EGF and virus scaffolds Live and Dead® assay: fluorescence micrographies of fibroblasts attached on GelMA, GelMA with EGF, GelMA with TuMV and GelMA with TuMV-EGF after 72-h seeding.

Corresponding authors: grissel@tec.mx, mario.alvarez@tec.mx

A Versatile GelMA Bioink Engineered with Plant Nanoviral Meshes

Jorge Tavares-Negrete[1], Ivonne González-Gamboa[1], Edith Velázquez-Lam[3], Andrea Monroy-Borrego[1], Fernando Ponz[3], Mario Moisés Álvarez[1]*, Grissel Trujillo-de Santiago[1,2]*

[1] Centro de Biotecnología-FEMSA, Tecnologico de Monterrey, Monterrey, 64849, Mexico.
[2] Departamento de Ingeniería Mecátrónica y Eléctrica, Tecnologico de Monterrey, Monterrey, 64849, Mexico.
[3] Centro de Biotecnología y Genómica de Plantas, Universidad Politécnica de Madrid – Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria (CBGP, UPM-INIA), Madrid, 28223, Spain.

Bioprinting, an emerging biofabrication technology capable of manufacturing engineered tissues with complex three-dimensional architecture, has become popular as an alternative to conventional 2D culture techniques with high perspectives on its applications in tissue engineering and regeneration medicine. In typical extrusion bioprinting, a bioink (i.e., generally a suspension of cells in a hydrogel) is extruded through a printing head to build a 3D artificial tissue in a layer-by-layer-fashion. The bio-ink is a key component of a bioprinting process. They have to meet appropriate physical and biological characteristics to be extrudable, self-standing and to provide proper scaffolding for cells to achieve tissue maturation.

Bio-ink portfolios include polymers and composite hydrogels, combining micro and nano arrays to offer new cell attachment motives, reduce the maturation time and enhance the cell differentiation. Gelatin methacryloid (GelMA) has become an attractive ink in 3D printing due to its excellent biological performance. However, due to its low viscosity and long photocrosslinking time, printing GelMA by extrusion-based 3D printing continues to remain a challenge. Therefore, biological cues could be introduced to enhance the ink's mechanical stability and aid in anchoring the cells.

To balance printability and biocompatibility, we propose a bio-ink composed of GelMA and plant viral nano-meshes. Tissue regeneration using these virus-based biomimetic materials has been an emerging trend recently due to their biocompatibility and scaffolding properties. Viral nanomeshes were produced, characterized (Fig. 1) and introduced to the hydrogel. The nanostructured bio-ink's printability was evaluated using extrusions pressures of 20, 30 and 40 KPa. Live and dead assays were performed to evidence biocompatibility and cell proliferation. In this work, we demonstrate that the incorporation of viral nanonets improved the printing fidelity of the constructs, as well as enhanced cell proliferation compared to the control treatments. Furthermore, our viral nanonets were functionalized with Alexa Fluor 555 to show the versatility of the system and elucidate the possibility of bio conjugating peptides or molecules (i.e. growth factors) to the viral nanonet's surface to promote tissue maturation. This work devises the potential of virus-incorporated biomimetic nanocomposites and lays the groundwork for their application in tissue engineering and bioprinting.

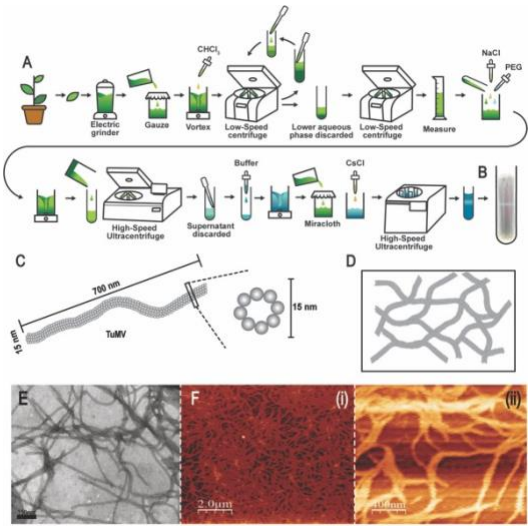

Figure 1. Viral nanomeshes' production and characterization. A) Schematic representation of the viral nanoparticles' purification. B) Cesium purified virus band. C) TuMV structure, dimensions and cross-section. D) Schematic representation of the viral nanomesh. E) Transmission electron microscopy (TEM) of the nanomesh. F) Atomic force microscopy (AFM) of the viral nanomesh at different scales.

Corresponding authors: grissel@tec.mx, mario.alvarez@tec.mx

Centrifugal-spun wool fibrous structure: a novel 3D-scaffold for tissue engineering

Saeed Beigi-Boroujeni[1,2], Mahdi Saeed[2]

[1] Tecnologico de Monterrey, Monterrey, Nuevo León, 64849, Mexico
[2] Hard Tissue Engineering Research Center, Tissue Engineering and Regenerative Medicine Institute, Tehran Central Branch, Islamic Azad University, Tehran, Iran

Bone tissue engineering is concerned with creating implantable bone substitutes for critical skeletal defects that cannot heal on their own. These defects are common clinical scenarios in orthopedics and craniofacial surgery, for the treatment of bone loss due to trauma, infection, and tumor resection.
Nanofibrous scaffolds are artificial extracellular matrices which provide natural environment for tissue formation. In comparison to other forms of scaffolds, the nanofibrous scaffolds promote cell adhesion, proliferation and differentiation more efficiently due to having high surface to volume ratio.

The most common method of making nano-fibrous scaffolds, is electrospinning. Main limitation of electrospinning method is problematic to obtain 3D structures as well as sufficient size of pores needed for biomedical applications, process depends on many variables, low speed production rate, use of high electric field, which increases complexity, increases the biomaterial degradation risk, increases the cost and depreciation of nanofiber production instruments and etc. Because of these limitations, scientists have been looking for a more efficient way of making nanofibers. In recent years the centrifugal spinning method has shown a good potential for the manufacture of fibrous scaffolds.

In this study, we used the centrifugal spinning for preparing gelatin nanofibers and then we prepared the 3D scaffold for hard tissue engineering. The physic-mechanical analysis as well as biological tests showed the acceptable results for this 3D scaffolds.

Parallel Session-3

Advanced Nanomaterials and Nanophotonics

Chiral response of plasmonic metasurface

N. Apurv Chaitanya and Israel De León*

Tecnológico de Monterrey, Escuela de Ingeniería y Ciencias, Ave., Monterrey, N.L., Mexico, 64849

Circular dichroism (CD) defined as the difference in extinction cross-section for right and left circularly polarized light, originates from the interaction of light with molecules having chiral geometry [1]. In recent times, the advancements in (a) nano-fabrication techniques (b) powerful computational tools have opened the windows for exploring the light matter interaction in unexplored domains. Metasurfaces with tailored optical response has been demonstrated to have better performance compared to naturally occurring systems and even had led to new optical phenomenon. CD, initially envisaged to be exhibited 'only' by three-dimensional structures having broken mirror symmetry, has eventually been reported in two dimensional structures (metasurfaces) by illuminating of light at oblique incidence, thereby by forming a chiral triad of the wavevector, the surface normal, and the polarization vector [2,3]. Here we report on the observation of strong CD on 2D metasurface at normal incidence. The metasurface consisted of periodic arrangements of gold nanoantenna designed such that the system supports lattice modes, which are diffractive coupling of input light into propagating electromagnetic fields along the surface. The square lattice consists of 4 gold nanorods along the sides of a square forming a “quadrumer". We show that it is possible to extract CD response even though the quadrumer itself is achiral. The CD response was found to be associated with the surface lattice modes supported by the metasurface. More results will be presented in the meeting.

