

Supporting Information

An aluminum-based hybrid film photoresist for advanced lithography by molecular layer deposition

1050	1100	1150	1200	1250
800	850	900	950	1000
550	600	650	700	750
300	350	400	450	500
50	100	150	200	250

$\mu\text{C}/\text{cm}^2$

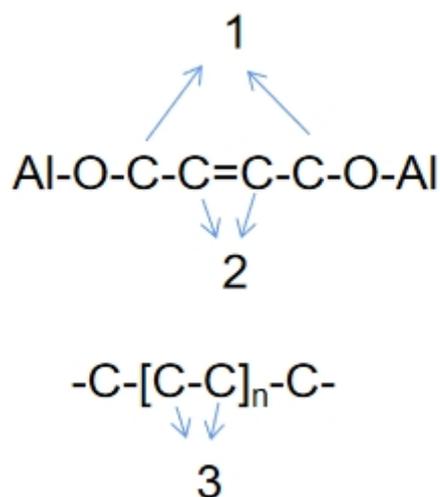
Table S1. E-beam dose ($\mu\text{C}/\text{cm}^2$) matrix depicting the dose array exposed for patterning exposure dose matrix.

Process	Temperature (°C)	Pressure (mTorr)	ICP Power (W)	RF Power (W)	Gas flow rate (sccm)	Etching speed nm/min
Bosch	20	15	400	20	C ₄ F ₈ :60 SF ₆ :15	1900

Table S2. Summary of ICP conditions used in the study

Resist	Positive/negative	Etch Recipe	Selectivity with Si
PMMA	positive	HBr	3
ZEP	positive	HBr	5
HSQ	positive	SF ₆ -C ₄ F ₈ -Ar	6
DPhAl	negative	SF ₆ -C ₄ F ₈ -Ar	60
our work	negative	SF ₆ -C ₄ F ₈	86

Table S3. Comparison of selectivity with Si etching of different photoresists.



	Unexposed				Exposed		
Peak	Position (ev)	Area	FWHM (ev)	Peak	Position (ev)	Area	FWHM (ev)
C-C/C-H	284.58	3308	1.8	C-C/C-H	284.671	6891	1.8
1	286.28	516	1.6	3	286.071	731	1.8
2	288.58	720	2.2	Impurity carbon	288.395	395	2.2
Al 2p	74.948	8464	2.5	Al 2p	73.980	453	2.1

Table S4. The XPS peak position and the corresponding area of C 1s, Al 2p of the unexposed and exposed resist film.

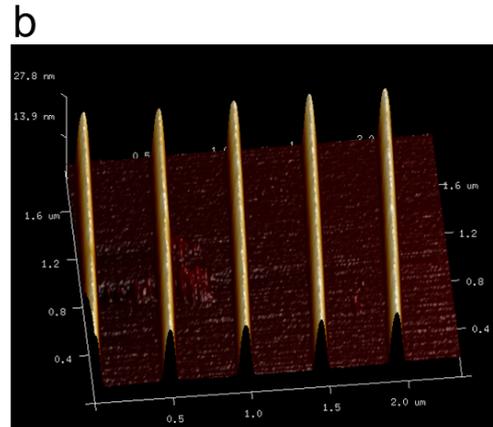
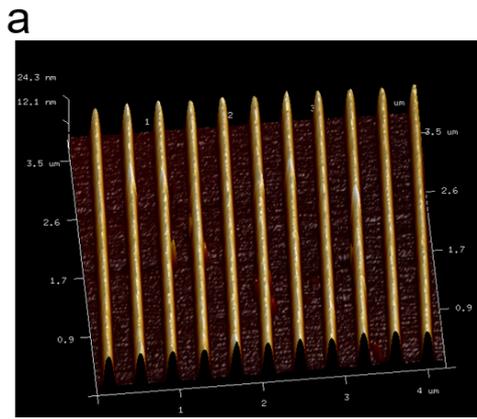


Figure S1. a) oblique views of AFM imaging of 100 nm, L/S=1:3 at 30 keV. b) oblique views of AFM imaging of 50 nm, L/S=1:9 at 30 keV

