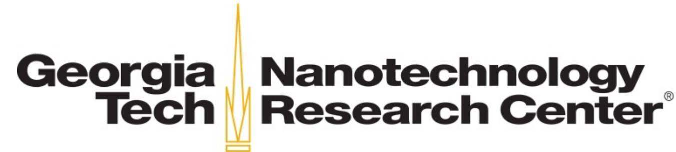

A comparison of electron beam lithography resists PMMA and ZEP520A

material properties

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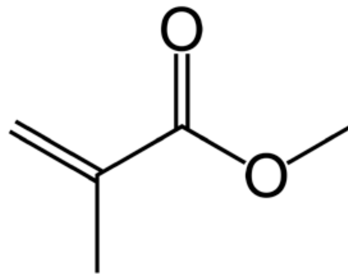
property	PMMA	ZEP520
manufacturer	Micro Chem (USA)	Zeon Chemicals (Japan)
polymer	poly methyl methacrylate	1:1 co-polymer α-chloromethacrylate, α-methylstyrene
chemical formula	$(C_5O_2H_8)n$	$C_3H_3O_2Cl$, C_9H_{10}
molecular weight	950,000	55,000
solution suspension	anisole	anisole
appearance	clear liquid	clear liquid
density	1.18 g/cm3	1.053 g/cm3
Tg / melting point	105º C	105º C[1], 145º C[2]
melting point	160º C	?
refractive index @ 600 nm	1.49	1.56

[1]ZEP520A Technical Report Ver.2 Oct 2010, http://www.zeonchemicals.com/pdfs/ZEP520A.pdf

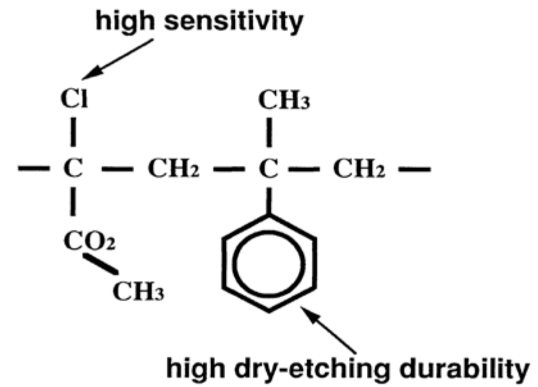
[2]Nishida, "Quantum Wire Fabrication by E-beam Elithography Using High-Resolution and High-Sensitivity E-Beam Resist ZEP-520", Jpn. J. Appl. Phys. Vol. 31 (1992) pp. 4508-4514

chemical structure

PMMA



ZEP



PMMA Process Conditions

Substrate:

- 4” silicon wafer cleaved into 1”x1” piece, then spun

Coat:

- PMMA A6 resist
- 6000RPM, 3000 RPM / sec, 60sec
- 180°C hot plate bake for 90 sec
- Thickness: 301 nm (measured on the Nanospec reflectometer)

Expose:

- 2 nA current, 100 kV accelerating voltage, 8 nm shot pitch
- Dose varied for 100 nm line features

Develop:

- 1:1 MIBK:IPA immersion for 2 minutes
- Isopropanol immersion for 30 seconds
- N_2 blow dry

ZEP520A Process Conditions

Substrate:

- 4” silicon wafer cleaved into 1”x1” piece, then spun

Coat:

- ZEP520A resist
- 5000 RPM, 2500 RPM / sec, 60sec
- 180°C hot plate bake for 2 minutes
- Thickness: 312 nm (measured on the Nanospec reflectometer)

Expose:

- 2 nA current, 100 kV accelerating voltage, 8 nm shot pitch
- Dose varied for 100 nm line features

Develop:

- Amyl acetate immersion for 2 minutes
- Isopropanol immersion for 30 seconds
- N_2 blow dry