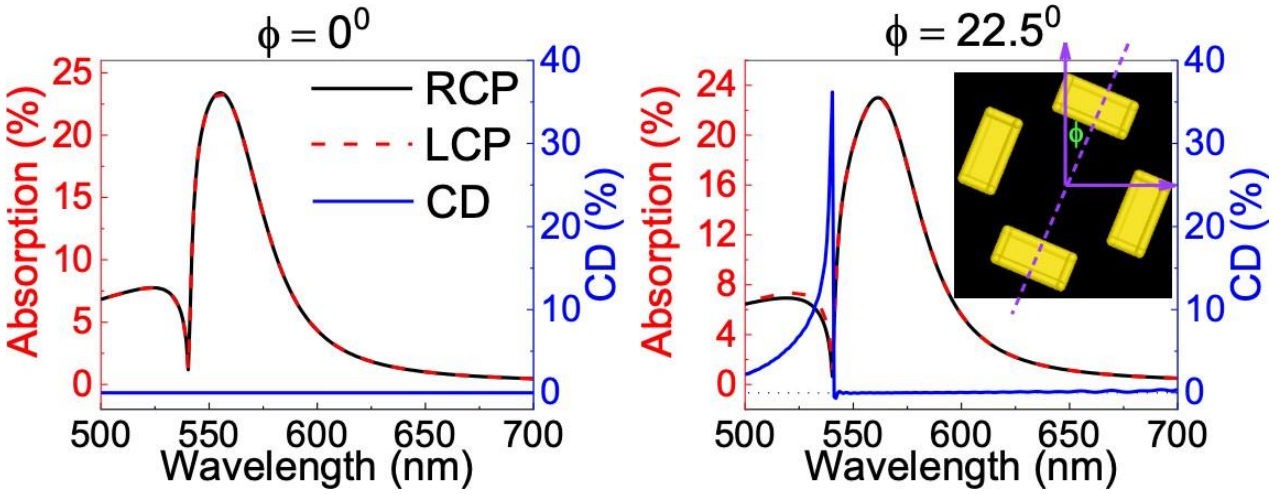

Figure: Absorption measurement of plasmonic metasurface for right (solid black) and left (dashed red) circularly polarized light and corresponding CD signal (solid blue). Gold quadrumer (Inset of fig. on right) is arranged over a square lattice of period 540 nm. The metasurface shows no CD (left fig) when the quadrumer is aligned, ϕ=0, with respect to the y axis and exhibits a very strong CD response when ϕ= 〖22.5〗^0.

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*corresponding author: ideleon@tec.mx

High-Q Nanobeam Cavity on Silicon Nitride Platform

Zeinab Jafari[1], Jiahao Zhan[2], Mario Dagenais[*2] and Israel De Leon[*1]

[1] School of Engineering and Sciences, Tecnológico de Monterrey, Ave. Eugenio Garza-Sada 2501 Sur Monterrey, NL 64849, Mexico
[2] Department of Electrical and Computer Engineering, University of Maryland, College Park, MD 20742 USA

In the past few years, photonic crystal-based devices have attracted enormous attention due to more degrees of freedom in their design. Particularly, photonic crystals are useful for implementation of high-Q and compact optical cavities. Q factors as high as 109 have been numerically achieved for silicon nanobeam cavities which are made of one-dimensional photonic crystal [1]. Obtaining a high Q factor is important for a wide variety of applications such as narrowband filtering, ultra-low energy switching and modulation, sensing and cavity quantum electrodynamics (QED) [2-5].

Although silicon photonic devices are favored because of their compatibility with CMOS Technology, silicon has some limitations. First, it is absorptive at the visible range. Second, it suffers from two-photon absorption at the telecommunication band. Silicon nitride (Si3N4) is a good alternative to silicon which could be used to overcome these limitations. However, the refractive index of Si3N4 is smaller than that of silicon. Consequently, achieving high Q factor in Si3N4 cavities is quite challenging due to larger radiation loss and narrower grating bandgap in comparison to those in silicon cavities. For suspended Si3N4 cavities, theoretical and experimental Qs as high as ~106 and ~5.5×104 have been reported, respectively [5, 6]. Q factor is significantly reduced when the cavities is laid on top of a substrate [7]. In this work, we exploit different techniques to increase the Q factor of Si3N4 nanobeam cavities on a glass substrate. The cavity is encapsulated in SiO2 to remove the radiation loss originated from the asymmetry of the structure [7, 8]. In addition, large elliptical holes are used to increase the bandgap and the mirror reflectivity [9]. Q factors as large as several millions have been achieved in numerical simulations. The largest Q factor obtained in experiment is ~4.55×105 which is ~8 times larger than the previously reported experimental values for Si3N4 nanobeam cavities.

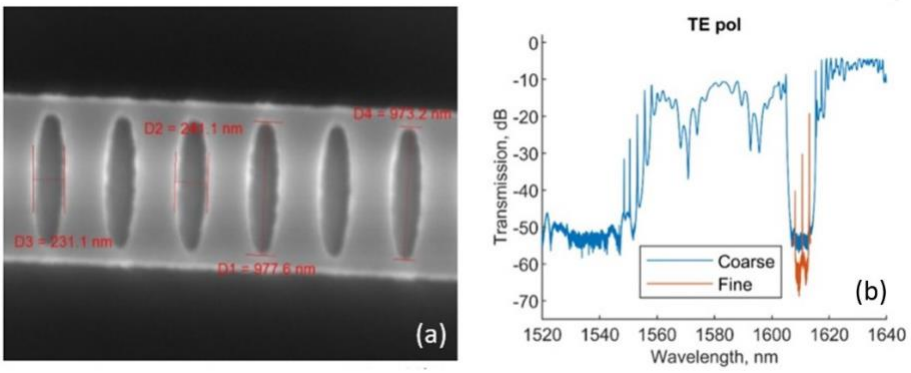

Figure 1: (a) SEM image of one of the fabricated Si3N4 nanobeam cavities, and (b) its transmission spectrum which shows a sharp resonance with Q of 4.55×105 at 1610.65 nm.

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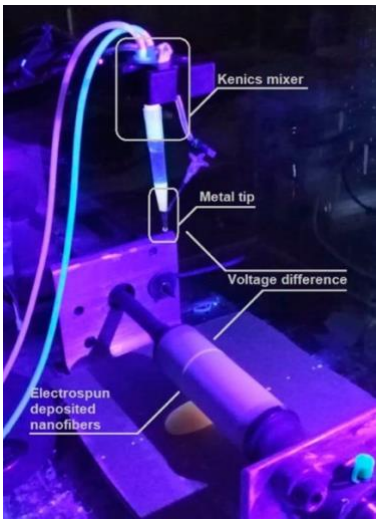
*corresponding authors: dage@ece.umd.edu and ideleon@tec.mx

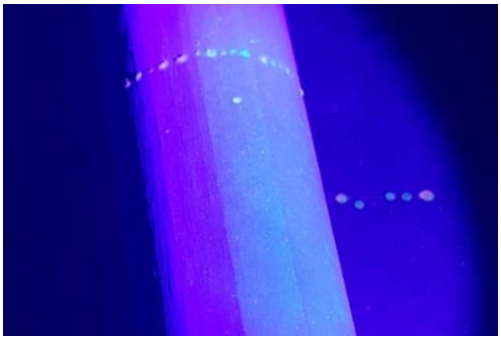
Fabrication of carbon-based supercapacitors through electrospinning of partially mixed solutions

Sunshine Holmberg[1,2] , Alejandro Lujambio Ángeles[1], Claudia Bautista Flores[1], Carolina Chávez Madero[1] and Sergio O. Martinez-Chapa[1]*

[1] School of Engineering and Sciences, Tecnológico de Monterrey, Av. Eugenio Garza Sada 2501 Sur, 64849, Monterrey, NL, Mexico.
[2] Department of Mechanical and Aerospace Engineering, University of California, Irvine, CA, USA.

Modern advances in electric vehicles has created a huge demand in developing electrochemical power cells that can meet their needs. Among these power cells, supercapacitor is a prominent topic of research for their necessity in electrical power system due to their incredibly high-power density. Current state of research into supercapacitor has been focused on the development of nanocomposite materials that can maximize the power density of supercapacitors through introducing pseudo capacitance, enhancing active surface area, or increasing the range of the stable voltage window. In particular, manganese oxide nanocomposites have been shown to be able to address all of these aspects of supercapacitor design. However, manganese oxide composites also face its own challenges, particularly in their low conductivity, mechanical fragility, and difficulty in scaling their fabrication process. Herein, it is described novel far field electrospinning method for fabricating a carbon/manganese oxide nanofiber composite. This process uses a newly developed technique that allows for nanofibers with internal striated structures of different materials using a static, Kenics mixer. This mixer exploits the viscous properties of the polymer solutions to induce laminar flow during the production of the nanofiber, which allows for the preservation of the internal striated structures. This new technology enables the ability to combine two different materials without losing the individual properties of each, such as pyrolizability, conductivity, thermal conductivity, refraction index, etc.