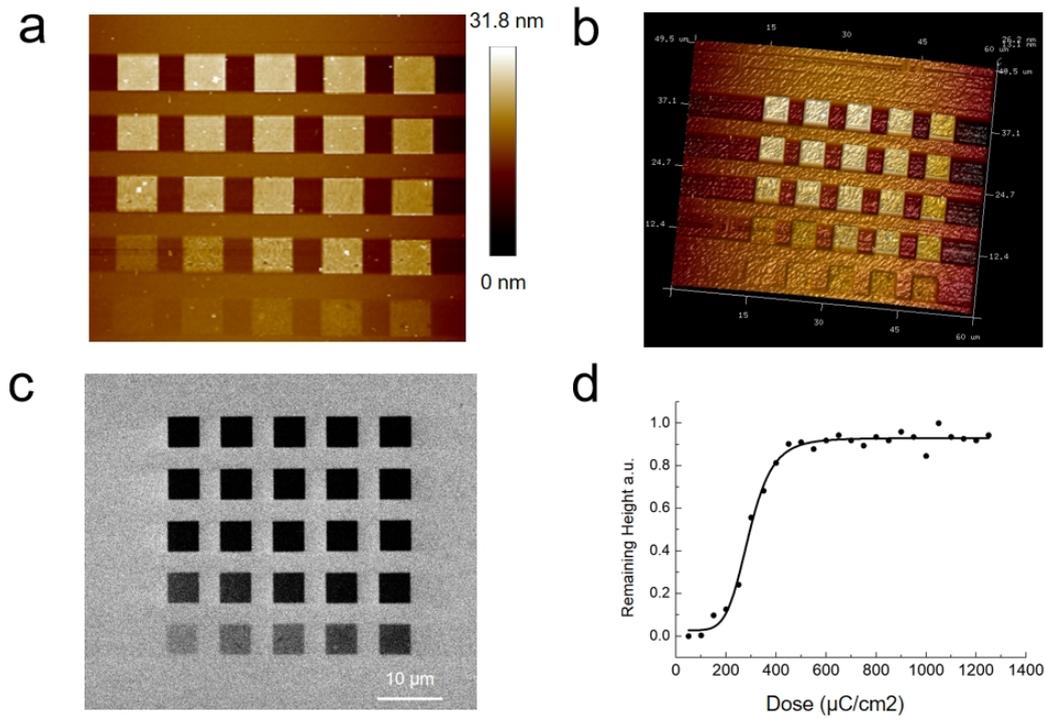


Figure S2. a) is the dose array (50-1250 $\mu\text{C}/\text{cm}^2$) exposure dose matrix AFM top view plot. b) is the AFM oblique view. c) is the SEM plot. d) Contrast curve of the TMA-BED resist. E-beam exposure was performed at 2 keV and developed using 10 wt% ammonia for 15 s. The exposure array dose is shown in Table S1.

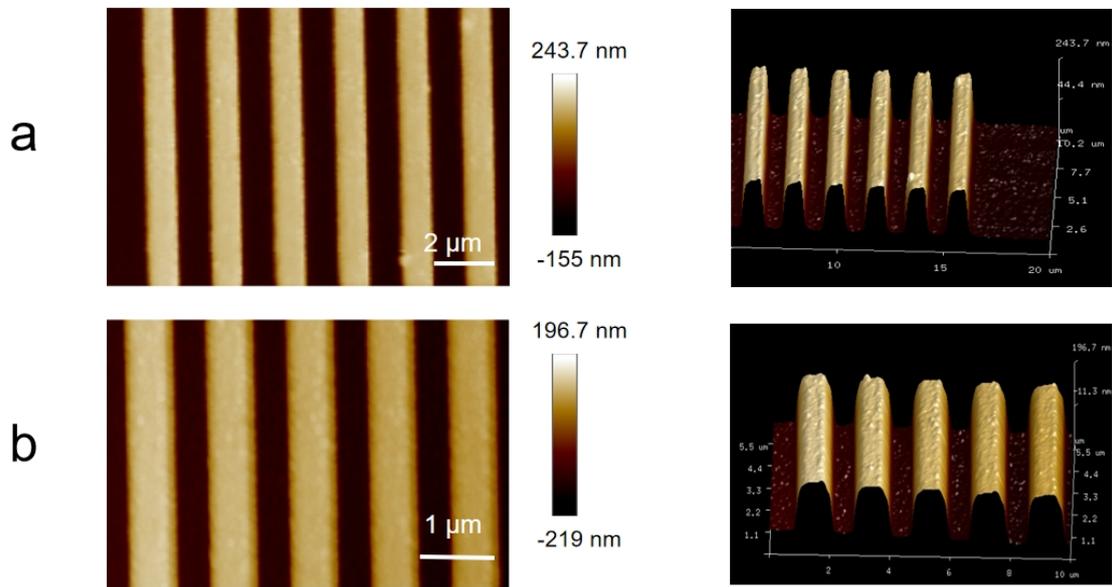


Figure S3. Top and oblique views of AFM with different line widths at an etching depth of 240 nm:a) 1000nm;b) 500nm.