Dose sensitivity curve

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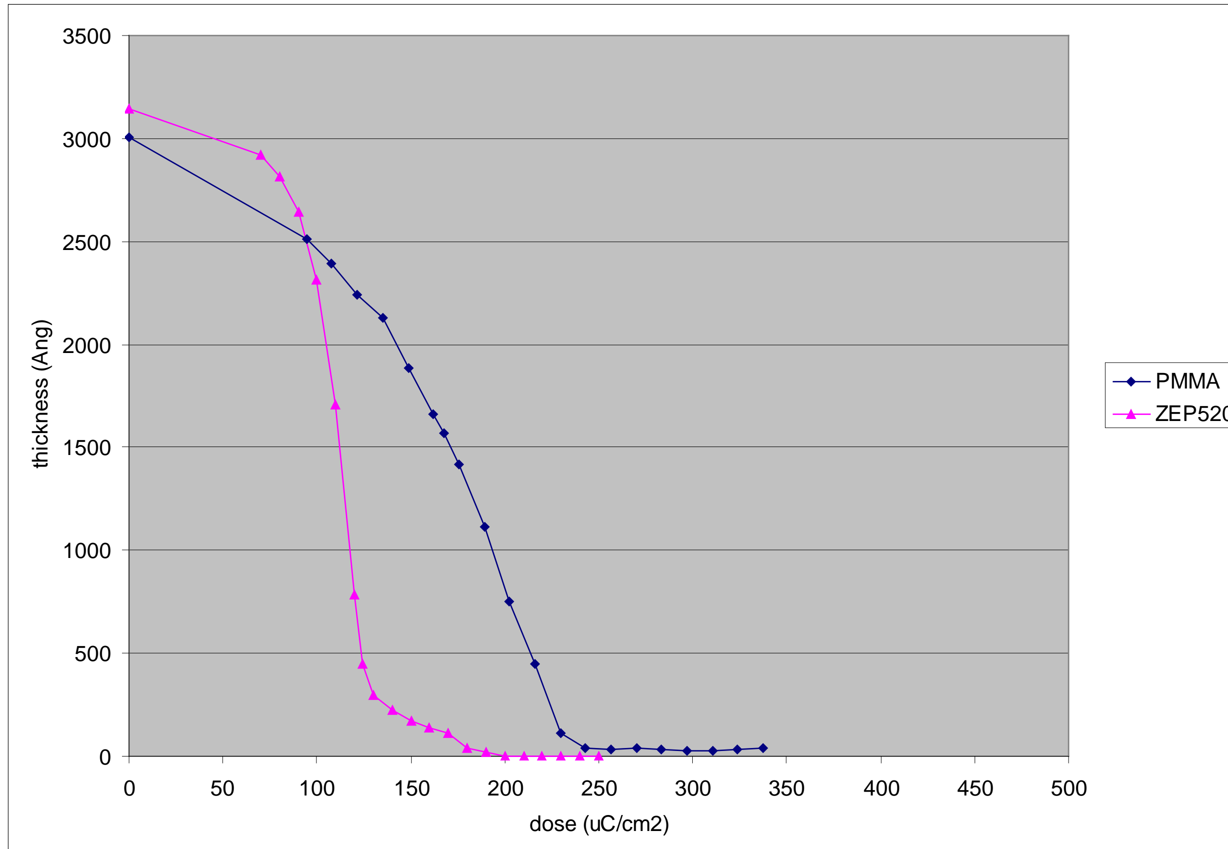
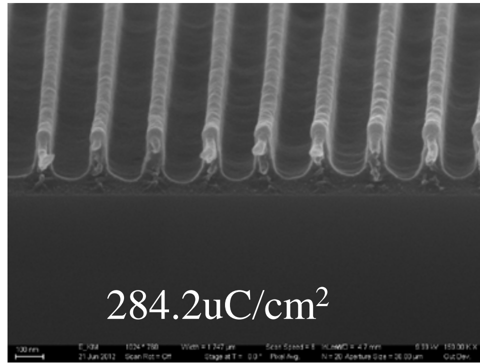
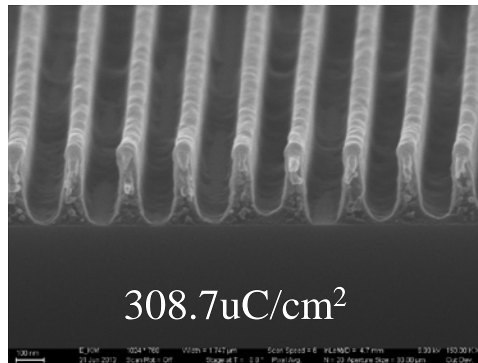