*Corresponding author: smart@itesm.mx

Characterization of PVA based CNT nanofibers for electrochemical sensing

Josué Hernández[1], Jorge Chanona[1], Rodolfo Estrada[2], Paloma Vilchis,*[2,3]

[1] ENCB IPN, Mexico City, CP: 11340, Mexico
[2] Iberoamericana University, Mexico City, CP: 01219, Mexico
[3] Universidad Tecnológica de México (UNITEC MÉXICO) Campus Ecatepec, Ecatepec, CP: 55107, Mexico

Polyvinyl alcohol (PVA) is a material that present a high level of compatibility with biological environment. We modify the electric properties of PVA with Multiwall CNT that were obtained by CVD from Nanotechnology Lab of the Iberoamericana University, after the functionalization of the CNT, were mixed with the PVA Solution in a different concentration to obtain the nanofibers by electrospinning process. For the characterization, XRD, FTIR and Raman spectroscopy techniques were used. Finally, we try out the mats of nanofibers in a potenciostat to demonstrate that nanofibers increase the sensitivity in a electrochemical analysis. This kind of material could be used in combination with aptamer as biosensor with high selectivity.

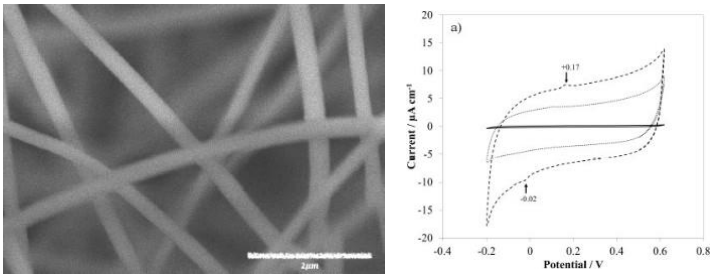


Figure 1: a) SEM micrograph of nanofibers, b) Electrochemical kinetics of PVA nanofibers printed electrode. Cyclic voltammograms of reference electrode (solid line), pure PVA (dotted line) and PVA + CNx (dashed line) with electrochemical response to aqueous solution of 1M KCl.

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*corresponding author: paloma.vilchis@correo.uia.mx

Galvanostatic Electrodeposition of Silver Nanoparticles: Nucleation and Growth Studies

Ana Sofía Elizondo[1], Daniel Herrera[1], D. Alfonso Crespo-Yapur[1] and Marcelo Videa[*1]

[1] Department of Chemistry, School of Engineering and Sciences, Tecnológico de Monterrey, Monterrey, NL 64849, Mexico

Silver nanostructures can be used in a wide spectrum of applications, such as CO2 reduction (1), nitrate detection (2), and surface-enhanced Raman scattering (3). Thus, a large number of works have been devoted to the synthesis of such structures (4). Among the synthesis methods, electrodeposition stands out as a fast and simple technique, that allows a high degree of control in the direct formation of the nanostructures on the substrate. Commonly, electrodeposition is carried out through potential-control techniques, like chronoamperometry; however, it has been shown that galvanostatic control, applying a constant current pulse, can lead to smaller structures with narrower size distributions (5). The goal of this work is to study the effects of applied current on the size and morphology of silver nanostructures on an ITO coated glass substrate.

Figure 1a presents the potential transients obtained during the electrodeposition of Ag on ITO at two different applied currents. In both cases, the length of the current pulse was adjusted to fix the total charge to 120 µC. The curves show the expected behavior for a galvanostatic electrodeposition (5,6), i.e. a first stage in which the electrode potential polarizes to more negative potentials at which silver nuclei are produced on the surface of the electrode. These nuclei grow on the following stage, where the potential raises to reach a stationary value. The lowest potential reached becomes more negative as the magnitude of the applied current is increased. Isolated particles of average sizes of 100 to 200 nm with irregular to cubic shapes (see Fig. 1b) were produced. The histograms shown in Fig. 1c, suggest that the average particle size increases at larger applied currents, which is at odds with the observations of Martinez et al. (5) and the predictions of theoretical models (6) of smaller particles being produced with larger pulses. On the other hand, the particle density behaved as expected, larger currents leading to a larger number of particles per area unit: 1220 particles per cm2 and 832 particles per cm2 for the 376 µA and 188 µA pulses, respectively.

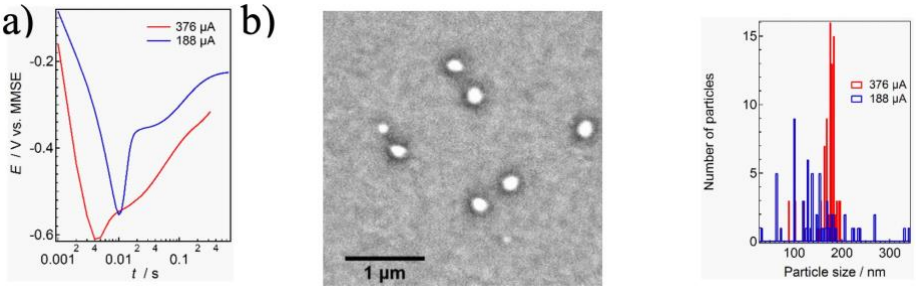

Figure 1: (a) Potential transients obtained during the galvanostatic deposition of Ag on ITO from a plating bath containing 10 mM AgNO3 + 1 M KNO3 + 1.6 M NH4OH (b) SEM image of the Ag nanoparticles on ITO obtained with a pulse of 376 µA (c) Particle size distribution plots for deposits obtained at different applied currents.

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*corresponding author: mvidea@tec.mx

Advanced Nanomaterials and Nanophotonics

Introduction of Coiled Flow Inverter as Photoreactor for Water Treatment

Chinmay P. Tiwari[†, ‡], Fernando Delgado-Licona[†, ¥], María Valencia-Llompart[†], Sara Nuñez-Correa[†, ƒ], Krishna Deo Prasad Nigam[†, §], Alejandro Montesinos-Castellanos[†], Enrique A. López-Guajardo[†, *], Alan Aguirre-Soto[†, ‡, *]

[†]Department of Chemical Engineering, Tecnologico de Monterrey, Monterrey, Nuevo León, 64849, Mexico
[‡]Nanotechnology Graduate Program, Tecnologico de Monterrey, Monterrey, Nuevo León, 64849, Mexico
[¥]Engineering Sciences Graduate Program, Tecnologico de Monterrey, Monterrey, Nuevo León, 64849, Mexico
[ƒ]Faculty of Chemical Science, Universidad Veracruzana, Coatzaocalcos, Veracruz, 96538, Mexico
[§]Department of Chemical Engineering, Indian Institute of Technology, Hauz Khas, New Delhi, Delhi 110016, India

In recent years photochemistry has gained attention for its potential to utilize abundant renewable energy like sunlight as the principal energy source for driving these chemical reactions. However, widespread adoption and implementation have not yet been achieved. Several obstacles and challenges have influenced this, mainly light penetration gradients, light uniformity on the system and homogeneous mixing. In order to overcome these challenges a custom continuous milli-fluidic photochemical reactor system was built. Commercial ZnO functionalized with APTMS & doped with Au-nanoparticles was used alongside a high intensity and high efficiency LED (resembling sunlight spectrum) to degrade a dye solution. Uniformity in mixing is achieved by using Coiled Flow Inverter as a static mixer, which promotes the formation of secondary flows enhancing mixing and mass transfer processes. Special reflective containment was designed for avoiding light leakages and better constancy of light intensities for the CFI reactor. The continuous nature of the system allows for on-line spectroscopic monitoring of the reaction kinetics. Challenges and improvements of the approach are discussed.

*corresponding author: alan.aguirre@tec.mx, enrique.alopezg@tec.mx

Electrospinning Oxygen-Less Polymers to Fabricate Carbon-Based Nanostructures

Osamu Katagiri[1], Alán Aguirre[2]

[1]ITESM CEM, Cd López Mateos, 52926, Méx.
[2] ITESM MTY, Monterrey, N.L, 64849, Méx.

Carbon nanomaterials are subjected to great interest for research purposes due to their various potential applications in diverse areas that take advantage of the nano-scale properties. Carbon nanomaterials are suitable for catalysis, adsorption, carbon capture, energy and hydrogen storage, drug delivery, bio-sensing, and cancer detection. Some matchless properties that allow carbon nanomaterials to be utilized within multiple functionalities include high porosity, distinguished structures, uniform morphologies, high stability, high magnetic properties, and high conductivity. [3]

This conference event bestows the engineering and design of a polymer solution to achieve mass scale manufacturing of high conductive carbon nanowires with a reduced diameter in an inexpensive, continuous, simple and reproducible manner. The research intends to involve several manufacturing processes such as near field electrospinning, photopolymerization, pyrolization, and carbonization, as they have shown to be promising methods for the fabrication of carbon nanomaterials. [1] See Figure 1. A few processes have been developed for specific purposes of polymeric nanofibers, some include surface deposition, composites, and chemical adjustments. Polymeric nanofibers must be also pyrolyzed to generate carbon nanowires with conductive capabilities [2] for electrochemical sensing and energy storage purposes.

