Fabricating ultrathin isoporous membranes as a platform to understand nanoscale aqueous transport behavior

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Understanding of nanoscale transport behavior of aqueous ions and particles through membranes could be enabled by the realization of an experimental platform allowing systematic pore morphology control with high spatial resolution. The fabrication of membranes with homogeneity in structure and interfacial chemistry is critical to investigate complex nanoscale transport. Fabrication of membranes with well-controlled pore size and tortuosity, mechanical robustness, and sufficient membrane area has been a longstanding challenge.

We demonstrate that, by using a nanofabrication process built around block copolymer self-assembly and sequential infiltration synthesis, we are able to produce a nanoporous hexagonal alumina structure with a high etch selectivity to silicon nitride (SiN_x) and uniform pore morphology. Through controlling the etching chemistry, we successfully pattern transfer the cylindrical nanostructure to a 100-nm-thick SiN_x layer and release this ultrathin film in the air. Quantitive analysis of the pore-size distribution of an individual membrane and multiple membranes produced in a 4-in wafer reveals high reproducibility and reliability at wafer-level. With subsequent surface treatment, these pristine isoporous membranes can be further tuned to vary pore size and/or surface chemistry, which provides a powerful platform to inform a high-level understanding of fundamental transport processes.

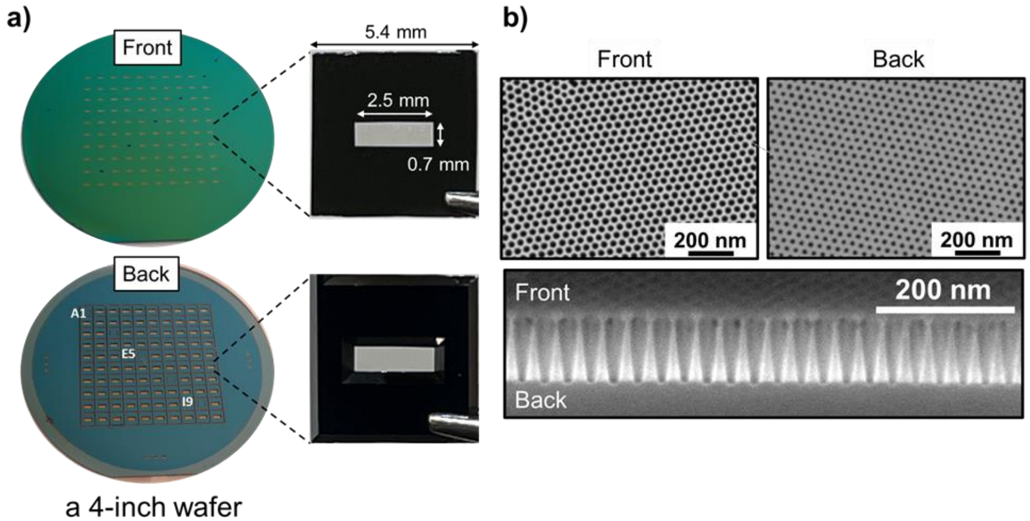

Figure 1: a) 100 chips each with a rectangle membrane window (2.5 cm × 0.7 cm) are produced on a 4-inch wafer. b) Scanning electron microscopy (SEM) images of silicon nitride isoporous membranes. Each pore has a conical shape with a smaller diameter on the back and a larger diameter on the front side.