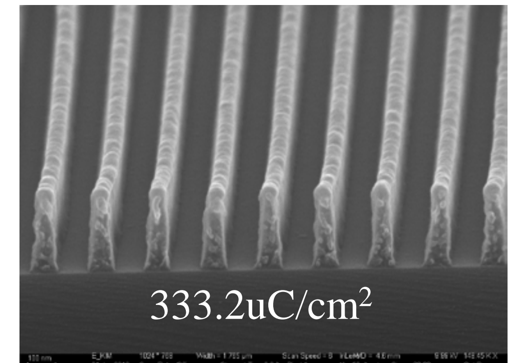
- dose sensitivity curve for 75 x 75 um squares
- ZEP520 has higher contrast (although PMMA develop conditions could be modified)
- dose to clear
  - ZEP520 = ~220 uC/cm2
  - PMMA = ~270 uC/cm2

SEM image of 100 nm line and space

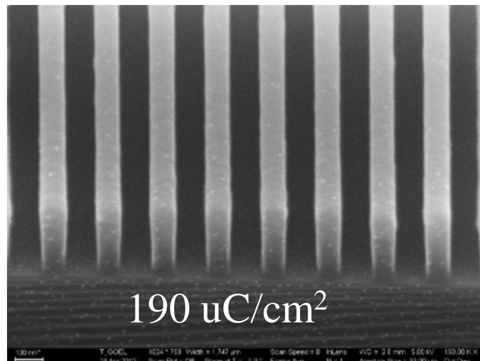
PMMA

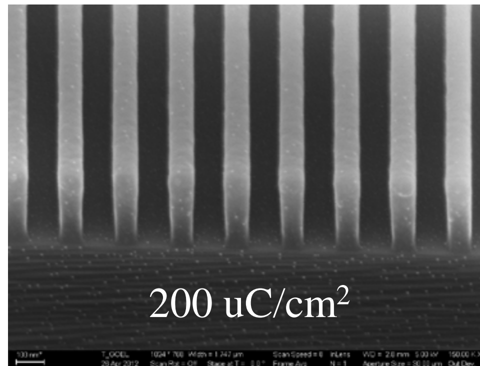


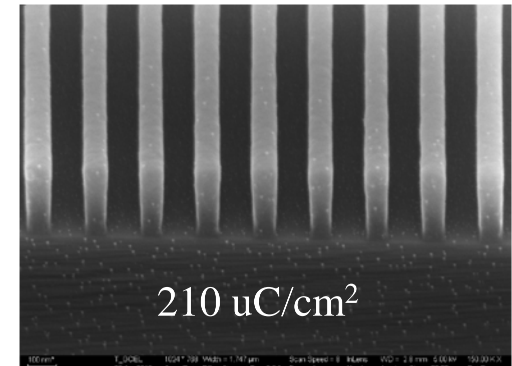




