Patterned freestanding Carbon Nanomembranes and Graphene via Extreme UV interference Lithography

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Freestanding carbon nanomembranes[1,2] (CNMs) are thin (~1.0 nm), two-dimensional (2D) sheets with tailored physical, chemical or biological function. With their two opposing surfaces they interface and link different environments by their distinct physical and chemical properties, which depend on their thickness, molecular composition, structure, and the environment on either side. Together with graphene and other 2D materials, CNMs can be regarded as "surfaces without bulk" that can separate regions with different gaseous, liquid or solid components and control any materials exchange between them[3]. For such filtering and sieving applications[4], a scheme to fabricate large-area patterns of nanopores is required.

Here we present the fabrication of nanopore arrays in freestanding CNMs and graphene using extreme ultraviolet interference lithography[5] (EUV-IL), a high resolution, large area, and high throughput nanopatterning technique. Using EUV-IL, layers of suitable precursor molecules can be directly converted into porous CNMs. In addition, CNMs and graphene can be perforated using resist patterning and pattern transfer. We show the fabrication of freestanding nanomembranes with nanopores with diameters varying from 500 nm to 50 nm. These nanostructures are characterized with helium ion microscopy (HIM) which provides high resolution, high surface sensitivity, and a chemical contrast, especially suitable for two-dimensional materials.

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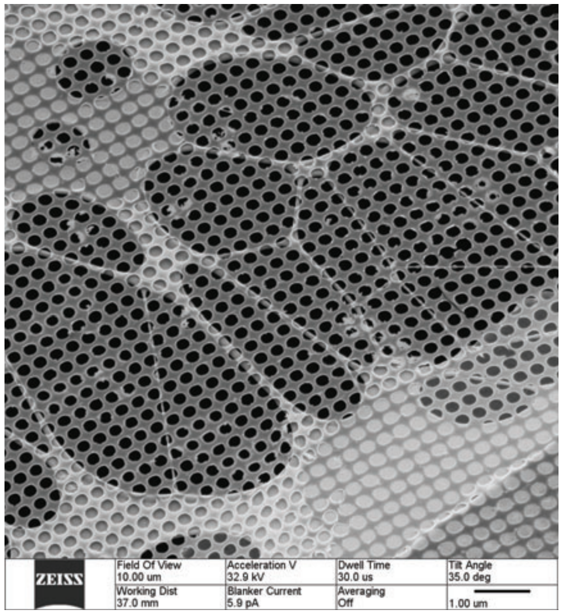

Figure 1: Helium ion microscope (HIM) image of a freestanding two-dimensional nanostructure of patterned graphene. The periodicity of the nanopore pattern of 177×180 nm is very homogeneous with a standard deviation of 6% over the whole sample.

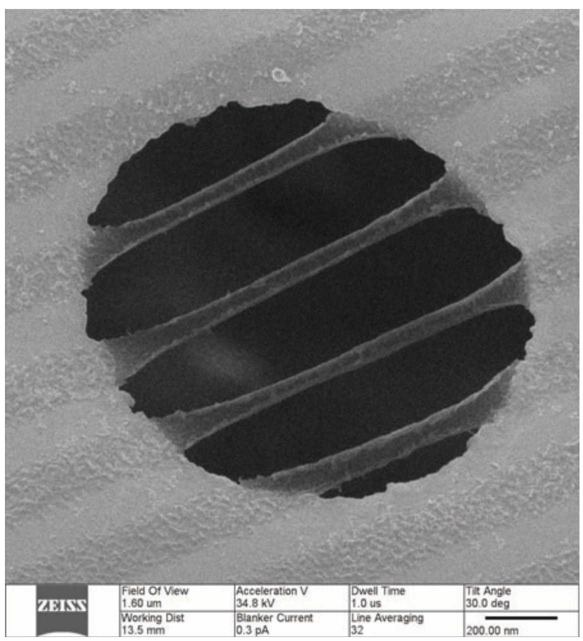

Figure 2: HIM image of 150 nm wide nanoribbons of carbon nanomembrane. In the freestanding area the ribbons are rolled up due to internal stress, which can be investigated in detail, making use of the high surface sensitivity of the helium ions.