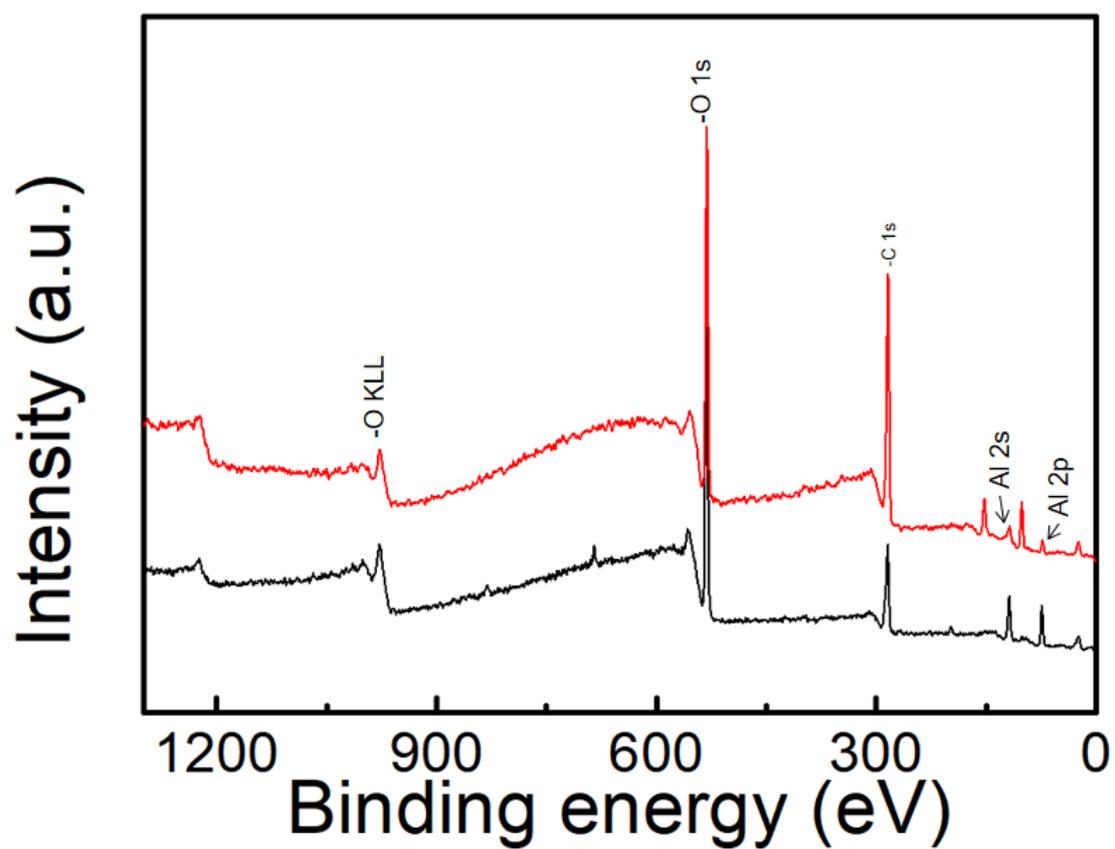


Figure S4. XPS survey scan of the Al-based film. The black line is unexposed, and the red line is exposed.

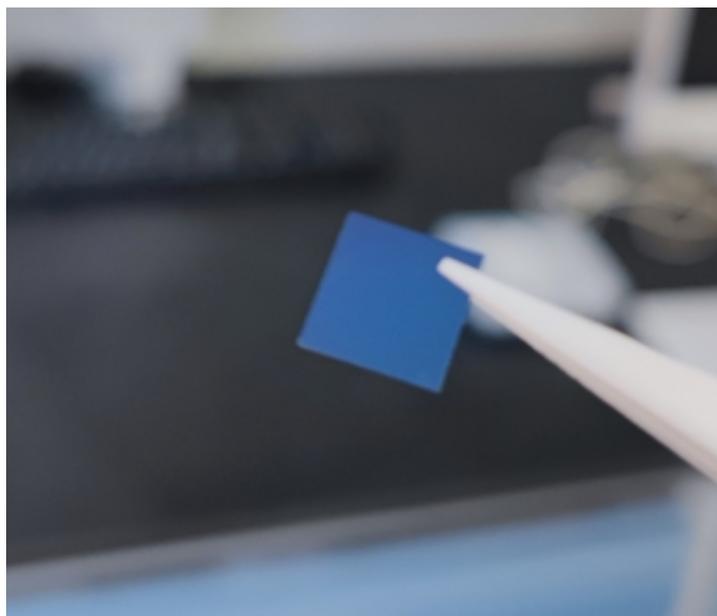


Figure S5. Images for the 400-cycle TMA-BED film on 1cm ×1cm wafers.