ZEP520







ICP Etch Process Conditions

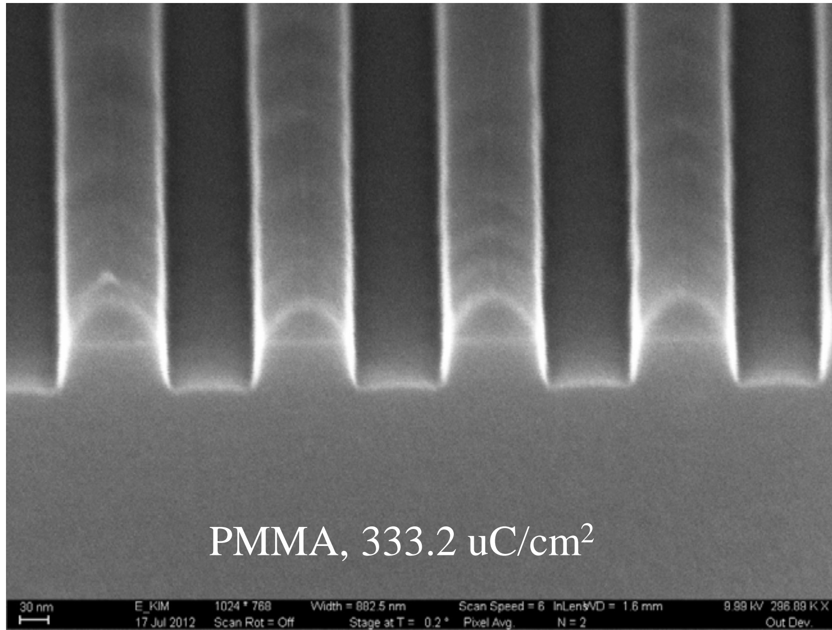
Substrate:

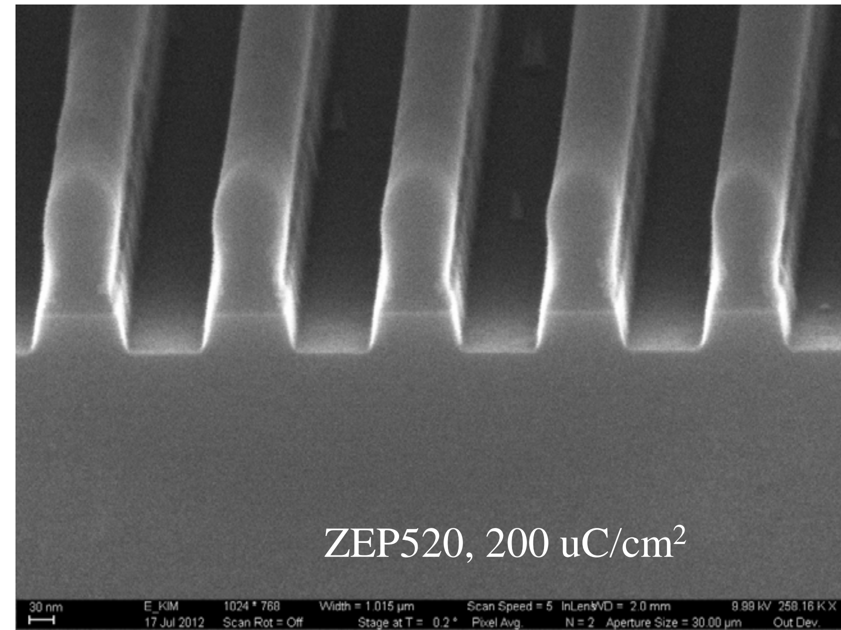
- 4” SiO2 coated silicon carrier wafer
- resist samples (ZEP520, PMMA) mounted simultaneously on carrier wafer and etched together

Etch:

- Plasma Therm ICP
- recipe = DKB_SI
- press = 5 mTorr
- 16 sccm Cl_2
- 4 sccm Ar
- 50W RIE power
- 200W coil power
- etch time = 30 sec

