base dose determination for various thickness HSQ

background

• normally we measure base dose by reflectometry or contact profilometry to produce thickness vs. dose, but both methods require optical detection of features. 1% HSQ (15 nm) is too thin to be observed optically.

• 1% HSQ can be observed in SEM easily

• expose 500 nm line/space at 6%, 2%, 1% HSQ thicknesses and examine in SEM to establish dose vs feature to determine base dose.

• also can observe solid squares for qualitative base dose determination

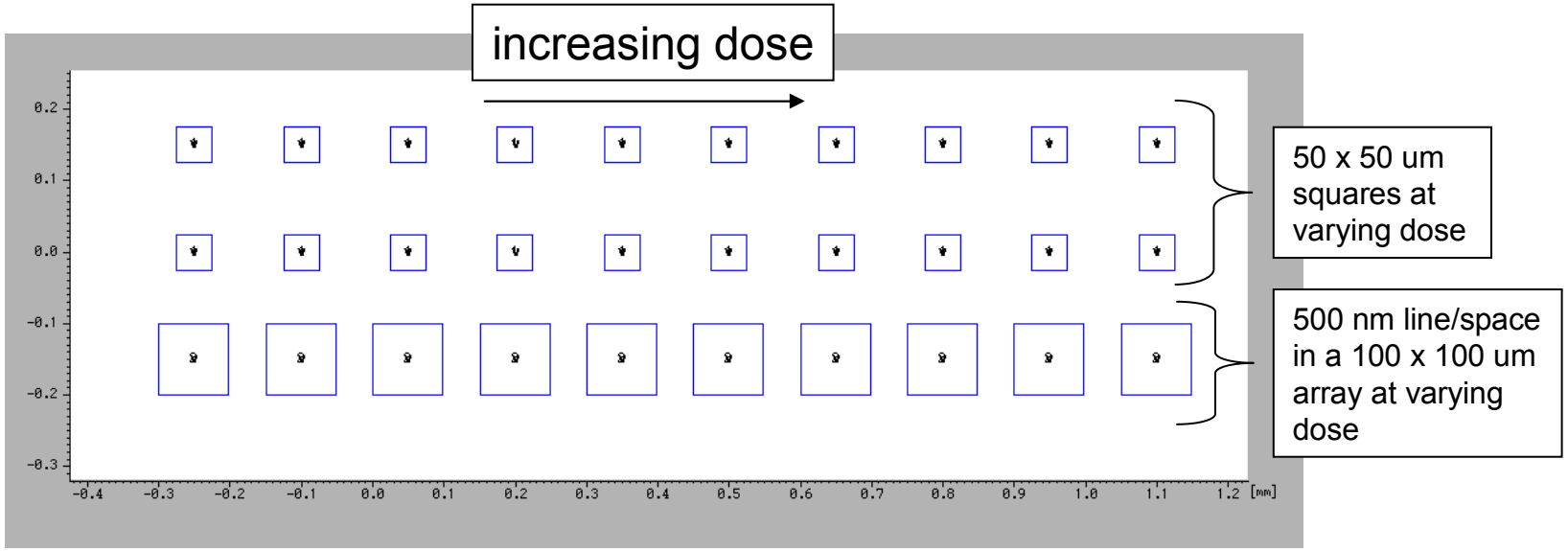
process flow

- spin coat
  - silicon piece substrate (qty = 3)
  - each sample is coated with 6%, 2% and 1% HSQ as follows
  - 5000 RPM, 2500 RPM/s, 60 sec
  - 80 C hot plate bake, 4 min

