



International Conference on Micro Nano Fluidics (ICOM 2025)



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Tentative topic of the invited talk

Organ-on-a-chip: The new microfluidic machine for biological research

Abstract of the invited talk

Organ-on-a-chip (OOC) is an emerging technology which replicates the functions of human organs on a microfluidic chip. It holds significant potential for advancing research in tissue development, organ physiology, and the underlying causes of diseases. Microfluidics is a crucial element in OOC design, enabling the creation of stable concentration gradients, fluid shear stress variations, thermal gradients, dynamic mechanical stress simulations, and precise reconstruction of the cellular microenvironment. OOC offers the distinct advantage of allowing full observation and control of the system that are difficult to achieve in traditional in vitro cell culture models. The introduction of polydimethylsiloxane (PDMS) as a microfluidic structural material through soft-lithography has revolutionized device fabrication along with 3D printing which avoids expensive and complex mask making using silicon substrate. Its ease of molding into various shapes, combined with key properties such as transparency, biocompatibility, and gas permeability, has expanded the use of microfluidic devices across a wide range of biological research and clinical applications. Several studies have successfully recreated the functions of organs such as the kidneys, lungs, heart, and liver by integrating microfluidic systems, biocompatible materials, and sensing components to mimic physiological conditions and monitor cellular responses. In recent years, cardiac and kidney disorders have increasingly been linked to metabolic imbalances, primarily driven by hypertension and diabetes. Globally, nearly 85% of cardiac deaths result from heart attacks and strokes. In most heart patients, cardiovascular-related fatalities are primarily caused by myocardial injury induced by ischemia. Recently, heart-on-a-chip microfluidic platforms have emerged as effective in-vitro models for assessing drug-induced cardiotoxicity. Likewise, chronic kidney disease (CKD) represents a significant global health burden, with a rising prevalence and limited treatment options, including dialysis. In our studies, we primarily focus on developing heart- and kidney-on-chip models that replicate physiological and pathological conditions such as ischemia, while also investigating the influence of curvature on cell function and analyte transfer across different nephron segments to closely mimic the biophysical aspects of human physiology. Also, different human organs experience varying levels of mechanical stimulus, which directly influence the morphology and function of their cells and tissues under both normal and diseased conditions. Hence, it is crucial to understand how cardiac and renal cells respond in terms of proliferation under varying magnitudes of mechanical stimulus. Investigating the influence of mechanical and chemical stimulus and their interplay can significantly advance our understanding of heart and kidney pathophysiology, ultimately aiding in improved disease diagnosis and treatment strategies.