Process Optimization for HSQ/AZPN Bilayer Resist E-Beam Lithography:

Effects of PAB and Development Time

Kyoungsub Shin

EE290B Class Project, Spring 2003

HSQ (Hydrogen SilsesQuioxane)

- Before e-beam exposure (Weak Bond)

 : incompletely closed and crosslinked cage structure

- After e-beam exposure (Strong Bond)

 : weak Si-H bonds are broken by e-beam

 : stable three dimensional network formed by crosslinking

- Development

 : ionization process by bond scission

 : weak bond is dissolved more easily

How to improve process latitude of HSQ?

- Poor process reproducibility
- Too sensitive to the condition of HSQ solution

- Control of crosslinking sensitivity to dose

: PAB time split

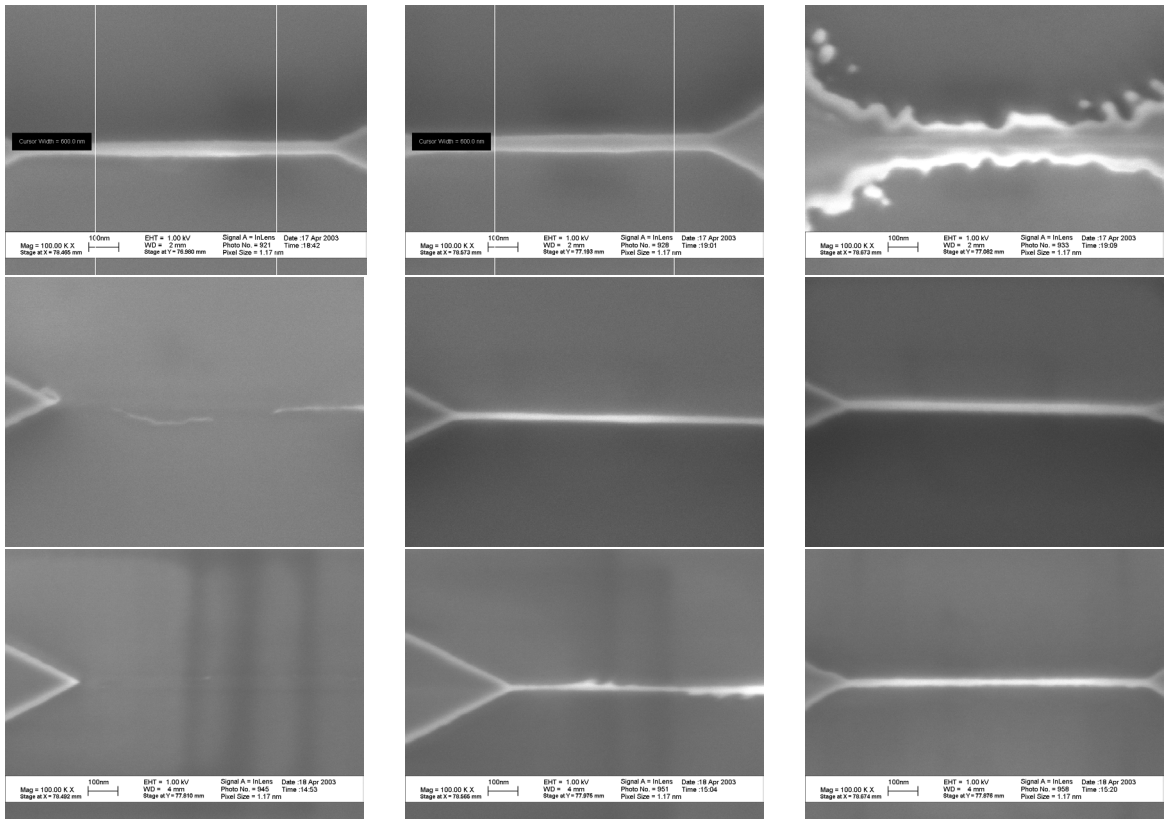
- Control of dissolution amount

: Development time split

Experimental Procedure

1. Spin 30% AZPN114 with 1000rpm
2. Crosslink bake at 250°C, 5min
3. Spin 1.8% HSQ with 2700rpm
4. Soft bake at 170°C, 2min30sec,*5min* and 10min (reference is 5min)
5. e-beam exposure with dose range of 2000~5700 $\mu C/cm^2$
6. Develop in LDD26, 30sec, *60sec*, 90sec and 120sec, DI rinse (reference is 60sec)
7. AZPN etch with O_2 ICP, 3min30sec
8. SEM inspection