Traditional near-field electrospinning or NFES allows large scale manufacturability combined with spatial control of material deposition. However, the reported efforts required the use of electric fields in excess of 200 kV/m for continuous operation, resulting in limited control for nano-fiber patterning in traditional NFES processes. Madou et al. [2] conclude that the current state-of-the-art synthesis processes for polymer nano-fibers lack to yield precise, inexpensive, fast, and continuous manufacturing properties.

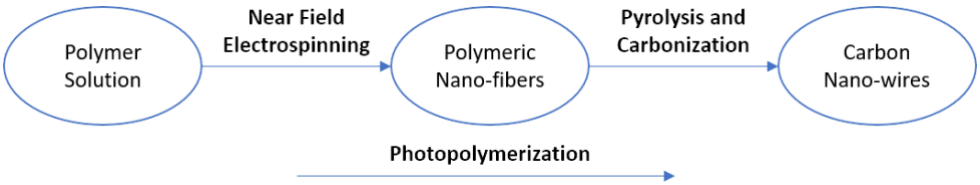

Figure 1: Fabrication process of conductive carbon nanowires to achieve through the dissertation

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Antonio Osamu Katagiri Tanaka: A01212611@itesm.mx

Posters Session

Research for the chemical synthesis of BSA nanoparticles

Alan Alberto Guevara*

J Pichardo - Centro de Investigación en Óptica, - Mexico

This research provides a study on the preparation of BSA nanoparticles, based on a simple based on an improved desolvation procedure followed by glutaraldehyde fixation for drug delivery applications. The Procedure used for the nanoparticles preparation was simplified by using a designed automatic syringe pump for controlling the addition of ethanol. The apparatus designed which enabled the preparation of nanoparticles under defined conditions. Numerous experimental variables were examined in order to characterize their impact on absorbance and emission. Particle synthesis was controlled by adjusting self-assembly phenomena of the protein molecules, which was affected by preparation conditions including pH, glutaraldehyde concentration, alkali used (NaOH and NH4OH) and the rate of addition of the dehydrating agent (ethanol). Changes in glutaraldehyde volume, and rate of addition of the dehydrating agent (ethanol) also affect nanoparticle characteristics, as they influence the absorbance and nanoparticle emission. Nanoparticles surface charge was modulated with the extension of cross-linking. Finally, long-term colloidal stability of samples was evaluated after 6 months of storage where is possible to see an absence of a specific excitation wavelength at 500 nm representing the chemical molecule degradation responsible for the emission spectrum in the sample at this wavelength.

*corresponding author: albertormzguev@gmail.com

Study of the Effect of Different Ni Thickness on the Diffusion of C-MEMS Based on Electrospun SU-8 and CNT

Sveidy Vaca[1], Oscar Pilloni[2] and Laura Oropeza-Ramos*[,3]

[1]Programa de Maestría y Doctorado en Ingeniería, Universidad Nacional Autónoma de México, UNAM,Ciudad de México, 04510, México
[2]Instituto de Ingeniería, Universidad Nacional Autónoma de México, UNAM, Ciudad de México, 04510, México
[3]Facultad de Ingeniería, Universidad Nacional Autónoma de México, UNAM, Ciudad de México, 04510, México

Knowledge of carbon one-, two- and three-dimensional materials has been revolutionized in recent years due to advancements in the understanding of the effects of its different hybridizations. There is a growing interest in improving the processes to obtain highly graphitic carbon microstructures in particular graphene and highly ordered pyrolytic graphite, motivated by the outstanding properties of the resulting material There are reports on conventional methods to produce monolayers or multilayers using a catalytic metal, but extra processes are needed in order to obtain a specific pattern. These processes require etching away the metal foil and transferring the carbon allotrope layer to a specific purpose substrate, producing contamination and defects on the graphene film; thus, changing its properties (1) – (3).

Recent works have reported graphene layers obtained by the diffusion of carbon in nickel films using different carbon sources like polymethyl methacrylate (PMMA), high impact polystyrene (HIPS), acrylonitrile-butadiene-styrene (ABS), or gas flow of methane (4) – (6). In particular, Carbon-MEMS technology consists of a thermochemical decomposition of a polymer precursor in an inert atmosphere (7). Using photosensitive polymers as precursor is highly attractive due to the fact that micro-shapes can be defined by photolithographic means previous to the pyrolysis process. On the other hand, it has been discovered that it is possible to improve the graphitization of carbon nanofibers generated by electrospinning polyacrylonitrile (PAN) combined with carbon nanotubes (CNT) by applying mechanical stress during the stabilization process of the polymer (8).

In this work we combined both techniques to produce pyrolyzed electrospun nanofibers of SU-8 with CNT previously micro-defined structure by photolithography followed by the diffusion of the resulting carbon in nickel, using different metal thickness, to study the effects on the ordering of the carbon atoms and the properties of the material. Finally, we characterize the process and resulting material using SEM and Raman spectroscopy in order to study the transition from a polymeric to a graphitic material.

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*corresponding author: loropeza@unam.mx

Rapid Determination of Dopamine at Electrochemically Activated Commercially Screen-Printed Carbon Electrodes Integrated with a 3D-printed Microfluidic Platform

Jesús E. Contreras-Naranjo, Oscar Aguilar *

Tecnológico de Monterrey, Escuela de Ingeniería y Ciencias, Monterrey, 64849, N.L., México

Dopamine (DA) is a neurotransmitter that is involved in several central nervous functions such as body movement, memory and learning. A decrease or disequilibrium of DA levels can cause neurodegenerative illness such as Parkinson's disease, schizophrenia, Huntington's disease and other health problems including drug addiction. Nowadays, liquid chromatography is the standard method to determine DA in clinics; however, electrochemical methods are an attractive choice for DA determination because they are rapid, sensitive, selective, and low-cost. In this sense, voltammetric sensing of DA in the presence of uric acid (UA) and ascorbic acid (AA) using electrochemically activated commercially disposable screen-printed electrodes have been successfully performed (1,2). Microfluidic devices are used for rapid determination of analytes reducing the required sample amount and processing time. The most common techniques developed for manufacturing microfluidic devices are soft lithography, laser ablation, and micromachining. 3D-printing is a non-conventional technique used either to print masters for soft lithography mold or to print the device itself. Recently, an easy and low-cost two-step fabrication technique named ESCARGOT (Embedded SCAffold RemovinG Open Technology) has been used to build 3D-intricate micrometric channels into a single block of PDMS. By using ESCARGOT, there is no need of complex lithography steps nor silicon masters nor of repetitive procedures when micrometric channels are desired (3). Here we present, for the first time, an approach based on a microfluidic platform fabricated using a combination of 3D-printing technology and ESCARGOT coupled to a successfully activated disposable commercially available screen-printed carbon electrode for rapid detection of dopamine (Figure 1). This microfluidic electrochemical sensor allows the measurement of dopamine by cyclic and differential pulse voltammetry in the presence of UA and AA as interfering agents. The simplicity of the electrochemical activation procedure makes this an interesting and attractive approach, especially for disposable sensors that offer increased sensitivity towards DA

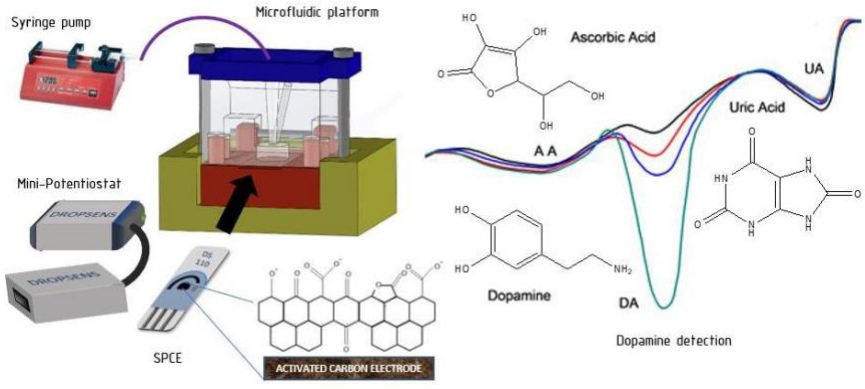

Figure 1: Microfluidic electrochemical sensing platform for rapid detection of DA.

