MSE 2024

24 - 26 Sep 2024 (Darmstadt)

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Topic B: Biomaterials

B07: Vertical nano and microstructures for cellular interrogation and manipulation

Motivation: Simple, controllable, and versatile access to the intracellular space as well as tuning cell networks with minimal perturbation is crucial to advancing new nanobioelectronic, sensing, therapeutic, and diagnostic technologies. Such emerging material-based technologies—broadly called vertical micro and nanostructures—are rapidly transforming our capacity to (i) interrogate and manipulate cells providing avenues to sense the intracellular environment, (ii) stimulate and record cellular electrical activity, (iii) target biophysical stimuli to intracellular compartments, (iv) sampling of cell states (nanobiopsy), and (v) transport hard-to-deliver drugs. Nanoneedles are right now rapidly transitioning from laboratory proof-of-principles to transformational approaches in cell and gene therapy, spatial biology, and neural modulation. This symposium will consolidate existing and emerging knowledge, comparing performance across nano and microstructures technology for intra and extra cellular interrogation and manipulation. Such symposium is essential for broadening the use of this technology across cognates research communities, and will significantly contribute toward the early commercial activities of the current and future vertical micro and nanostructure technology market.

First, the symposium will highlights the relevant design and manufacturing of passive and electroactive nanoneedle devices. In particular, showcasing how rational design and fabrication play crucial roles in achieving efficient and minimally-invasive nanoinjection (the use of nanoneedle for intracellular delivery). This will be achieved through presenting: (i) approaches for advanced nanoneedle manufacturing through micro and nano-fabrication methodologies, (ii) approaches available to control and regulate the physical and chemical properties of nanoneedles and their substrates to achieve desirable optimal interfacial interactions, and (iii) approaches for increasing nanoneedle technology readiness level by scaling up fabrication for translational uptake.

Second, the symposium will focus on designing and investigating the cell–nanoneedle interface. This will be achieved through presenting: (i) approaches for modelling of the biointerface to predict the underpinning mechanisms and dynamics of interactions between nanoneedles and cells as a function of the physicochemical properties of the nanostructures, of the cellular system and the target applications. The modelling comprises analytical, numerical, and machine learning approaches. (ii) experimental approaches to visualise, characterise and analyse the cell–materials interface across scales from the nanoscale interactions at the molecular level to the macroscopic interactions with tissues and organisms, comprising advanced electron microscopy strategy for high-resolution ultrastructural visualisation and optical microscopy approaches for quantitative, real-time biomolecular visualization. Critically, the symposium will probe the impact of biointerface design and characterisation and the methodologies to be developed in the transition from laboratory to a diverse landscape of applications the biomedical sector.

Third, the symposium will cover the widespread adoption of nanoneedles in emerging biomedical applications. These broadly include: the delivery of drugs and biologicals, in particular in vivo gene therapy alongside ex vivo cell and gene therapy; intracellular biosensing with a focus on longitudinal sampling of live systems and spatial biology; the stimulation and recording of electrical activity in complex networks of excitable cells; the high-precision biophysical interrogation of mechanosensitive elements of the cells. The symposium will discuss the potential market, the scale of interest and investment, regulatory issues, and approaches devised to address the challenges of translating a high-control minimal-invasiveness afforded by nanoneedles to the biomedical industry.

Bridging the worlds of medical technologies, bioengineering and material science, this transdisciplinary symposium will bring together the chemical, physical and biological aspects of emerging technologies for intracellular manipulation.

Symposium Organizer


Dr. Roey Elnathan
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Prof. Dr.-Ing. Francesca Santoro
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