CPP 9: Biomaterials and Biopolymers (joint session BP/CPP)

Time: Monday 15:00–16:45 Location: H46

CPP 9.1 Mon 15:00 H46

Ferroelectric Microelectrodes for Hybrid Neuroelectronic Systems — •Maximilian T. Becker[1,2], Roland Thewes[3], and Günther Zeck[4] — [1]Department of Embedded Systems, Hahn-Schickard, Freiburg, Germany — [2]Faculty of Engineering, University of Freiburg, Freiburg, Germany — [3]Chair of Sensor and Actuator Systems, TU Berlin, Berlin, Germany — [4]Institute of Biomedical Electronics, TU Wien, Vienna, Austria

Direct electrical interfacing of semiconductor chips with individual neurons and neural networks forms the basis for a systematic assembly and investigation of hybrid neuroelectronic systems with future applications in information technology and biomedicine. The neuroelectronic interface is realized via microelectrodes to bidirectionally transmit electrical signals between neurons and the semiconductor chip. Here, we introduce the concept of ferroelectric microelectrodes and discuss the physics of ferroelectric interfaces in neuroelectronic applications. As an example, we present neural recordings from retinal ganglion cells (RGCs) interfaced with a ferroelectric complementary metal-oxide-semiconductor microelectrode array (CMOS-MEA) and discuss the results in detail.

CPP 9.2 Mon 15:15 H46

Highly sensitive, specific and label-free detection of SARS-CoV-2, Influenza A and RSV proteins via surface plasmon resonance technique using the biofunctionalization with 1 nm thick carbon nanomembranes — •Ghazaleh Eshaghi[1], David Kaiser[1], Hamid Reza Rasouli[1], Rania Ennaciri[1], Martha Frey[1], Christof Neumann[1], Dominik Gary[2], Tobias Fischer[2], Katrin Frankenfeld[2], and Andrey Turchanin[1] — [1]Institute of Physical Chemistry, Friedrich Schiller University Jena, 07743 Jena, Germany — [2]Forschungszentrum für Medizintechnik und Biotechnologie (fzmb) GmbH, 99947 Bad Langensalza, Germany

Accurate and rapid detection of respiratory viruses like SARS-CoV-2, Influenza A and RSV is crucial for improving global health outcomes. We present a novel surface plasmon resonance (SPR) platform using a biofunctionalized 1 nm-thick carbon nanomembrane (CNM) for enhanced viral protein detection. The azide-modified CNM (N3-CNM) enables covalent antibody binding, ensuring selective immobilization of target proteins. Our platform achieves equilibrium dissociation constants (KD) of 570 * 30 pM and 22 * 3 pM for SARS-CoV-2 nucleocapsid and spike proteins, with detection limits (LODs) of ˜190 pM and ˜10 pM, respectively. For Influenza A and RSV, KD values are 86 * 4 pM and 3 * 0.2 pM, with LODs of ˜90 pM and ˜2 pM. Multiplexed detection with no cross-reactivity supports rapid, accurate point-of-care diagnostics. Validation with nasopharyngeal swabs confirms a LOD of ˜40 pM for SARS-CoV-2 spike protein, highlighting CNMs' promise in infectious disease diagnostics.

CPP 9.3 Mon 15:30 H46

Superselective multivalent client recruitment in biomolecular condensates — •Xiuyang Xia and Erwin Frey — Ludwig-Maximilians-Universität München

Biomolecular condensates (BMCs) are membraneless organelles formed via liquid-liquid phase separation, playing a crucial role in organizing cellular functions by selectively concentrating specific molecules. In this talk, I will present a new theoretical framework that models multivalent client recruitment in valence-limited, multicomponent systems like BMCs. We uncover how enthalpic and entropic factors interplay under valence constraints to enable switch-like recruitment and precise compositional regulation.

This work advances our understanding of the principles governing BMC composition and highlights the broader significance of multivalency in biological systems, offering insights into cellular organization and potential therapeutic applications.

