Abstract
Nanometer-scale fluidic channels have drawn tremendous research attention in recent years due to their unique electrokinetic properties and immense potential for developing novel applications. Surface charge-induced electric double layer (EDL) has been demonstrated to regulate ion transport in nanochannels, especially at low ionic strength. Beyond a certain threshold concentration of electrolyte, nanofluidic channels have been reported to become ion-perm selective and cause an unusual phenomenon known as ion concentration polarization (ICP). The exclusive physical properties of ICP, nonlinear current-voltage (I-V) characteristics being the most significant one, have been extensively studied in nanoslots. However, there is a distinct lack of studies on characterization of ICP in nanochannels imposing higher degree of confinement, such as nanocapillaries and nanopores, also known as one-dimensional (1-D) channels.

This thesis presents an elaborate study of ion concentration polarization in self-enclosed cylindrical glass nanocapillaries, with a nominal diameter of 70 nm, realized through a unique process involving low resolution photolithography and standard fabrication techniques. First, numerical simulation has been conducted to evaluate the effect of surface conduction in ICP and the results indicate that a high surface charge density in the channel walls can obscure limiting current region from the I-V characteristics. Later, a microfluidic platform was designed and fabricated with varying physical parameters, such as inter-capillary separation and capillary array size. The results obtained from a single capillary device showed linear I-V characteristics for lower ionic strengths ($\leq 10$ mM), which may indicate the masking of limiting current due to strong surface conduction. The results also showed the inter-capillary separation to modulate the onset-voltage of limiting current regime in the I-V characteristics. Additionally, results obtained from high concentration KCl ($\geq 100$ mM) revealed ICP to appear without the presence of perm-selectivity in the nanochannel. Finally, a highly efficient microfluidic sample preconcentration device utilizing electrokinetic trapping mechanism enabled by the permselective glass nanocapillaries is presented in this report, which has achieved concentration factor as high as $10^6$ in less than 50 minutes.

Date: 14 Aug 2019 (Wednesday)
Time: 3:00 pm
Venue: Room 4582 (Lifts 27-28)

Examination Committee:
Prof. Shuhuai Yao (Chair)
Prof. Levent Yobas (Supervisor)
Prof. Hongkai Wu

All are welcome!