Covalent Surface Modifications of Silicon Nitride Nanopores and the Development of a Fluidic Control Apparatus and Nanopore Characterization Method

PhD Seminar

Brian Sheetz
Department of Chemistry
University of Rhode Island

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Scientific fields exploring topics such as DNA, RNA, proteins, and glycans have embraced the use of nanopores as a robust and reliable molecular sensor platform for sequencing and single molecule analysis. Solid-state nanopores show promise in expanding the sensing platform's capabilities towards proteomics and even the complex challenges of glycomics. Nanopores formed in thin films of silicon-rich silicon nitride represent a class of solid-state nanopores that not only provide a single molecule analysis platform capable of classifying glycans but also demonstrate the ability to be custom-tailored for specific analytes and measurements using covalent surface modifications. Surface modification on this class of nanopores has enabled researchers to gain control over some of the basic nanopore translocation physics and manipulate analyte translocation dynamics, enabling more information to be obtained from experiments. The work I am presenting describes the development of a fluidic control apparatus to characterize nanopores, and specifically, characterize controlled dielectric breakdown fabricated silicon-rich silicon nitride nanopores and hydrosilylation-based surface modifications. A form of the nanopore characterization method has been used in the past and has been hypothesized to take advantage of the nanopore dynamics mentioned above. Using CAD software and 3D printing, we designed and prototyped an apparatus to assist researchers in performing the nanopore surface modification characterization experiments. The presentation will walk through the challenges of development including conducting current measurements at a picoamp-nanoamp scale under electrolyte flow, EMI, 3D printing constraints, bubbles management, and flow regulation. The apparatus and characterization method were validated by replicating results through the analysis of previously defined surfaces: non-modified bare silicon nitride, and surfaces modified with 4-pentenoic acid, and allylamine by photo-initiated hydrosilylation. I will share these results as well as data highlighting novel measurements that describe characteristics of the silicon nitride nanopore platform and hydrosilylation-modified surfaces.