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*corresponding author: alex.aguilar@tec.mx; Tel.: +52-81-8358-2000 (ext. 1972)

Electrified Lab-on-a-Disc

Saraí M. Torres Delgado,[1] Jan G. Korvink[1] and Dario Mager*[1]

[1]Karlsruhe Institute of Technology – IMT, Eggenstein - Leopoldshafen, 76344, Germany

Over the last decade centrifugal microfluidic platforms have been of increasing interest for use in decentralized bioanalytical testing such as point-of-care diagnostics. This technology is particularly powerful due to the inherent ability to centrifuge samples like the ones required for blood processing. However, while the LoaD technique compared to LOC, has simplified basic operations such as valving, pumping, metering, mixing and sample preparation, solutions to other arising needs, such as the integration of (active) operations, or the readout of a bioassay result, has proven more challenging to achieve when the platform is under continuous rotation, a characteristic inherent to their working principle. As anyone can foresee, power and signal cables cannot be connected to a rotating system, because they will twist, entangled, and finally, disconnect or brake, hampering the integration of actuators and/or detectors into the system. These components are needed for a sensitive, reliable, time-independent, fast, direct and continuous interaction with the microfluidic disc while spinning and, thereby, enhancing the success of LoaD systems.

Hence, here we present the design and development of a low cost, compact and portable platform that co- rotates with the microfluidics disc, called the “electrified Lab-on-a-Disc (eLoaD) platform” which includes all modules necessary for it to be used in any diagnostic assay. Because it requires power, wireless energy transmission was introduced into the system. Hence, the platform was designed and fabricated to behave as a wireless power receiver compatible with the Qi standard, better known for its use in wireless charging of consumer electronic devices. Since most envisaged applications will require a control unit that provides enough computational power, a way to record data and real-time bidirectional communication between the user and the ongoing experiment, the platform comprises an Arduino microcontroller, an SD-Card and a Bluetooth module. The inclusion of those modules renders a flexible platform, easy to operate for most users with backgrounds ranging from biology to engineering and compatible with concurrently emerging trends and standard technologies.

As any laboratory that operates on basic and specialized equipment, the capabilities of the proposed system can be augmented by the addition of a second electronic board plug-compatible to the eLoaD. This additional board referred to as Application Disc in Fig. 1 contains the application-specific sensors and actuators. Such scheme leads to a higher degree of interaction and enables more sophisticated concepts to be implemented both in the control as well as in the readout. The performance of the platform was tested under several sensing and actuation experiments (1-3), some of which will be presented at the conference.

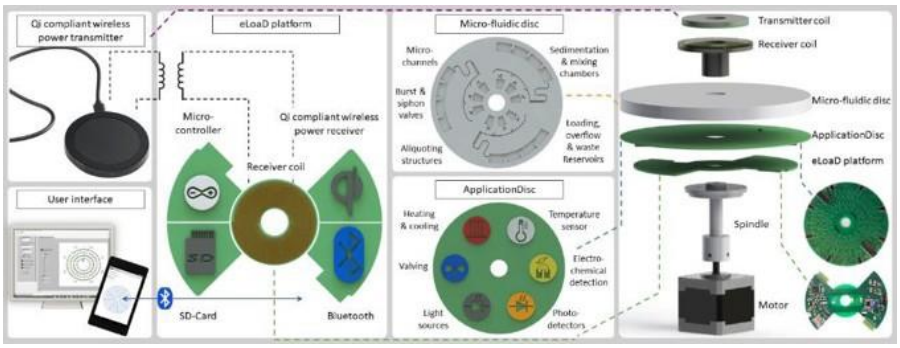

Figure 1: Integration of the wireless centrifugal system into conventional LoaD systems. A commercially available Qi-compliant transmitter is inductively coupled to the eLoaD platform. This fully integrated platform can control sensors and actuators located on the Application Disc, which itself is simultaneously interacting with the microfluidics disc. The disposable microfluidic disc and the reusable Application Disc are typically designed for a particular application, whereas the eLoaD platform, which implements the control logic, power, and communication, is reused as a generic framework for all possible applications. Interfacing of the eLoaD platform is enabled by Bluetooth communication, here exemplary via an Android application program running on a portable device, and from a PC running e.g. a LabVIEW script.

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*corresponding author: dario.mager@kit.edu

Nano co-amorphous solid dispersion of simvastatin – nifedipine for the treatment of cardiovascular diseases Main Area: Nanobiotechnology and Nanomedicine

Jorge Cruz-Angeles[1], Antonio Reyes[1], Marcelo Videa[1,2] and Luz María Martínez[1,2]*

[1]Escuela de Ingeniería y Ciencias

[2]Departamento de Ciencias: Químicas y Nanotecnología.Tecnológico de Monterrey, Campus Monterrey. Ave. Eugenio Garza Sada 2501 Sur. Monterrey, NL, C.P. 64849, México.

Cardiovascular diseases (CD) like arterial hypertension and hypercholesterolemia, are the leading cause of mortality in the United States [1]. Most patients suffer both diseases simultaneously, and it is for this reason that World Health Organization's Global Hearts has recommended the use of combination therapy [2]. One of the most important limitations of active pharmaceutical ingredients (API) used in the treatment of CD is their low solubility, most of these APIs are class II, i.e. present high permeability but very low solubility [3]. Therefore, several approaches have been followed to increase the solubility of drugs prescribed to cardiovascular diseases. Preparation of co-amorphous binary systems has been reported as one of the most efficient strategies to enhance their dissolution [4,5]. Previously, Martinez et al., [3] reported the co-amorphous system of simvastatin – nifedipine (SIM – NIF) with an increase of dissolution of both drugs in comparison with their commercial presentation. Martinez also reported an innovative methodology for the preparation of two-phase amorphous solid dispersions using ultrasound to reduce the size of the API in the dispersion, thus increasing the dissolution of simvastatin [6]. Taken advantage of this ultrasound- assisted methodology, a nanoscaled co-amorphous binary solid dispersion (CASD) based on simvastatin – nifedipine was prepared, using glucose as the dispersive matrix.

The co-amorphous solid dispersion of simvastatin – nifedipine – glucose was prepared in a molar ration 1:1 by melt-quenching. The co-amorphous was mixed with amorphous glucose to produce a molar fraction of 0.03 and ultrasound was applied to the mixture. Dissolution of crystalline SIM and NIF and the CASD was evaluated in water at 25°C; the concentration of both APIs was determined by HPLC. Also, samples were examined by PXRD diffraction and FTIR spectroscopy for structural analysis, and dynamic light scattering (DLS) was used to determine the particle size. X-ray powder diffraction results showed the characteristic halo of amorphous materials (see Figure 1a).

Infrared spectroscopy confirmed the amorphous structure of the formulation by showing broadening of signals due to the loss of long-range order. Figure 1b shows the particle size distribution measured

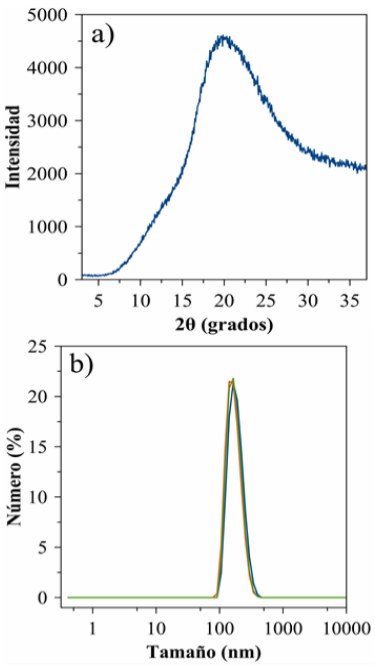

Figure 1. a) PXRD pattern of the co-amorphous solid dispersion of simvastatin – nifedipine (CASD $x_{SVS-NIF(x0.03)}$) and b) profile of average size of particles of the CASD of 157 nm.

by DLS for the CASD formulation, as it can be seen the two APIs (as a co- amorphous system) has an average size of particle of 157 nm. Finally, the dissolutions experiment showed an enhancement on the dissolution of nifedipine of almost 3 times, from 9 mg/L for the crystalline state to 26 mg/L in the CASD xSVS-NIF(x0.03). We are currently working in the evaluation of the dissolution profile for simvastatin. The increment in the dissolution of NIF was achieved due to the amorphous state of both APIs in the dispersion and the reduction of the particle size of the co-amorphous system. Th novel co-amorphous solid dispersion developed in this study is a potential combination therapy formulation with improved dissolution for the treatment of cardiovascular diseases.

