

Development of a Biomembrane Platform for the Study of Virus Infection

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Primary CNF Tools Used: Heidelberg DWL2000 Mask Writer, ABM Contact Aligner, Odd Hour E-beam Evaporator, Oxford PECVD, PT-740 etcher, Disco Dicing Saw, Bruker AFM, Malvern NS300 NanoSight

Abstract:

As a “label-free” alternative to optical sensing, electrical sensing represents a more feasible, reproducible, and scalable detection method for many biological processes.¹⁻² Among various electrical sensing techniques, the non-invasive electrochemical impedance spectroscopy (EIS) technique is especially suitable for accurately quantifying the bio-recognition events occurring at a variety of biointerfaces,³⁻⁴ such as bacterial, viral, cellular and synthetic lipid membranes. Our group has pioneered a microelectrode system that will support the self-assemble of lipid vesicles (SLBs) on the electrode surfaces, and their electrical properties (resistance, capacitance) can be extracted by applying an alternating voltage and recording the current response.⁵⁻⁷ In the past year, we reported a robust protocol to form SLB on such platform⁸ and we leveraged such platform to recreate viral infection of host cell and screen antibodies targeting different viral entry steps.⁹

Summary of Research:

To fabricate the microelectrode devices, photomasks were created using the Heidelberg DWL2000 Mask writer and used with the ABM Contact Aligner to pattern photoresist that was spun onto a fused silica wafer. A first layer of gold contact pad was patterned following the developing of S1813 photoresist and the deposition of Au thin film. A thin layer of SiO₂ insulating layer is then deposited directly on top of the Au contact pad using Oxford PECVD. Electrode area was then patterned on SiO₂ following the spin-coating and developing of the second layer of photoresist. PT-740 etched was then used to etch the exposed SiO₂ until Au contact pad has been exposed. A conductive polymer, PEDOT:PSS was then spun over the fused silica wafer followed by the deposition of a Germanium hard mask (odd hour e-beam evaporator). A third layer of photolithography was performed on a layer of negative photoresist (nLOF

2020) spun on top of Ge, where all resists above Ge at areas except active electrode surface were developed. Unprotected Ge and PEDOT:PSS underneath were then etched using PT-740. Ge on top of active electrode area was then etched in water bath overnight. Once the microelectrode device was fabricated, a PDMS well was stamped directly on top to create a reservoir for SLB self-assembling and allow following EIS measurement.

Conclusions and Future Steps:

The facilities and technical infrastructure provided by the Cornell NanoScale Science and Technology Facility (CNF) have been essential to the development of our SLB-integrated microelectrode platform. These capabilities directly supported our progress in establishing robust SLB formation, recreating virus–host membrane interactions and evaluating therapeutics targeting viral infection. Continued access to CNF will be critical as we further miniaturize the devices, improve fabrication reproducibility, and expand the platform toward higher-density and multiplexed bioelectronic sensing.

References:

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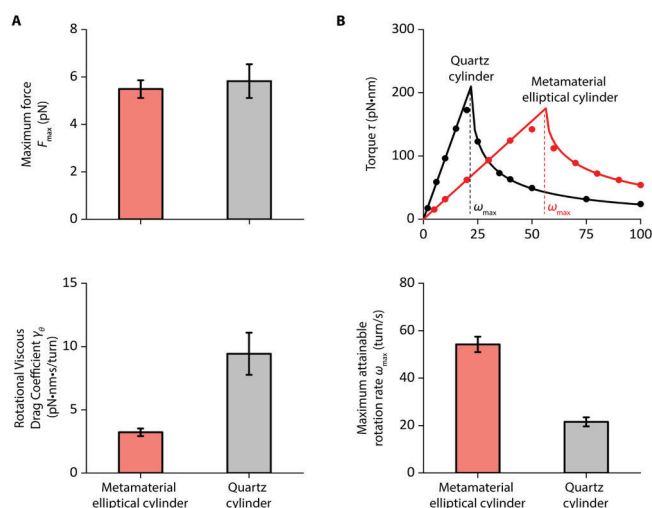


Figure 3: Trapping properties and maximum rotation rate of metamaterial elliptical cylinders. (A) Measurements of the maximum trapping force F_{max} (top panel) at 30 mW laser power before the objective and rotational viscous drag coefficient $\gamma\theta$ (bottom panel). (B) Method to determine the maximum trapping torque τ_{max} (top panel) and the maximum rotation rate ω_{max} (bottom panel) without slippage at 30 mW laser power before the objective.

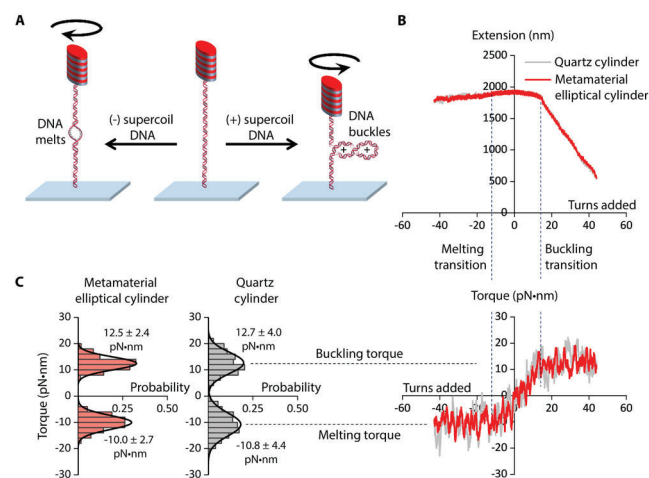


Figure 4: DNA torque measurements using a metamaterial elliptical cylinder; in comparison with those from a quartz cylinder. (A) experimental configuration for the measurements. (B) Measured DNA extension and torque as a function of turns added to DNA under 1 pN force. (C) Histograms of measured torque upon (+) DNA buckling and (-) DNA melting. Each histogram is fit by a Gaussian, with the mean and the SD of the fit shown.