CPP 9.4 Mon 15:45 H46

What is the structure of a biomolecular condensate? — •Charlotta Lorenz[1,2], Teagan Bate[1], Takumi Matsuzawa[1], Kaarthik Varma[1], Sully Bailey-Darland[1], George Wang[1], Dana Matthias[1], Harsha Koganti[2], Nicola Galvanetto[2], Matti Valdimarsson[2], Aleksander Rebane[3], Etienne Jambon-Puillet[4], Ben Schuler[2], and Eric R. Dufresne[1] — [1]Cornell University, Ithaca, NY, USA — [2]University of Zurich, Zurich, Switzerland — [3]New York University Abu Dhabi, Abu Dhabi, United Arab Emirates — [4]École Polytechnique Paris, Paris, France

Biomolecular condensates are important for a variety of cellular functions, such as biochemical regulation, structural organization, and RNA metabolism. While the properties and physiology of these condensates depend on their structure, this important aspect has received little experimental consideration. On the other hand, recent simulations of disordered proteins with interactions based on the sticker-and-spacer suggest fascinating structures in the bulk and surface of condensates. We aim to reveal the structure of biomolecular condensates using X-ray scattering. Here, we will present results for a simple model system and apply our approach to the structure of condensates made of disordered proteins. We particularly consider the change in condensate structure due to small molecules.

CPP 9.5 Mon 16:00 H46

Encoding how shear stress during gelation boosts the stiffness of collagen networks — •Pavlik Lettinga[1,2], Lens Dedroog[2], Olivier Deschaume[2], Yovan de Coene[2], Carmen Bartic[2], Erin Koos[2], and Mehdi Bouzid[3] — [1]Forschungszentrum Jülich — [2]KU Leuven — [3]Université Grenoble Alpes

Collagen is one of the main building blocks of the mammalian extracellular matrix, due to its ability to form tough structures with a wide variety of non-linear mechanical properties allowing it to support multiple tissue types. However, the mechanical properties of collagen gels have been extensively studied under static conditions, whereas in nature gelation will mostly take place in the presence of flow. Here we show how the elastic modulus of collagen hydrogels can be increased up to an order of magnitude by applying a stress ramp at a well-defined moment during gelation. Where the first stress block induces most of the final strain and alignment, sequential increases in stress cause a dramatic increase of the modulus. This high modulus is preserved by keeping the high stress until the gel is fully matured. Coarse-grained simulations of a model gel system show that that the microscopic mechanism of inducing high stiffness is due to formation of extra cross bridges and could be very generic. Thus, we not only show that the true non-linear capabilities of biomaterials are tenfold higher than previously assessed, but also provide insight into in vivo structure formation of collagen and potentially other (bio-)polymers.

Invited Talk CPP 9.6 Mon 16:15 H46

In situ control of cells and multicellular structures at the microscale by two-photon lithography — •Christine Selhuber-Unkel — Heidelberg University, IMSEAM, Heidelberg, Germany

In vivo, cells and multicellular assemblies often experience strong confinement by their surrounding tissue environment, particularly in cancer. Thus, replicating these confined environments in situ is essential for investigating their impact on cellular systems. Using two-photon lithography, we printed structures directly within and around multicellular assemblies. For example, we fabricated dome-shaped confinements with micrometer-scale openings to encapsulate cancer spheroids. This enabled us to study how confinement influences cancer cell migration and spheroid behavior. Our findings revealed that confinement slows cell migration and alters actin dynamics. In addition, in situ printed structures can also directly interfere with migrating cellular assemblies. Additionally, elastic structures can be created to mechanically stimulate cells, offering further control over cellular behavior. Therefore, two-photon lithography proves to be a powerful tool for manipulating the growth, migration, and morphology of live cells, making it particularly useful for exploring how changing physical microenvironment in situ affect cell responses.