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*corresponding author: *luzvidea@tec.mx

Microstructure of Polycrystalline Solids: A Brief Review from Methods in X-Ray Line Profile Analysis

Ana C. Murrieta and Flavio F. Contreras-Torres*

Escuela de Ingeniería y Ciencias, Tecnológico de Monterrey, Monterrey, 64849, Mexico

Solid materials that do not present a perfect crystalline structure at long range are called polycrystalline materials (1). This deviation from a perfect crystallinity is known as the microstructure and determines the properties of materials. The microstructure can be studied by the analysis of X-ray diffraction patterns, which is known as X-ray line profile analysis (XLPA). The peaks in the diffractogram can broaden due to crystallite size, density of dislocations, planar defects, chemical heterogeneities, and surface relaxation (2). This allows the analysis of the microstructure via XLPA (see Figure 1). XLPA analytical methods can be classified as: (a) peak by peak adjusting methods, and (b) whole profile adjusting methods. The first set of methods (3,4) is focused on XLPA analysis in each peak separately. The methods are very flexible and can be applied in a great number of situations (e.g. existence of more than one crystalline phase). Among these methods the Williamson-Hall (WH) and Warren-Averbach (WA) methods are found. While the WH method applies the integral breadth of the diffraction peak (3), the WA method is based on the Fourier coefficients transform for each diffraction peak (4). The WH and WA methods are commonly used due to their usefulness for the analysis of grain solid materials (i.e. submicro, micro and macroscopic).
Whole Profile Modelling methods (WPM) (5-7) allow the modelling of the whole diffraction profile defining the interest parameters with relative precision and regardless the peak overlap. Gubizca and Ungar (5,6) have demonstrated the versatility of WPM methods even for the study of nanocrystalline materials. The efficiency of these methods, nonetheless, can require the use of ab initio analytical functions of high complexity for the representation of stacking faults (7), and their implementation has only been developed for cubic materials. Here a review of the methods developed for XLPA analysis is presented. From the classical methods of Williamson-Hall and Warren-Averbach, to their modified versions and modern analysis methods are briefly described, as well as their scope and limitations. The conclusions present the area of opportunity of XLPA in polycrystalline solids today, as well as potential applications in materials science.

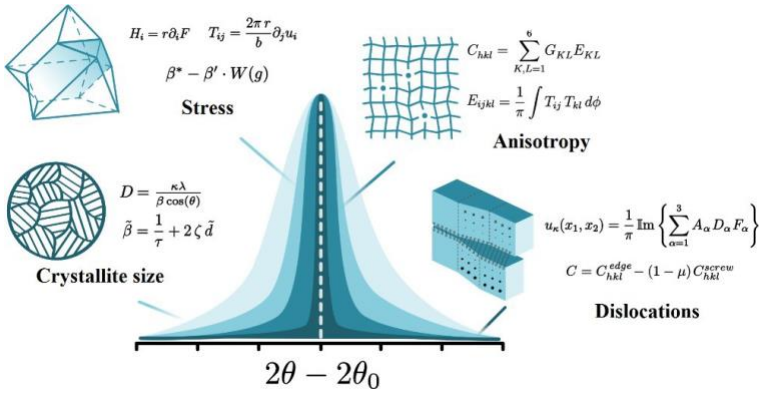

Figure 1: The broadening of X-ray peaks can be used to characterize the microstructural properties of polycrystalline materials.

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*corresponding author: contreras.flavio@tec.mx

Modern Raman Spectroscopy Advances for Biomedical Applications

Fausto Abril-Martinez[*1]

[1] Escuela de Ingeniería y Ciencias, Tecnológico de Monterrey, Monterrey, N.L 64849, México

Raman Spectroscopy is an optical technique based in the inelastic scattering of light from elementary excitation in molecules, phonons and magnons. Structural and dynamic information on a molecular level can be derived from such excitations. Due to Raman spectroscopy is a noninvasive technique, it can be used in medical diagnostic applications without altering the chemical composition of the samples. Biomedical applications of Raman spectroscopy include the detection and quantification of molecular changes caused or triggered by diseases in cells. Therefore, Raman spectroscopy can allow to observe samples from tissues in order to formulate an objective diagnosis. Despite this advantage, it is common that the acquisition time requires a long exposition to obtain high level signals by the sample being analyzed. Novel strategies have been developed and integrated to Raman spectroscopy to enhance the Raman signal, reduce acquisition time and increase spatial accuracy such as: nonlinear optics, nanoparticles and multimodal integration.
In this study, we summarize Raman-based techniques for biomedical applications. The state-of-art is reviewed through different modes of Raman spectroscopy including: SERS, CARS, TERS and micro Raman. It is also reviewed applications such as cellular internalization, tissue imaging, drug delivery, disease diagnostics and circulating tumor cells which are applications that could extend humans life expectancy by developing faster and more precise diagnostic systems. In particularly, emphasizing in skeletal tissues, cartilage tissue, tumor cell and cancer cells.

*corresponding author: faustoabril@tec.mx

Caracterización de los Mecanismos de Citotoxicidad Mitocondriales de Óxido de Grafeno en Células Ventriculares Hipertróficas

Estefania Luna-Figueroa[1], Fausto Abril[2], Flavio F. Contreras-Torres[2] y Gerardo García-Rivas[*1,3]

[1]Cátedra de Cardiología y Medicina Vascular, Escuela Nacional de Medicina, Tecnológico de Monterrey, Monterrey
[2]Escuela de Ingeniería y Ciencias, Tecnológico de Monterrey, Monterrey
[3]Centro de Investigación Biomédica, Hospital Zambrano-Hellion. Tecnológico de Monterrey. San Pedro Garza García.

El oxido de grafeno (GO) y el oxido de grafeno reducido (RGO) son nanomateriales de carbono derivados del grafeno, los cuales destacan para su uso a nivel industrial y biomédico debido a sus propiedades fisicoquímicas. Sin embargo, posibles riesgos a la salud ponen en duda los beneficios derivados de su uso. La toxicidad de estos nanomateriales se ha relacionado con la translocación hacia el torrente sanguíneo a través de procesos de inhalación, ingestión o por exposición dermal (Ahmed, 2012). En particular, nuestro interés está enfoca en el tejido cardiovascular. Acumulación de partículas menores a 2.5 micras puede ser factible en este tipo de tejidos (Kanakia. et al., 2014), un riesgo que supone ser mas severo en tejidos con predisposición a daño (Ruiz-Esparza et al., 2016). Incluso en concentraciones bajas de partículas, el cociente de riesgo señala la posibilidad de desórdenes cardiometabólicos (Pope III et al., 2014). En años recientes, nuestro grupo demostró que la citotoxicidad de materiales grafénicos está relacionada con la composición química y, particularmente, con el nivel de oxidación (Contreras-Torres et al., 2017). En el presente estudio se analiza la citotoxicidad de GO y RGO en cardiomioblastos sanos y cardiomioblastos con daño celular, utilizando un modelo patológico de hipertrofia inducido por Angiotensina
II. Los mecanismos de citotoxicidad se determinarán a dosis y tiempo de respuestas, usando marcadores de remodelación, el aumento en la generación de especies reactivas de oxígeno y la función mitocondrial. Resultados preliminares muestran que los cardiomioblastos disfuncionales exhiben mayor susceptibilidad a las partículas de GO y RGO en comparación con cardiomioblastos control.

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*corresponding author: E-mail: gdejesus@itesm.mx

Electroactive and non-electroactive molecule in-vitro detection using glassy carbon microelectrode arrays

Sandra Lara[1] Amish Rohatgi[1] Alexis Oyawale[1] and Sam Kassegne*[1]

[1] San Diego State University, San Diego, 92182, U.S.

Using Glassy Carbon (GC) electrodes we aim to detect both electroactive and non-electroactive molecules intended for neural implantation. Through the use of fast scan cyclic voltammetry (FSCV) we pass a current through an electrode which oxidizes electroactive molecules in contact with the electrode surface such as Dopamine and Serotonin at specific voltages *in-vitro*. For non-electroactive molecules such as Lactate and Glutamate the electrode must be functionalized in order to be detected by FSCV. To detect non- electroactive molecules, we immobilize molecule specific enzymes to catalyze a reaction to convert a molecule such as glutamate into an electroactive molecule that can then be oxidized by the electrode surface. Using chitosan as an immobility matrix to trap the enzymes onto the electrode surface we change the properties of the probe and characterize these changes through potentiated readings as well as confirm working detection through FSCV.