Post etch cross section comparison





- 100 nm line and space
- x-section images post silicon ICP etching
- resist still remaining

etch rate and selectivity data

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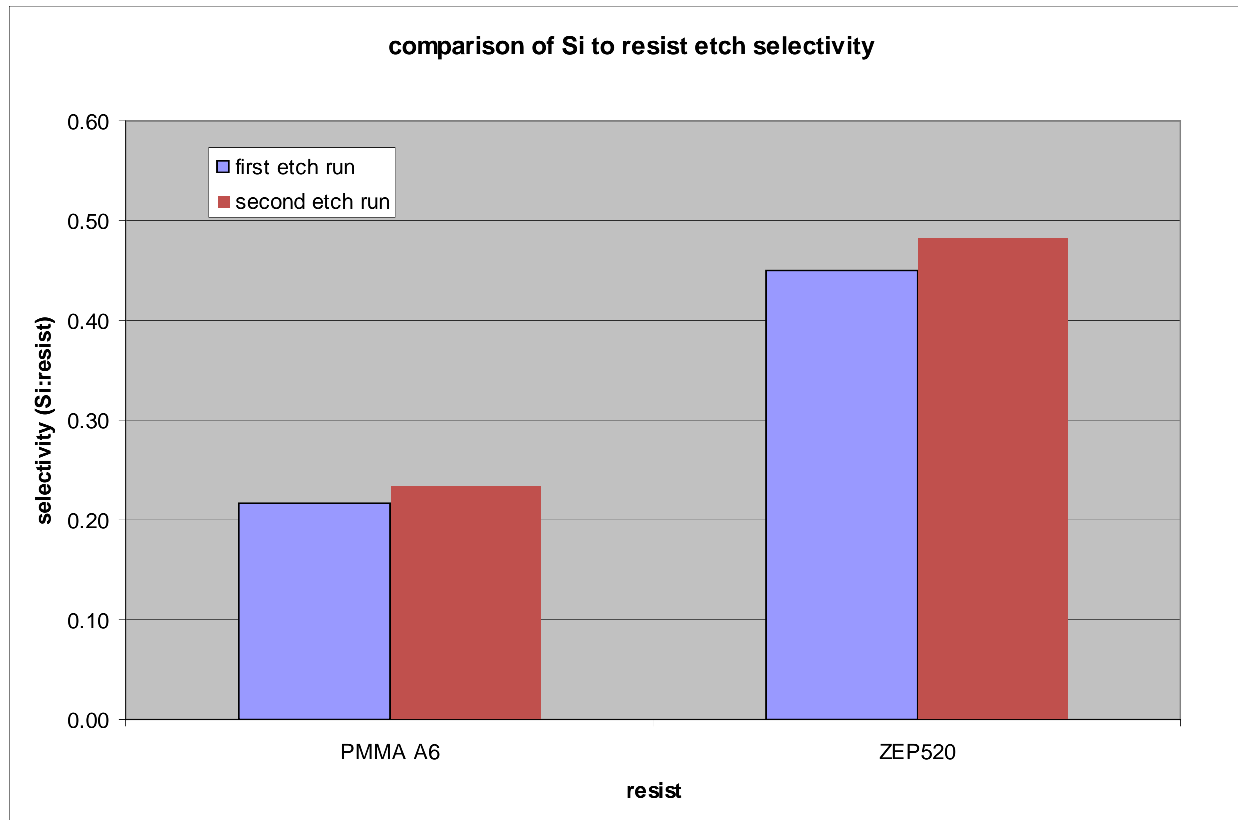

first etch run

resist	pre-etch resist thickness (Ang)	post-etch thickness (Ang)	etched resist (Ang)	resist etch rate (Ang/sec)	etched silicon (Ang)	silicon etch rate (Ang/sec)	selectivity (Si to resist)
PMMA A6	3013	1077	1936	65	419	14.0	0.22
ZEP520	3117	2125	992	33	446	14.9	0.45

second etch run

resist	pre-etch resist thickness (Ang)	post-etch thickness (Ang)	etched resist (Ang)	resist etch rate (Ang/sec)	etched silicon (Ang)	silicon etch rate (Ang/sec)	selectivity (Si to resist)
PMMA A6	3329	1742	1587	53	372	12.4	0.23
ZEP520	2996	2199	797	27	384	12.8	0.48