PAB Time Effects



2min 30sec

5min

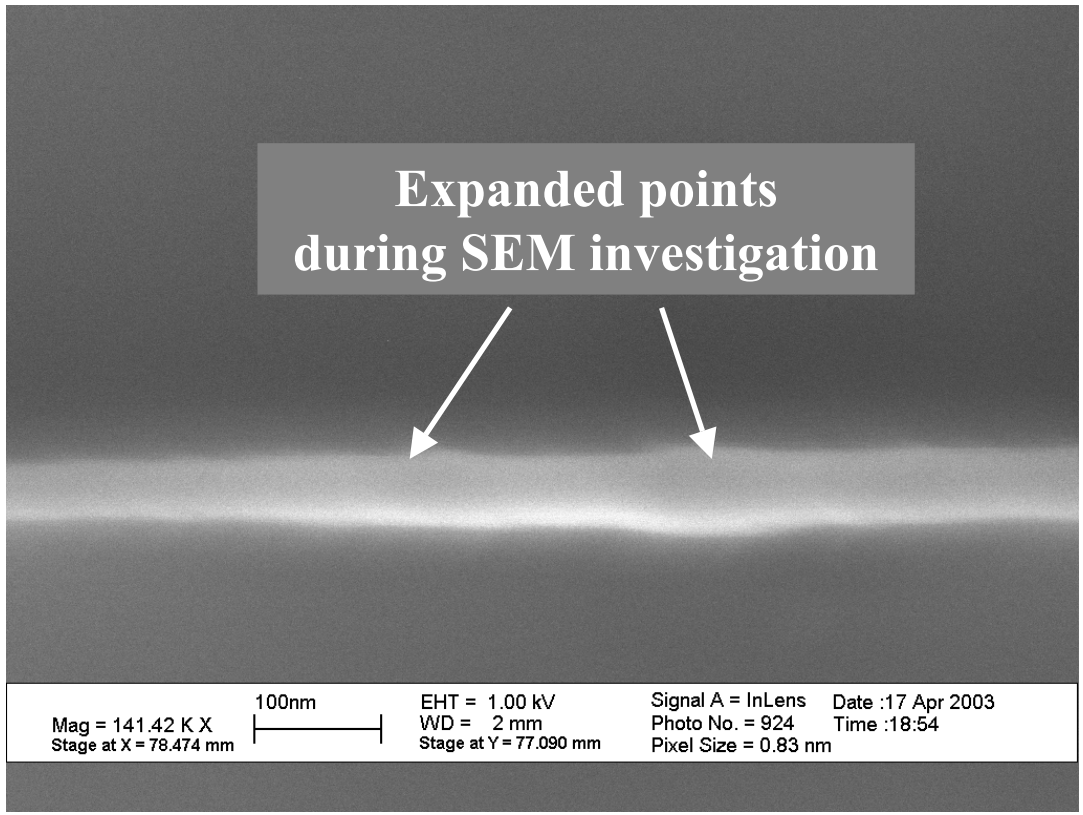
10min

2000 μ C/cm^2 3221 μ C/cm^2 4716 μ C/cm^2

Increasing Dose

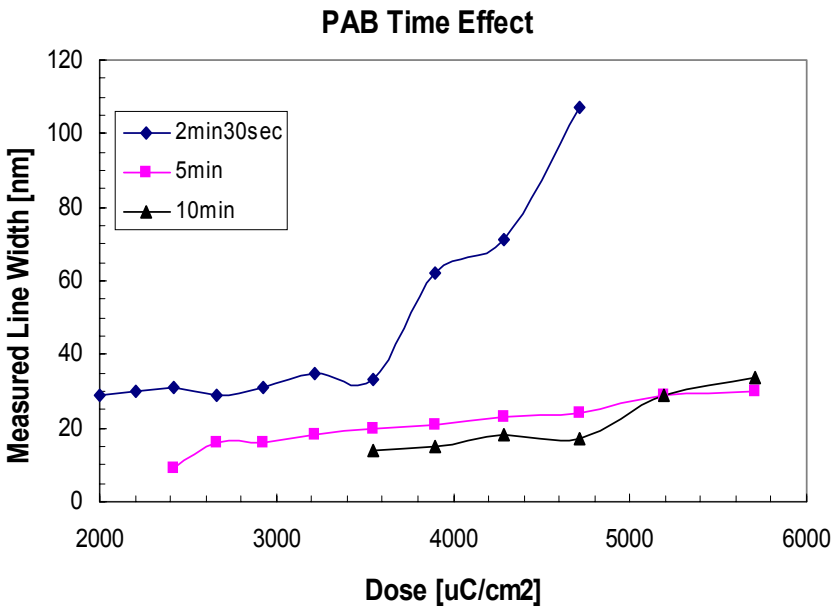
Crosslinking sensitivity of HSQ is improved as PAB time decreases.

