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INM COLLOQUIUM

"TAPERED OPTICAL FIBERS TECHNOLOGY FOR MULTIFUNCTIONAL NEURAL INTERFACES"

Dr. Ferruccio Pisanello – REMOTE!
IIT – Center for Biomolecular Nanotechnologies, Arnesano LE, Italy

Wednesday, March 18, 2020 1:30 pm
INM, Leibniz-Saal, Campus D2 5
Host: Prof. Dr. Aránzazu del Campo

Last decade has seen the development of a set of technologies to access sub-cortical regions of the mouse brain, with the main goal to obtain fully-integrated implantable devices enabling optical control and monitor neural activity, extracellular readout and localized drug delivery. These approaches include the use of integrated optoelectronic elements on both flexible or stiff substrates, multifunctional polymeric optical fibers, micro and nanophotonic circuits, as well as tapered optical fibers [1-11]. After a review of the state-of-the-art in this field, this presentation will focus on the engineering and use of multifunctional tapered optical fibers to control and monitor neural activity using only one optical waveguide with reduced invasiveness. The technology exploits mode-division demultiplexing operated by a millimeters-long taper that allows to redirect and/or collect light over different brain regions and subregions [11]. Exploiting micro and nanotechnologies to structure the highly curve surface of the fiber taper, it is possible to engineer the stimulation and the collection volume, as well as to realize multiple electrodes for extracellular electrophysiology along the taper. The simplicity of this technique, together with its versatility and reduced invasiveness, indicate this approach can greatly complement the set of existing methods for multifunctional neural interfaces with deep brain regions.

1. Grosenick et al, Neuron 86, 106 (2015)

2. F. Pisanello et al, Frontiers in neuroscience 10, 70 (2016)

3. Wu et al, Neuron 88 1136 (2015)

4. Scharf et al, Scientific Reports 6, 28381 (2016)

5. Moretti et al, Biomedical Optics Express 7, 3958 (2016)

6. Lee et al, Nat. Methods 12, 1157 (2015)

7. F. Pisanello et al Neuron 82, 1245 (2014)

8. M. Pisanello et al Biomedical Optics Express 6, 4014 (2015)

9. F. Pisanello et al, Nature Neuroscience 20, 1180 (2017)

10. M. Pisanello et al, Scientific Reports 8, 4467 (2018)

11. F. Pisano et al, Nature Methods 16, 1185 (2019)

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INM COLLOQUIUM

"BIOELECTRONICS WITH NANOCARBONS - BRIDGING THE GAP BETWEEN THE DIGITAL WORLD AND THE SOFT AND SQUISHY WORLD"

Assoc. Prof. Dr. Itzhaq Cohen-Karni – REMOTE!
Carnegie Mellon University, Pittsburgh PA, USA

Wednesday, March 19, 2020, 2:30 pm

INM, Leibniz-Saal, Campus D2 5
Host: Prof. Dr. Aránzazu del Campo

The interface between nanoscale electronic devices and biological systems enables interactions at length-scales natural to biology, maximizing communication between these two diverse yet complementary systems. Such nano-bio interfaces offer better sensitivity and spatial resolution as compared to conventional planar structures. We focus on developing a new class of nanoscale materials and novel strategies for the investigation of biological entities at multiple length scales, from the molecular level to complex cellular networks. Our highly flexible bottom-up nanomaterials synthesis capabilities allow us to form unique hybrid-nanomaterials that can be used in various input/output bioelectrical interfaces. For example, we have developed several bioelectrical platforms based on graphene, a two-dimensional (2D) atomically thin carbon allotrope. We have demonstrated recording of the electrical activity of excitable cells with graphene-based ultra-microelectrodes as small as the size as an axon ca. 2µm in size. Using graphene-based hybrid-nanomaterials, we have formed remote, non-genetic bioelectrical interfaces with excitable cells and modulated cellular and network activity with high precision and low needed power. We have also developed a breakthrough bioelectrical interface, a 3D self-rolled biosensor arrays (3D-SR-BAs) of either active field effect transistors or passive microelectrodes to measure both cardiac and neural spheroids electrophysiology in 3D. Our approach enables electrophysiological investigation and monitoring of the complex signal transduction in 3D cellular assemblies toward an organ-on-an-electronic-chip (organ-on-e-chip) platform for tissue maturation investigations and development of drugs for disease treatment. In summary, the exceptional synthetic control and flexible assembly of nanomaterials provide powerful tools for fundamental studies and applications in life science and open up the potential to seamlessly merge either nanomaterials-based platforms or unique nanosensor geometries and topologies with cells, fusing nonliving and living systems together.

