Block Copolymer Directed Self-Assembly Standard Operating Procedure

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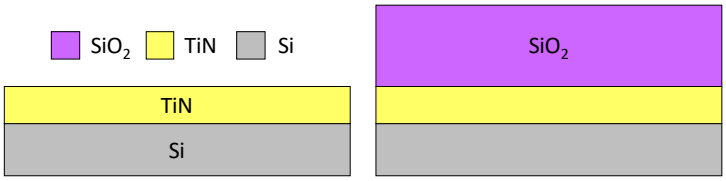
Block copolymer directed self-assembly (DSA) is a next-generation photolithography technique. In contrast to the extreme ultraviolet (EUV) lithography and multiple patterning, DSA provides a cost-effective method of patterning sub-20 nm features. In this standard operating procedure (SOP), we propose a recipe for DSA with 70:30 PS-*b*-PMMA. This widely used block copolymer self-assembles into PMMA cylinders surrounded by a PS matrix. After the PMMA is selectively removed, the remaining porous PS film can be used for etching or lift-off. Here, we detail a method of directing the self-assembly process using SiO_2/TiN guiding wells to achieve one PMMA cylinder inside each well. Using this procedure, we succeeded in shrinking the size of the guiding wells to 1/4 of their original diameter (80 nm to 20 nm). We also fully imported the process onto SNF equipment, which enables future applications throughout the SNF community.

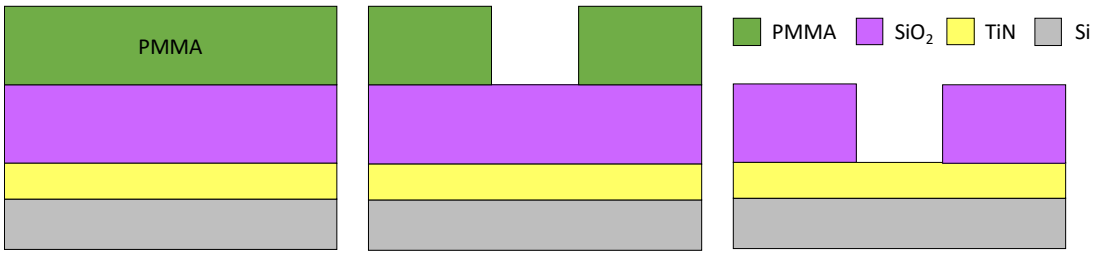
Part I: Deposition of guiding well materials



Step 1 **Step 2**

1. Deposit TiN layer (15 nm) as hard mask in lesker-sputter
    a. Sputtering target: TiN
    b. Deposition conditions: 5 mTorr, 150 W, 10 sccm Ar, 20 sccm N_2
    c. Deposition time: 30 min
2. Deposit PECVD SiO_2 layer (100 nm) in ccp-dep
    a. Recipe name: SiO350-0
    b. Deposition conditions: 1100 mTorr, 200 W, 250 sccm SiH_4, 800 sccm He, 1700 N_2O, 350 °C
    c. Deposition time: 95 s

Part II: Guiding wells fabrication

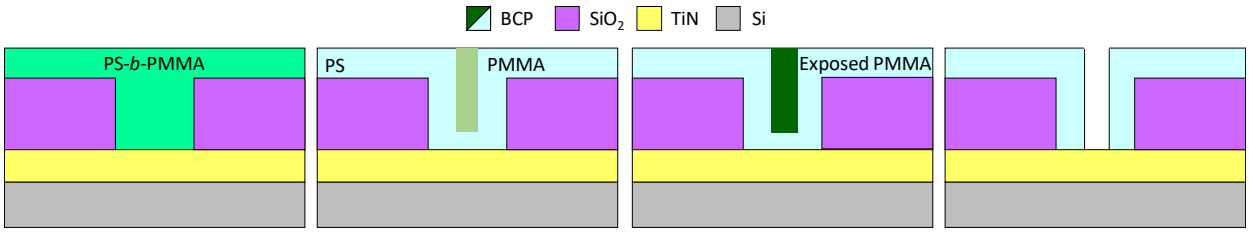


Steps 3 & 4 **Steps 5 & 6** **Steps 7 & 8**

3. Spin-coat with ~150 nm of 950K PMMA
    a. Spinning recipe: PMMA A3 solution at 2000 rpm
4. Pre-bake on hot plate at 180 °C for 90 s
5. Expose with e-beam lithography (raith or JEOL) to get circles with CD ≈ 80 nm

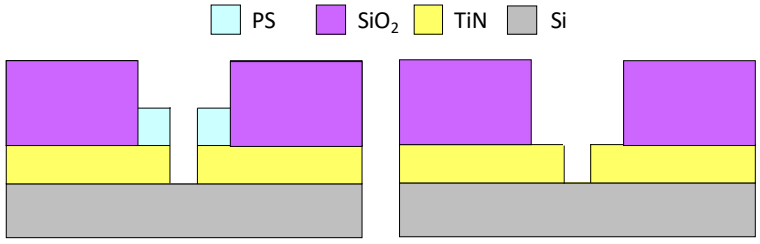
6. Develop sample with 1:3 MIBK:IPA for 30 s
7. Etch SiO_2 in oxford-rie such that TiN is exposed in the bottom of the wells
    a. Etch recipe: 30 mTorr, 100 W, 20 sccm CHF_3, 5 sccm CF_4, 10 sccm Ar
    b. Etch time: 5 min
8. Remove excess PMMA through O_2 plasma etch in oxford-rie
    a. Etch recipe: 100 mTorr, 50 W, 15 sccm O_2
    b. Etch time: 2 min

Part III: Directed self-assembly of block copolymer (PS-*b*-PMMA)



9. Spin-coat with PS-*b*-PMMA on headway3
    a. Polymer: P2400P-SMMA (M_n = 46.1-21.0 kg/mol) from Polymer Source Inc.
    b. Solution recipe: 1 wt% PS-*b*-PMMA in PGMEA
    c. Spinning recipe: 2500 rpm for 60 s
10. Anneal in white-oven at 200 °C for 15 min
11. Expose with deep UV irradiation in the Oriel lamp in ExFab 155A
    a. Exposure parameters: 6.0 mW/cm^2 intensity for 3 s
12. Remove PMMA by soaking in acetic acid (10 min) at wbflexcorr, rinse, and blow dry

Part IV: Pattern transfer



13. Etch the BCP-coated sample in pt-mtl such that TiN is etched through
    a. Etch recipe: 10 mTorr, 50 W bias, 30 sccm Cl_2, 5 sccm BCl_3, 10 sccm Ar
    b. Etch time: 70 s
14. Remove remaining PS through O_2 etch in drytek2
    a. Recipe name: Descum
    b. Etch recipe: 150 mTorr, 500 W, 100 sccm O_2
    c. Etch time: 5 min