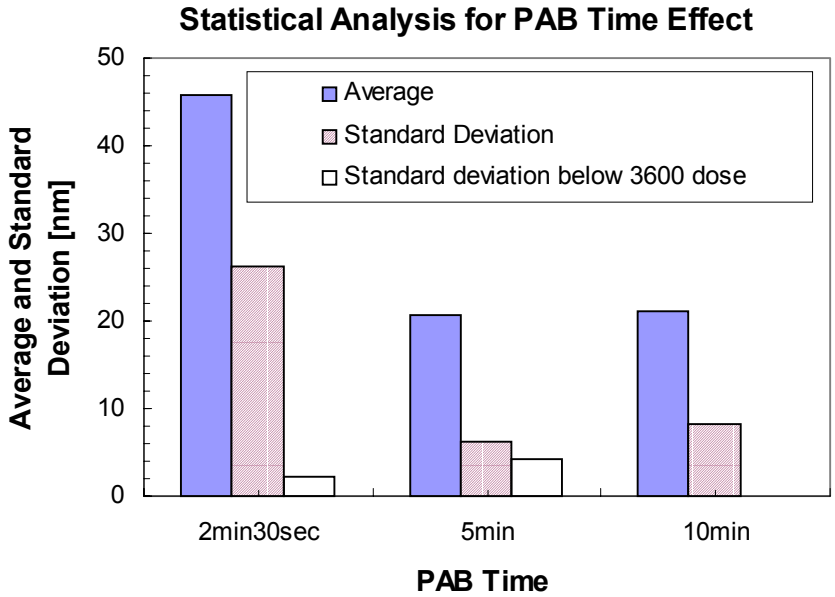
Proof of crosslinking sensitivity improvement



Crosslinking of HSQ becomes to be very sensitive to dose as the PAB time decreases.

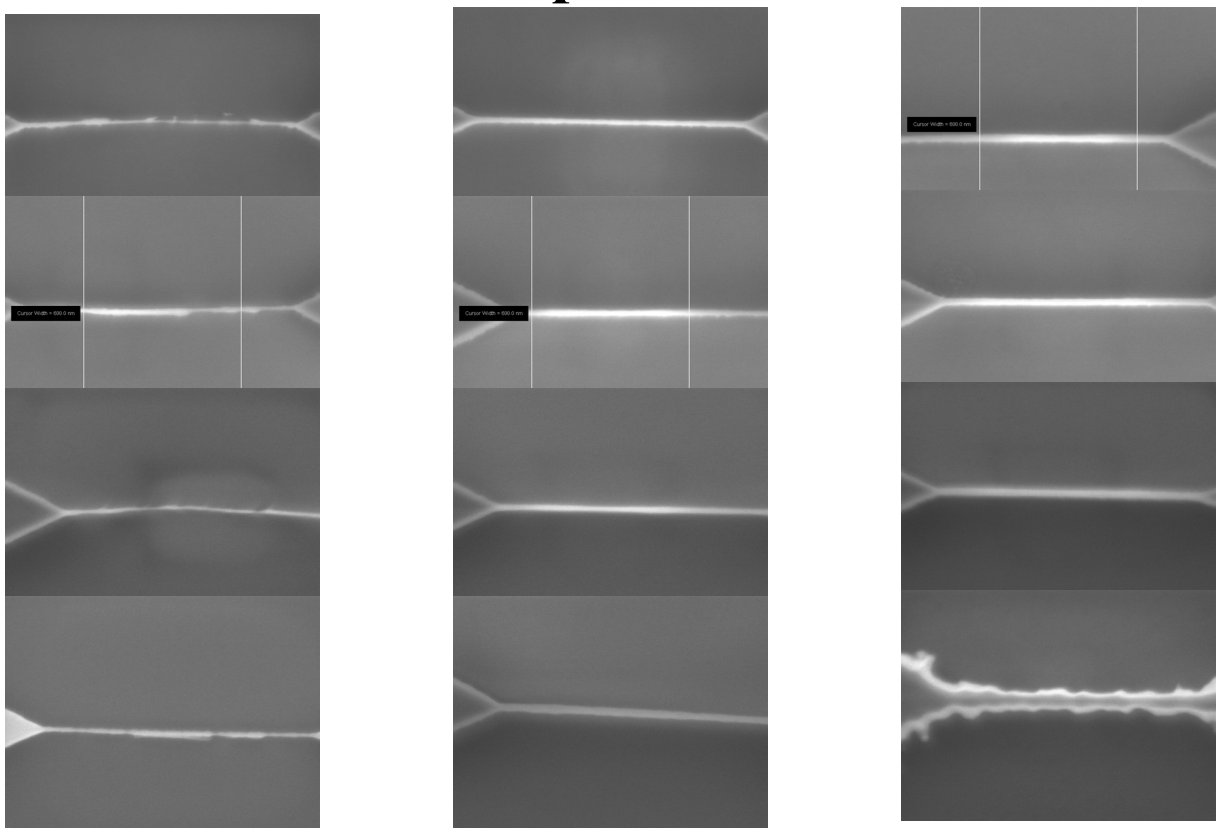
PAB time effects for more dose conditions