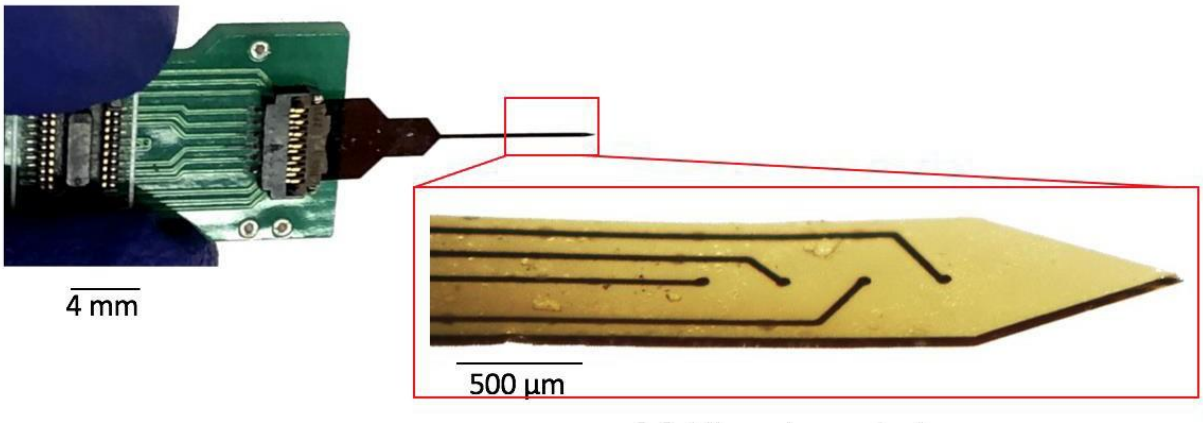

Figure 1: Glassy carbon microelectrodes connected to a PCB board

*corresponding author: kassegne@sdsu.edu

Green synthesis of silver nanoparticles using microalgae acclimated to high CO_2

Shirley Mora-Godínez[1], Fausto Abril[1], and Adriana Pacheco[1*]

[1]Tecnológico de Monterrey, Campus Monterrey, Monterrey, Mexico

Green synthesis of metallic nanoparticles using biological molecules represents a cost-effective and environmentally friendly alternative. Several microalgae species have shown potential, where enzymes and biomolecules such as polysaccharides, pigments and peptides are hypothesized to be responsible for the reduction of metal ions. Even more, this application of microalgae biomass could represent an interesting byproduct of CO2 mitigation systems. The objective of this study was to analyze the effect of pH and the use of cells or supernatant on production of silver nanoparticles (AgNPs) using an environmental microalgae Desmodesmus abundans acclimated to low CO2 (0.04%, LCA strain) and high CO2 (50%, HCA strain) compared to a collection strain, Spirulina platensis. Triplicates of cultures were harvest at exponential growth by centrifugation and washed to remove the supernatant, when necessary. The pellet was resuspended in 10 mM AgNO3 solutions at pH 5, 7.5 and 11. Then, solutions were incubated under continuous light for 40 h at 24 °C. Filtrated solutions (0.2 µm) were analyzed with UV-visible absorption spectra to confirm formation of AgNPs, Fourier transform infrared (FTIR) to evaluate presence of organic compounds and, finally, silver was confirmed by energy-dis persive X-ray spectroscopy (EDS). Also, size and zeta potential were determined using a Zetasizer. Results showed that microalgae acclimated to different CO2 concentrations showed drastic differences in AgNPs formation. No nanoparticles were observed with strain LCA, only at pH 11 using the cell biomass (no supernatant present) large diameter AgNPs (127.8 ± 14.8 nm, -26.7 ± 2.4 mV) were observed. In contrast, the HCA strain showed the smallest nanoparticles with the lowest zeta potential (14.9 ± 6.4 nm, -32.7 ± 5.3 mV) in this condition. However, when the supernatant was conserved, HCA strain exhibited AgNPs in all pH solutions but with larger sizes. Even though the supernatant alone (no cells present) showed reducing potential, 3.5 times larger particles were obtained (51.8 ± 20.7 nm, -17.4 ± 1.3 mV). The collection strain, S. platensis, also showed AgNPs in all pH solutions with similar results as the HCA strain at pH 11 (18.3 ± 7.5 nm, -33.9 ± 2.4 mV). In conclusion, microalgae represent a platform for green synthesis of metallic nanoparticles, where the species, pH and presence of supernatant are of relevance. Particularly, microalgae grown under high CO2 atmospheres seemed to potentiate synthesis of AgNPs with interesting properties.

*Corresponding author: adrianap@tec.mx

Research on Structural and Optical Properties of Superlattice Tin/CrN Nanocoatings on glass via PVD sputtering

Luis L-Garza[1], J.A. Aguilar-Martínez[2], Mónica M-Vázquez[1], Rodrigo Cue-Sampedro[*1]

[1]Tecnológico de Monterrey, Monterrey, 64849, México
[2] Universidad Autónoma de Nuevo León, Monterrey, 66600, México

CrN and TiN are ceramic materials used in a variety of coating applications relating to tribological enhancements in material science. This work intents to research into structural and optical properties combining CrN and TiN ceramics into superlattice coatings over glass substrate. This research seeks to correlate the structural properties with its optical behavior in the transition from thin film to superlattice. For this, thin films, multilayers and superlayer of TiN / CrN were deposited by reactive magnetron sputter deposition. These films were characterized by UV-Vis spectroscopy for optical properties and GI-XRD for structural properties.

*corresponding author: rodrigo.cue.sampedro@tec.mx

Fabrication and Preliminary Characterization of Glassy carbon on Flexible substrate interdigitated supercapacitor

O. Nunez Cuacuas[1], S. Kassegne[2] and S. Nimbalkar[2]

[1]San Diego State University, San Diego, 92182, U.S.A

Improved energy storage technologies have received intense attention since there is a fast- growing market for portable electronic devices. Micro-supercapacitors possess a remarkable feature of high electrochemical performance and relatively small volume in which they can reach high power density and fast charge-discharge rates. In contrast to batteries, they have longer life cycles without losing significant energy storage capacity. We developed a novel integrated, flexible glassy carbon micro- supercapacitor technology with 30 interdigitated fingers as seen in figure 1. We compacted the complete electrical routing path and contact pads within the device´s area, utilizing through-via bottom electrodes. The contact electrodes enable surface-mounting of multiple single devices side by side on a patterned circuitry substrate, achieving ultracompact flexible glassy carbon micro-supercapacitor modules. The device showed a capacitance of 62930 μF, an energy density of 19.2 $\mu J/cm$ and power density of 370 $\mu W/cm$.

Figure 1: Interdigitated glassy carbon electrodes with 30 fingers

Corresponding author: kassegne@sdsu.edu

Fabrication of pyrolytic carbon microneedles by de-focused maskless lithography

Long Quang Nguyen[*,1], Sheida Esmail Tehrani[1], Thomas Aarøe Anhøj[1] and Stephan Sylvest Keller[1]

[1]DTU Nanolab, Technical University of Denmark, 2800 Kgs. Lyngby, Denmark

In the past few decades electrochemical sensors have become widespread for biosensing due to their fast response, cost-effectiveness, easy miniaturization and high sensitivity [1]. These electrochemical sensors also have high potential to be combine with carbon-based materials such as carbon nanotubes (CNT) or graphene to improve the sensitivity and selectivity by increasing the electrode surface area. Recently, pyrolytic carbon electrodes have been applied in electrochemical sensors due to their conductivity and excellent electrochemical properties. Furthermore, 3D structures of pyrolytic carbon have been fabricated as working electrode for electrochemical sensors [2, 3].

Here, for in vitro electrochemical sensing, the pyrolytic carbon microneedles are introduced with the prospective application as working electrode for *in vivo* electrochemical sensing. Microneedles have been used as devices for minimally invasive sampling of body fluid. In Microelectromechanical systems (MEMS) technologies, microneedles were fabricated with many different materials such as silicon [4], metals [5] or polymers [6] by many different methods [7]. The most popular method for preparing microneedles is the molding technique where a master mold is created followed by a secondary mold replicated in PDMS. Finally, the microneedles are fabricated by the PDMS mold. However, for using microneedles as the sensing device, either the needles themselves have to be conductive or another conductive material needs to be coated on top of the needles. Therefore, the molding technique is not suitable for integrated electrical measurement. By using pyrolytic carbon microneedles which themselves are conductive, the application of microneedles as sensing device is possible. Until today, SU-8 is still one of the best precursor materials for fabricating pyrolytic carbon structures. In our study, by exploring the novel technique called de-focused maskless lithography (DFML), we are able to use SU-8 to fabricate arrays of pyrolytic carbon microneedles with sharp tips as working electrode in a 3-electrodes configuration for electrochemical sensing.

