Development of Nanoporous Ultrathin Membranes For Implantable Drug Delivery

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For drug release or physiological sensing with advanced functionality, an implanted device must have an interface that permits passage of drugs or analytes while blocking immunoproteins and other physiological fouling agents. To this end, we have developed a composite membrane which integrates the nanoscale size selectivity of block-copolymers with the mechanical strength and order of micromachined silicon. A silicon wafer was coated with low-stress silicon nitride (LSN) and patterned with 20 μm squares on the bottom side by photolithography. These squares were etched through the underlying silicon, using the LSN on the top side as an etch-stop. Poly(styrene)-poly(isoprene)-poly(lactide) (PS-PI-PLA) triblock terpolymer was spin-coated onto the top-side LSN surface and annealed under vacuum. The PLA domains self-assembled into cylinders perpendicular to the coating, nearly spanning it. The PLA was etched away, leaving 40 nm pores in the polymer film. The device was subjected to hydrofluoric acid to remove the LSN capping the microscale pores and a final, brief oxygen plasma etch removed any PS capping the nanoscale pores. The resulting composite membrane consists of a 80 nm thick PS layer with 40 nm wide pores overlaying a 100 μm thick silicon support with 20 μm wide pores. Preliminary mechanical tests have demonstrated the membrane's robustness. Such membranes should provide immuno-isolation without retarding small molecule transport and should integrate well with the burgeoning number of BioMEMS devices under development.