Advanced fabrication technique of nano-patterned ALD membrane

Farhana Anwar
IBM Research, 257 Fuller Rd, Albany, NY 12203
notfarhana@gmail.com

Frank Ogletree, Adam Schwartzberg, Stefano Cabrini

The Molecular Foundry, Lawrence Berkeley National Laboratory, Berkeley, CA 94720

Nanopatterned ALD (Atomic layer deposition) films has many applications as templates for various functional nanostructures.[1] In this article we demonstrate for the first-time fabrication process of nano-patterned thin ALD membrane by patterning top layer of a double layer electron beam resist stack, depositing a thin conformal ALD layer and use the resist underneath as a sacrificial layer. Unlike conventional ways of achieving patterned ALD membrane reported in literature[2] our technique requires significantly less fabrication steps and paves the way for novel ALD membrane-based technology.

Figure 1 outlines fabrication process of our transferable nano-patterned ALD membrane. It begins with spin coating a clean Si substrate with PMMA C4 at a spin speed of 2000 rpm and bake it for five minutes at 180C. Next, we spin coat with diluted Zep with a spin speed of 4000 rpm and bake it for five minutes at 180C. Finally, the sample is patterned by e-beam lithography using well calibrated dose (~180 μC/cm^2) to expose the top layer resist leaving the bottom layer resist (PMMA C4) unaffected. Next, we develop the sample in amyl acetate for one minute. Alpha step measurement of PMMA & Zep is 440.853nm & 125.63nm. Later we deposit Al_2O_3 on the patterned resist using a plasma enhanced atomic layer deposition. Using similar approach but with different set of calibrated doses we also fabricated nanostructures on KOH etched Si_3N_4 windows.

Cross sectional scanning electron micrographs shows successful pattern transfer only on the top layer resist and ALD film(~20nm) grown on nanopatterned multilayer resist (Figure 2(C)). We also confirm grating pattern depth developed on top layer resist by doing AFM which shows depth of 130nm (Figure 2(B)). Next, we demonstrate successful pattern transfer on Si_3N_4 windows and ALD layer Al_2O_3 on top (Figure 2(H) &(I)).

[1] K. Davami, L. Zhao, E. Lu, J. Cortes, C. Lin, D. E. Lilley, P. K. Purohit, and I. Bargatin, Nature communications 6, 1(2015).
[2] L. Sainiemi, K. Grigoras, and S. Franssila, Nanotechnology 20, 075306 (2009).

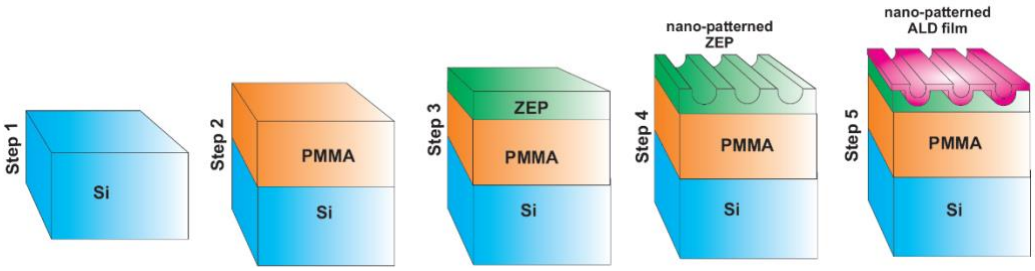

Figure 1: Fabrication process steps of nanopatterned ALD membrane.

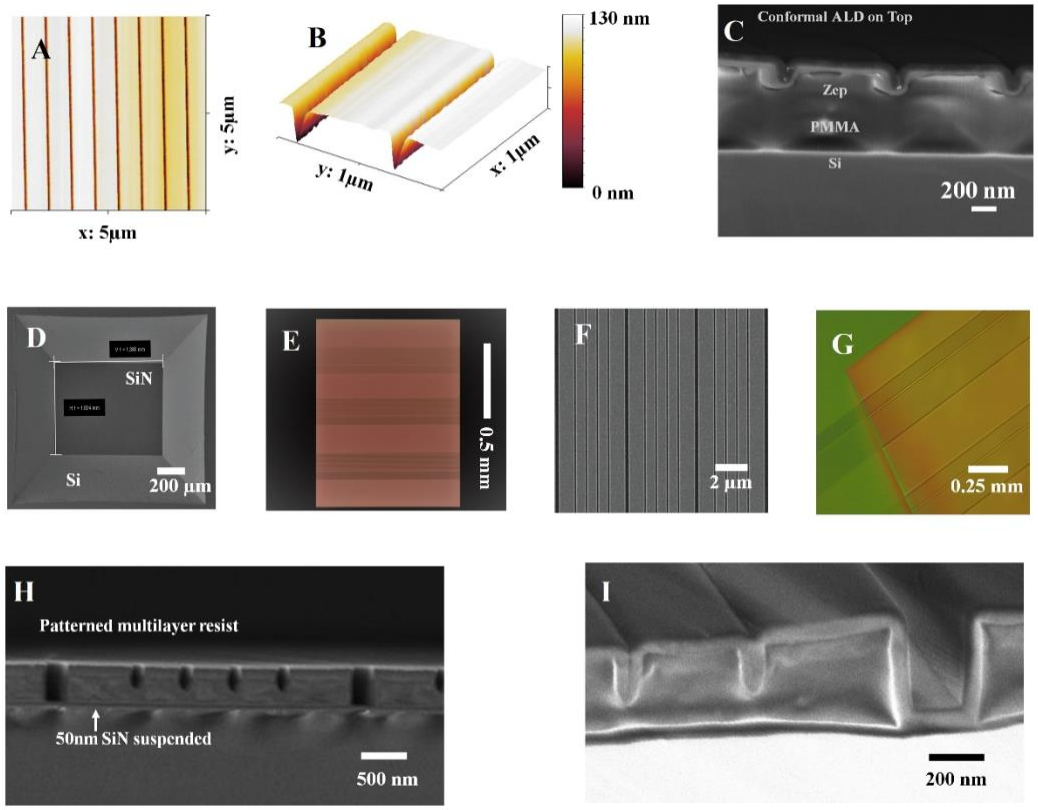

Figure 2:(A) AFM of the grating pattern (B) 3D profile shows depth of the grating after resist development. (C) Shows cross sectional Scanning electron micrographs of ALD film grown on nanopatterned multilayer resist (D) KOH etched 50nm thick Si_3N_4 windows (E)&(F) Microscopic & SEM Image of E-beam resist after development on Si_3N_4 windows (G) microscopic image of ALD film grown on top of Si_3N_4 windows (H) cross sectional SEM picture of developed resist on 50nm thick Si_3N_4 windows (I) cross sectional SEM image of ALD film grown on multilayer resist stack Si_3N_4 windows.