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INM COLLOQUIUM

"ELECTRONICS ON THE BRAIN"

Prof. Dr. George Malliaras
University of Cambridge, UK

Wednesday, March 18, 2020, 4:00 pm

INM, Leibniz-Saal, Campus D2 5
Host: Prof. Dr. Aránzazu del Campo

One of the most important scientific and technological frontiers of our time is the interfacing of electronics with the human brain. This endeavour promises to help understand how the brain works and deliver new tools for diagnosis and treatment of pathologies including epilepsy and Parkinson's disease. Current solutions, however, are limited by the materials that are brought in contact with the tissue and transduce signals across the biotic/abiotic interface. Recent advances in electronics have made available materials with a unique combination of attractive properties, including mechanical flexibility, mixed ionic/electronic conduction, enhanced biocompatibility, and capability for drug delivery. I will present examples of novel devices for recording and stimulation of neurons and show that organic electronic materials offer tremendous opportunities to study the brain and treat its pathologies.

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INM COLLOQUIUM

"HYDROGEL-BASED ELECTRONICS: ULTRACOMPLIANT ELECTRODES FOR NEURAL INTERFACES AND BEYOND"

Prof. Dr. Christopher Bettinger
Carnegie Mellon University, Pittsburgh, PA, USA

Thursday, March 18, 2020, 10:00 am

INM, Leibniz-Saal, Campus D2 5
Host: Prof. Dr. Aránzazu del Campo

Implantable neural interfaces underpin many technologies that rely on recording and stimulating neuronal activity from organs in the central and peripheral nervous systems. Reliable and stable chronic recording from excitable tissues using implantable multielectrode arrays has been elusive to date due, in part, to host tissue interactions that contribute to device failure. Local tissue damage and device failure is worsened by the mechanical mismatch between materials used to fabricated rigid silicon-based microfabricated multielectrode arrays (EMEA ~ 100 GPa) and tissues in the nervous system (EPNS ~ 10 kPa). Hydrogel-based electronics could reduce the mechanical mismatch across the tissue-device interface and enhance performance. Here we present materials and companion fabrication strategies to create ultracompliant electronic devices for use in peripheral nerve interfaces. Integrated strategies for polymer synthesis, processing, and microfabrication are described. Details regarding the in vitro and in vivo performance of these devices will also be presented.

Short bio

Christopher Bettinger is a Professor at Carnegie Mellon University in the Departments of Materials Science and Engineering and Biomedical Engineering. He directs the laboratory for Biomaterials-based Microsystems and Electronics at CMU, which designs materials and interfaces to integrate medical devices with the human body. Chris has published over 80 articles and has been issued over 10 patents. Chris has received honors including the National Academy of Sciences Award for Initiatives in Research, the MIT Tech Review TR35 Top Young Innovator under 35, and the DARPA Young Investigator Award. Prof. Bettinger is also a co-inventor on several patents and Co-Founder and CTO of Ancure, an early stage medical device company. Prof. Bettinger received an S.B. in Chemical Engineering, an M.Eng. in Biomedical Engineering, and a Ph.D. in Materials Science and Engineering as a Charles Stark Draper Fellow, all from the Massachusetts Institute of Technology. He completed his post-doctoral fellowship at Stanford University in the Department of Chemical Engineering as an NIH Ruth Kirschstein Fellow.

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INM COLLOQUIUM

"HIGHLY MINIATURIZED SOFT, WIRELESS AND BATTERY-FREE BIO INTERFACES"

Asst. Prof. Dr. Philipp Gutruf
The University of Arizona, Tucson, AZ, USA

Thursday, March 19, 2020, 11:00 am

INM, Leibniz-Saal, Campus D2 5
Host: Prof. Dr. Aránzazu del Campo

Recent advances in materials and fabrication concepts for the creation of soft electronics coupled with miniaturization of wireless energy harvesting schemes enable the construction of high-performance electronic and optoelectronic systems with sizes, shapes and physical properties matched to biological systems. Applications range from continuous monitors for health diagnosis to minimally invasive exploratory tools for neuroscience.

This talk introduces science and engineering aspects for the creation of soft devices with near field power transfer and data communication capabilities and discusses application in imperceptible body-worn devices for the assessment of hemodynamics, sweat and thermal properties of the skin.

Following advances in resonant power transfer opportunities for highly miniaturized embodiments arise and result in devices that can be deployed as subdermal neuroscience tools for wireless recording and stimulation of genetically targeted cell populations. These highly miniaturized systems enable untethered, operation for behavioral studies that eliminate motion constraints and enable new experimental paradigms in a range of complex 3D environments and contexts that cannot be explored with conventional technologies. We extend this concept to devices with capabilities in multimodal stimulation of the brain and the peripherals resulting in a broad suite of modulation and recording tools for the nervous system and major organs such as the heart.

In conclusion the talk introduces highly miniaturized wireless battery free sensors and stimulators that match mechanical and physical properties of biological systems to deliver clinical grade data streams and unparalleled stimulation capabilities that surpass performance of contemporary rigid systems through highly intimate contact.