Nanoporous ultrananocrystalline diamond membranes

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Nanoporous membranes have a wide range of biomedical applications such as immunoisolation devices, biosensors, smart as well as targeted drug delivery systems, bioanalytical devices, and hemodialysis. Some of the key properties that these membranes are required to posses are narrow pore size distribution, high porosity and low thickness to enable high flux, mechanical and chemical stability. For medical implant and drug delivery application, there is the additional requirement of biocompatibility and anti-biofouling. Ultrananocrystalline diamond (UNCD®) coatings are becoming more and more significant in medical applications because of the highest, unmatched by other materials degree of biocompatibility. The UNCD® porous membranes will open new opportunities in implant medicine.

Here we report results on high porosity high-aspect-ratio UNCD membranes fabricated using e-beam lithography, reactive ion etching and laser writing.

The membranes were fabricated in 1-μm-thick UNCD film on Aqua 25 UNCD® silicon wafers (Advanced Diamond Technologies). The Aqua UNCD® has the hardness, elasticity modulus and other extreme properties of natural diamond, as well as smooth surface, and a very low internal stress that are important for membrane fabrication.

Two ways of nanoporous UNCD membrane fabrication have been explored: (i) reactive ion etching of UNCD using silicon oxide as a mask[1], which was patterned by e-beam lithography (EBL) on ZEP positive resist; (ii) reactive ion etching of UNCD using Ni mask that was patterned by EBL on ma-N 2405 negative resist followed by lift-off. Resists were patterned with a Raith 150 e-beam lithography system. The pattern of silicon oxide mask consists an array of 125 nm-and 250-nm-diameter circular openings with 400 nm periodicity (Figure 1.A), and the pattern of Ni mask has an array of 80 nm-diameter circular openings with 400 nm periodicity (Figure 1.B).

Using laser writing lithography on the back side of the silicon wafer, windows with freestanding membranes were opened by etching the silicon.

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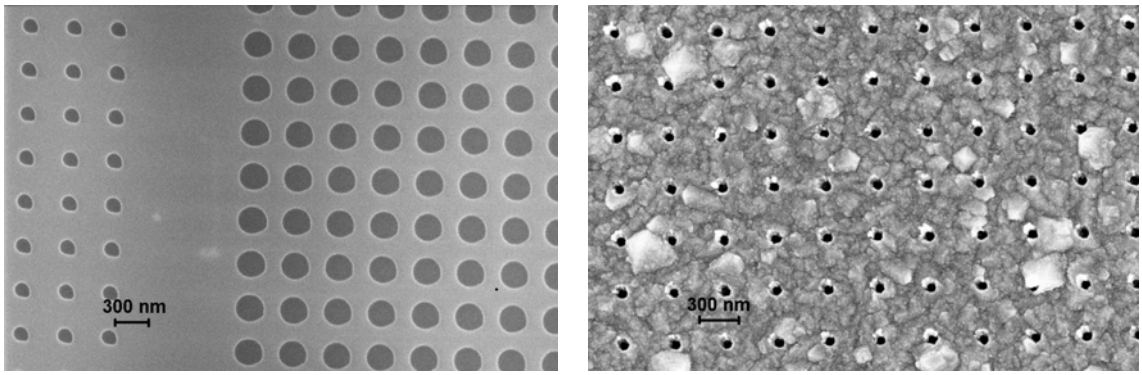
[1] N. Moldovan, R. Divan, H. Zeng, J.A. Carlisle, *"Nanofabrication of Sharp Diamond Tips by E-beam Lithography and ICP-RIE"* JVST B, 27, pp. 3125-3131, 2009.



(A) (B)

Figure 1. SEM images of an array of 125-nm- and 250-nm-diameter pores pattered on UNCD film with SiO_2 mask (A), and array of 80-nm-diameter pores patterned on UNCD film with Ni mask (B).