In DFML, the physical mask for fabrication is not required. A laser was used for direct writing of structural patterns on the photoresist layer. In direct laser writing, the laser light is usually focused on the surface of the photoresist. However, when the photoresist layer is thick enough the laser light is de-focused inside the photoresist layer. By using this feature, the structure of microneedles with sharp tip is formed. The microneedles with a height of 87.6±0.7 µm are fabricated on top of another layer of SU-8 (17 µm) which is patterned by conventional UV photolithography. After patterning, all the SU-8 structures are pyrolyzed at 1100$_{o}$C in inert atmosphere to form pyrolytic carbon electrodes (44.8±0.4 µm) with 284 microneedles on top. Finally, the microneedle electrodes are characterized by electrochemical techniques. This electrode shows the potential to work as bio electrochemical sensor.

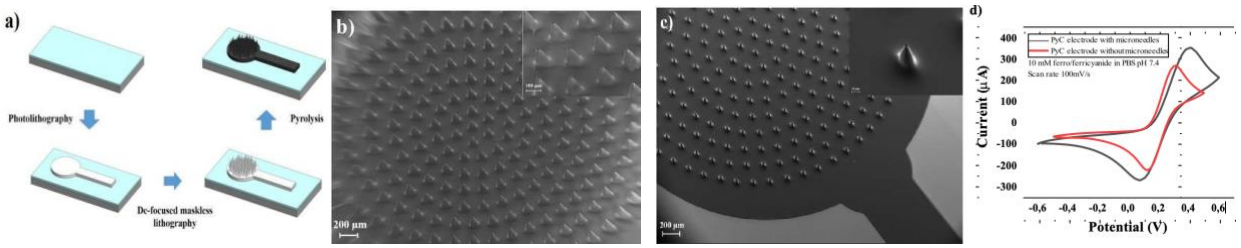

Figure 1: a) Fabrication process of pyrolytic carbon microneedles electrode, b) SEM image of the SU-8 microneedle with a height of 87,6±0,7 µm, c) SEM image of pyrolytic carbon microneedle with a height of 44,8±0,4 µm and d) Cyclic voltammetry characterization of the PyC microneedles electrode.

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*corresponding author: longq@dtu.dk

Preparation of electrospun fibers of Poly(L-lactide-co-D,L-lactide) with Na2Ti6O13, Ca3(PO4)2 and ZrO2 as a bioactive mesh.

Tejeda-Alejandre R.,[1] Ramírez-Cedillo E. [1] and Ortega-Lara W.[*1,2]

[1] Tecnologico de Monterrey, Escuela de Ingeniería y Ciencias, Av. Eugenio Garza Sada #2501 Sur, Monterrey, NL 64849, Mexico

[2] Laboratorio Nacional de Manufactura Aditiva y Digital (MADIT), Autopista al Aeropuerto, Km., 9.5, Calle Alianza Norte #100, Parque PIIT, Apodaca, NL 66629, Mexico

The formation of apatite is crucial on the regeneration process of a bone and soft tissue. In the field of tissue engineering membranes, fibers and composites have been implemented to help the body and accelerate the healing of bones (1). Several manufacturing processes have been used for the fabrication of these medical devices where electrospinning has been well recognized for its formation of fibers with random pattern which mimic the extracellular structure of cells (2).
In this study, morphology and diameter size distribution was analyzed with SEM, the meshes were chemically characterized with EDX, FTIR and XRD. Average diameter size of the meshes were in the range 5.58 - 7.28 µm. P(L/DL)LA/$Na_2Ti_6O_{13}$ and P(L/DL)LA/$Ca_3(PO_4)_2$ presented normality on the distributions with a $p<0.05$. Preliminary bioactivity results through different time proved that apatite formation was found on the meshes according to the EDX and FTIR analysis.

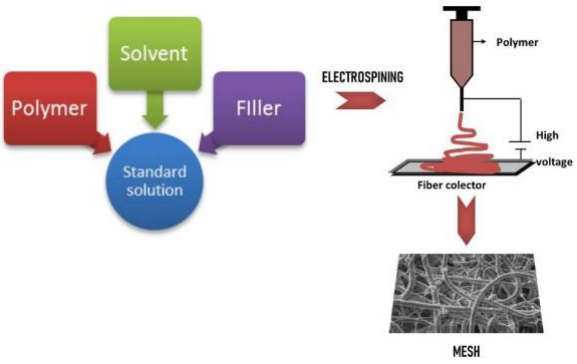

Figure 1. Schematic representation of methodology using a electrospinning technique.

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*corresponding author: wlortega@tec.mx

Surface modification of PLGA loaded resveratrol nanoparticles for the improved delivery of resveratrol in H9c2 cells induced by Ang II to hypertrophy

Héctor E. Flores-Hernández[1], Gerardo García-Rivas[1,2], Omar Lozano-García[1,2]

[1]Cátedra de Cardiología y Medicina Vascular, Escuela Nacional de Medicina, Tecnológico de Monterrey.
[2]Centro de Investigación Biomédica, Hospital Zambrano-Hellion, Tecnológico de Monterrey. Address: Av. Eugenio Garza Sada 2501 Sur, Monterrey, N.L., México 64710. Tel: (81)-8888-0471.

Nowadays 17.9 million of death are caused by cardiovascular disease (CVDs) annually, contributing to 31% of all deaths worldwide [1]. Amongst CVDs, hypertrophy of the heart is a common symptom of these pathologies, associated with excess production of reactive oxygen species (ROS) [2]. Resveratrol (RSV) is a powerful antioxidant, a stilbene, which has demonstrated protective effects as an antioxidant and anti- inflammatory agent in endothelial in vitro experiments, however limited results have been observed in in vivo experiments [3], [4]. Despite this, development of RSV to prevent and control heart diseases such as heart failure and pulmonary arterial hypertension has been sought, where challenges to delivery are due to poor solubility, low half-life and low bioavailability [5]. To overcome those limitations nanotechnology has allowed the development of new systems to improve its pharmacokinetic profile based on nanomaterials such as polymeric nanoparticles (NPs). In this work, PLGA NPs encapsulating RSV was synthetized by an evaporation method of O/W emulsion to reduce hypertrophy in H9c2 model induced by Ang II. We have developed two different formulations with different charges, one by surface covalent modification using glycol chitosan (CS), and another with only PLGA NPs given a shift on the surface potential respect from PLGA NPS of -13.3 ± 0.97 mV to 15 ± 1.10 mV with glycol chitosan. Their hydrodynamic diameters were 145.97 ± 0.97 and 300 ± 6.34 nm for PLGA-RSV and PLGA-RSV-CS. The NPs drug loading is 15.83% for both systems. Each nanoparticle system was characterized by infrared spectroscopy, in order to confirm the covalent functionalization, we observed a characteristic peak for esters in case of PLGA given by C-O and C=O stretching (1750 cm-1, 1100 cm-1 and 1000 cm-1) and in case of glycol chitosan we observed a peak at 1650 cm-1 given by N-H bending of primary amine. A release profile was performed simulating cytosol and endosome conditions. H9c2 cells where used in a hypertrophy model, with RSV was delivered through the SP NPs or freely, finding a reduction in hypertrophy in the SP NPs RSV administration.

Reference:

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[4] O. Lozano et al., Oxid. Med. Cell Longev., article ID. 7683051. 2019
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Corresponding author: omar.lozano@tec.mx

WORKSHOPS

WS-01: LOC Devices Prototyping

Number of Participants: 8
Organizer and Instructor: Roberto Gallo (rgallo@tec.mx)
Instructor: Alejandro Lujambio (alejandrolujang@gmail.com)
Location: Microfluidics Lab, CETEC Ground Floor

WS-02: CD-Microfluidic Devices Prototyping

Number of Participants: 8
Organizer and Instructor: Mehdi Aeinehvand (m.aeinehvand@tec.mx)
Location: CETEC Ground Floor

WS-03: Cancer Nanotechnology: Cellular Nanovesicle Recovery from Cancer Cell Lines

Number of Participants: 25
Organizer: José González
Instructors: Javier Donoso,Sergio Ayala
Location: Enzymology Lab, Biotec 2nd floor

WS-04: Preparation of Liposomes

Number of Participants: 10
Organizer and Instructor: Daniel Guajardo, Katya Huesca
Location: Bioprocesses Lab, Biotec 1st floor

WS-05: Electrospinning Technology

Number of Participants: 10
Organizer and Instructor: Daniel Guajardo
Location: Bioprocesses Lab, Biotec 1st floor