We need to minimize the PAB time for quite fine linewidth variation especially when the dose is moderate.

Development time effects

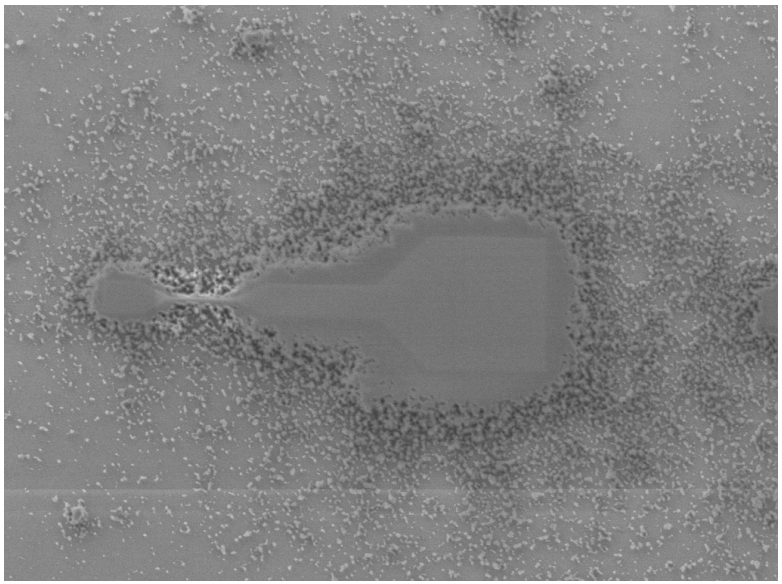


2420 μ C/cm^2 3221 μ C/cm^2 4716 μ C/cm^2

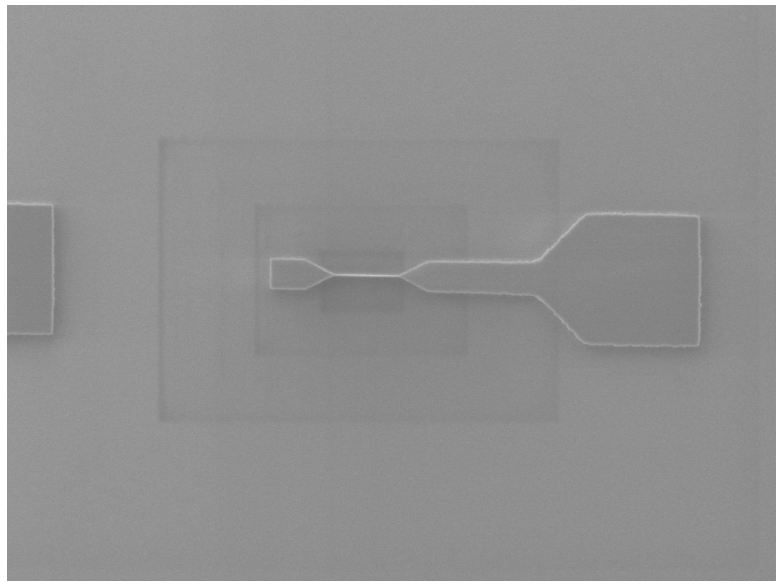
Increasing Dose

- Line edge roughness improvement
- Worse line shape at low dose

Development time effects (Dose = 5706 μC/cm^2)



