Fabricating bimodal pore size membranes as a platform to understand nanoscale aqueous transport behavior

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Transport of nanoscale solutes through nanoscale pores is important for applications ranging from biotechnology to water treatment, yet the fundamental physics governing this transport are not fully understood. Recently, we predicted and demonstrated that using a silicon nitride (SiN_x) isoporous membrane templated from block copolymer self-assembly and dextran as analyte, solute transport can exhibit time-dependent behavior where the rejection rate of solutes smaller than the pore diameter decreases with increasing filtration time. This behavior, although consistent with traditional hindered transport theory, has not been previously reported—most likely due to the typical broad pore-size distribution of membranes. By systematically varying this distribution, one can develop an experimental platform to study this time-dependence and potentially identify processes to exploit it for enhanced separations.

We hypothesize that precise nanofabrication of bimodal membranes, rather than those with a continuum of pore sizes, will enable assessment of the impact of structural defects as well as flux partitioning. The membranes are quantitatively analyzed using transmission electron microscopy (TEM) and the scanning electron microscopy (SEM) in order to establish a full understanding of the membrane pore-size distribution. With long-duration filtration experiments, the bimodal membranes reveal new insights into nanoscale solute transport and separations.

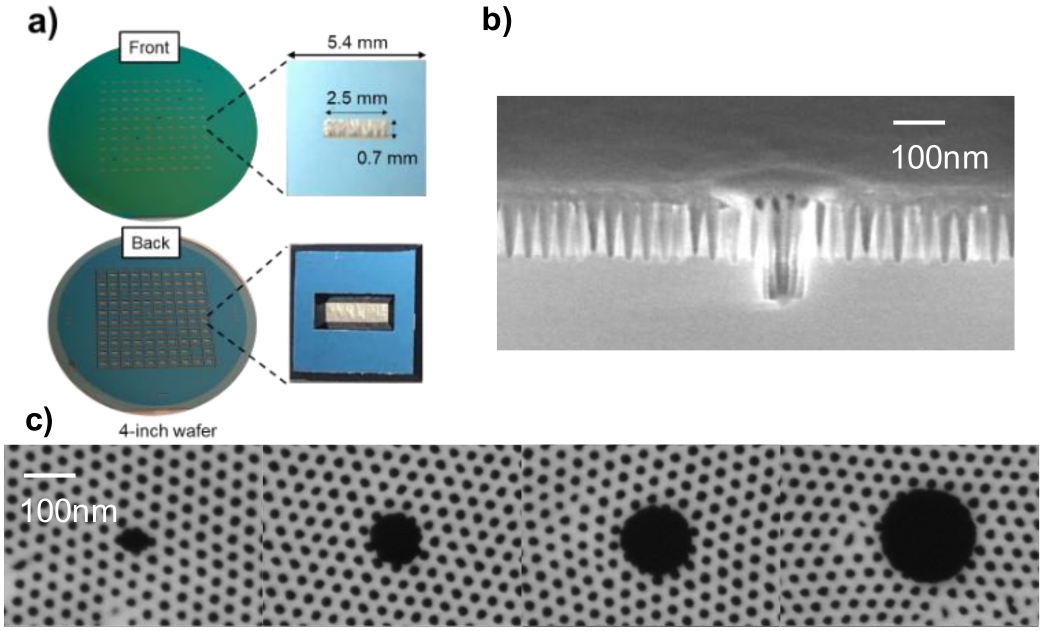

Figure 1: a) 100 chips each with a rectangle membrane window (2.5 cm × 0.7 cm) are produced on a 4-inch wafer. b) Cross section scanning electron microscopy (SEM) images of bimodal pore size membrane. c) SEM images of large pore embedded in isoporous membrane with a control of size.