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PMMA LIFTOFF OPTIONS

This document provides two different recipes for PMMA liftoff pattern transfer for electron beam lithography (EBL) processing.

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Mohammad Ali Mohammad – Single layer recipe

(1) PMMA 495k/950k BI-LAYER LIFT-OFF

1. Piranha clean wafers for **15 min**.
2. Dehydrate bake wafers at **200 °C** for **5 min**.
   - Let wafer cool for **2 min**.
3. Spin on **PMMA 495k A2** resist

Step	RPM	Ramp (s)	Time (s)
1	500	5	10
2	4000	10	45
3	4000	3	0
4	-	10	-

4. Bake on hotplate at **180 °C** for **10 min**.
   - Let wafer cool for **2 min**.
5. Spin on **PMMA 950k** resist.
   - Identical spin parameters to step 3.
6. Bake on hotplate at **180 °C** for **10 min**.

Total bilayer resist thickness ~ **120 nm**.

7. EBL exposure parameters

Voltage	Area Dose	Aperture
10 keV	120 μC/cm^2	10 μm

8. EBL development parameters

Temperature	Standard room 22 °C
Development	60 s in MIBK:IPA 1:3
Quench	20 s in IPA
Rinse	15 s in DI H_2O
Dry	Nitrogen dry

(2) PMMA 950k SINGLE LAYER LIFT-OFF

1. Piranha clean wafers for **15 min**.
2. Dehydrate bake wafers at **175 °C** for **5 min**.
   - Let wafer cool for **2 min**.
3. Spin on **PMMA 950k A1** resist

Step	RPM	Ramp (s)	Time (s)
1	100	2	10
2	2200	4	40

4. Bake on hotplate at **175 °C** for **5 min**.

Total resist thickness ~ **45 nm**.

5. EBL exposure parameters

Voltage	3 keV
Aperture	10 μm
Area Dose	600 μC/cm^2
Line (SPL) Dose	1.4 – 3.0 nC/cm

6. EBL development parameters

Temperature	- 15 °C (cold plate)
Development	5 s in MIBK:IPA 1:3
Quench/Rinse	15 s in IPA
Dry	Nitrogen dry

7. Electron beam evaporation parameters

Metal	Base Pressure	Current
Chromium	3×10^{-7} Torr	10 mA
Thickness	**Dep. Pressure**	**Dep. Rate**
12 nm	0.8×10^{-7} Torr	0.15 nm/s

9. The combination of the above exposure and development steps provides a straight sidewall. Depending on deposition parameters, there can be some minor sidewall coverage. This recipe works best for **evaporation** and thinner metal layers; however, it has been used for ~ **50 nm** thick layers of **sputtered Aluminum** and **Gold** successfully.

10. Lift-off PMMA layers in an **ultrasonic acetone bath**. Approx. time ~ **3 min**.

8. Lift-off PMMA layer in an ultrasonic acetone bath. Approx. time ~ **3 min**.

When conducting metal deposition for lift-off applications, a general rule of thumb regarding the metal thickness is known as the *one-third rule* i.e., the deposited metal should be no thicker than 1/3rd of the resist thickness. This works always for evaporation; however, sputtering may or may not work depending on the sidewall profile.

Option **(1)** is a very good general purpose recipe with lesser restrictions on metal thickness, EBL voltage, EBL development, deposition technique, etc. Option **(2)** is a more specialized recipe (see Fig. 1) for nanoscale processing; however, it imposes greater restrictions on the aforementioned variables.

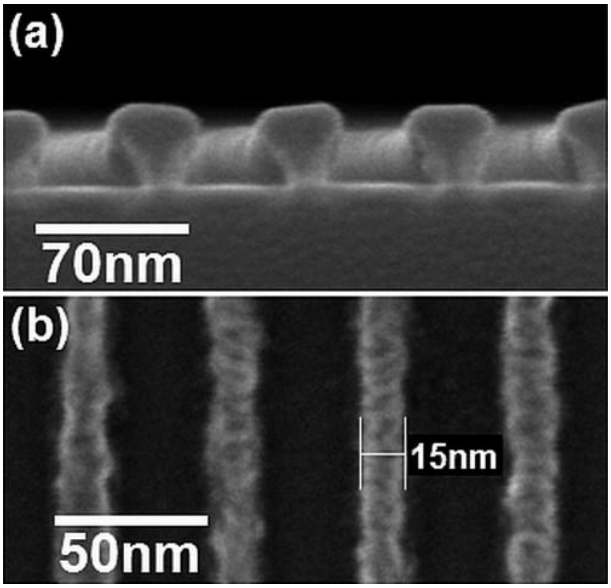

Figure 1
(a) Cross-sectional micrograph of 70 nm pitch gratings in PMMA exposed at 3 keV and developed with −15 °C MIBK:IPA (1:3) in order to get large undercuts for single layer lift-off while maintaining high resolution and (b) top-view micrograph of 12 nm thick and 50 nm pitch gratings in chromium after an ultrasonic lift-off showing ~ 15 nm wide lines using the above low keV, cold development process.

Reference
M. A. Mohammad et. al., J. Vac. Sci. Technol. B 28, C6P36 (2010) http://dx.doi.org/10.1116/1.3517683

For further information, please contact Mohammad Ali Mohammad (ebl.nanofab@ualberta.ca) or any NanoFab staff member for assistance. Please also do not hesitate to contact us if you would like to contribute a recipe for EBL process development at the NanoFab.