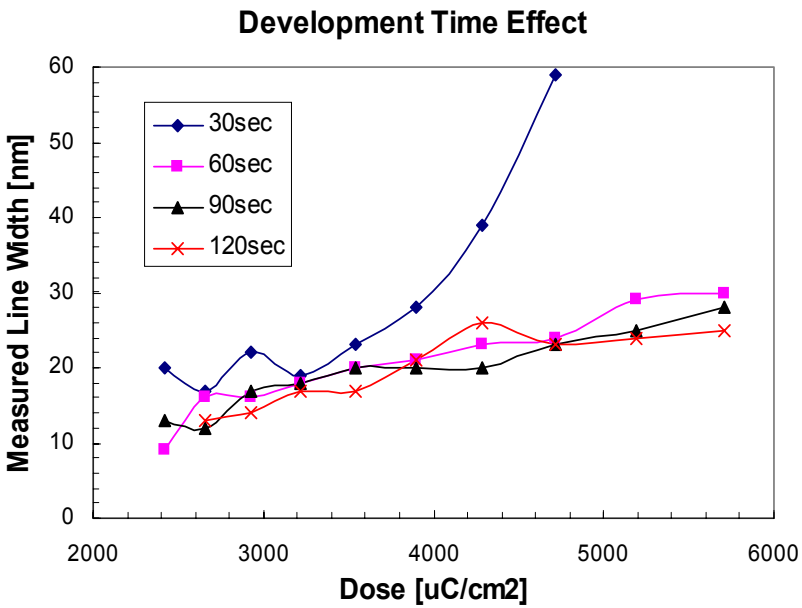
30sec

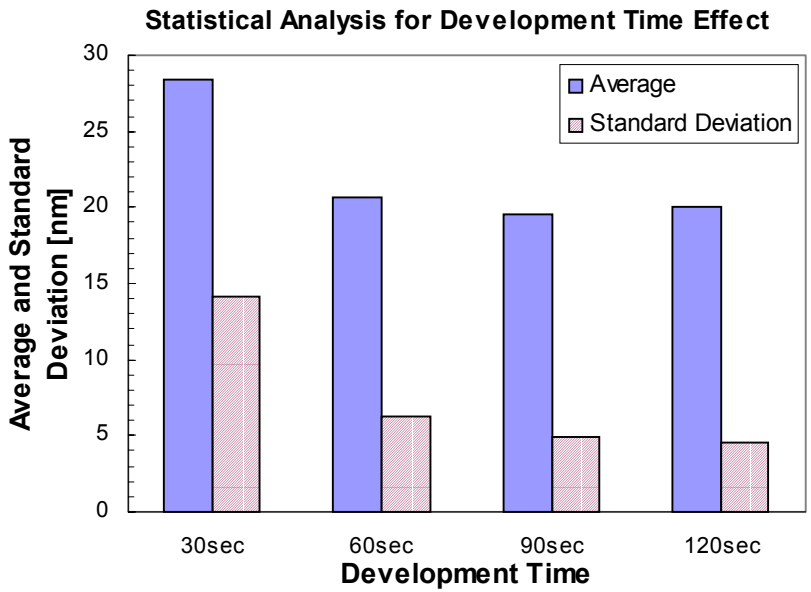


120sec

Elimination of undesirable patterns formed by e-beam scattering

Development time effects for more dose conditions





- Better linewidth variations as dose changes
- Linewidth reduction could be a problem at low dose conditions

Conclusions

- In order to minimize linewidth variation by dose change
  - Shorter PAB time, especially under the moderate dose conditions (e.g. below 3600 $\mu C/cm^2$)
  - Longer Development time
- Trade-offs
  - Too much crosslinking sensitivity at shorter PAB time
  - Too much linewidth reduction at longer development time
- Combination of PAB/Development time effects