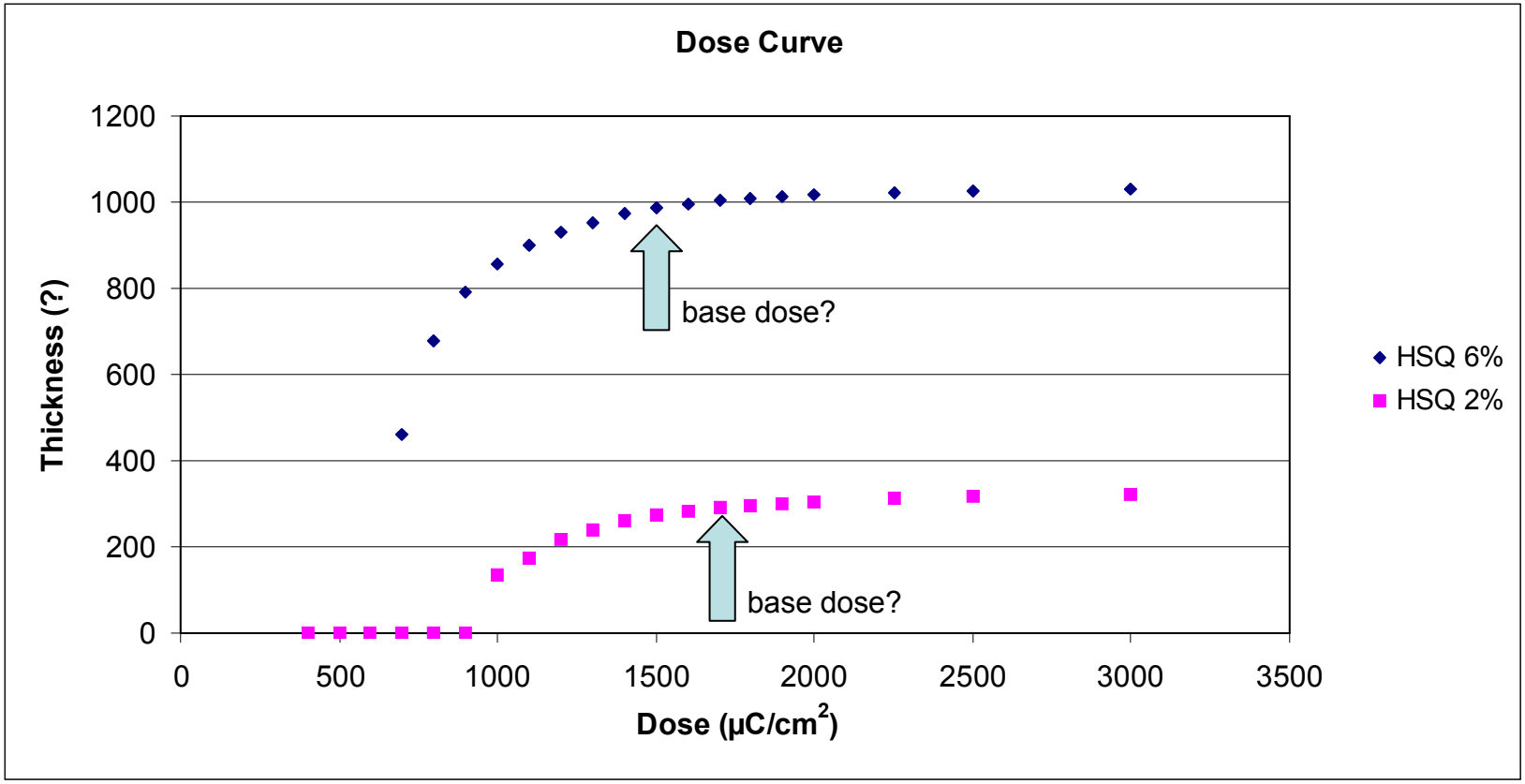
- expose
  - pattern
    - 50 x 50 um solid squares
    - 500 nm line/space over 100 x 100 um square
  - 2 nA, shot pitch = 6 nm, 100 kV
  - dose varies

- develop
  - 25% TMAH, 30 sec
  - DI water rinse, 1 min 30 sec

exposure pattern

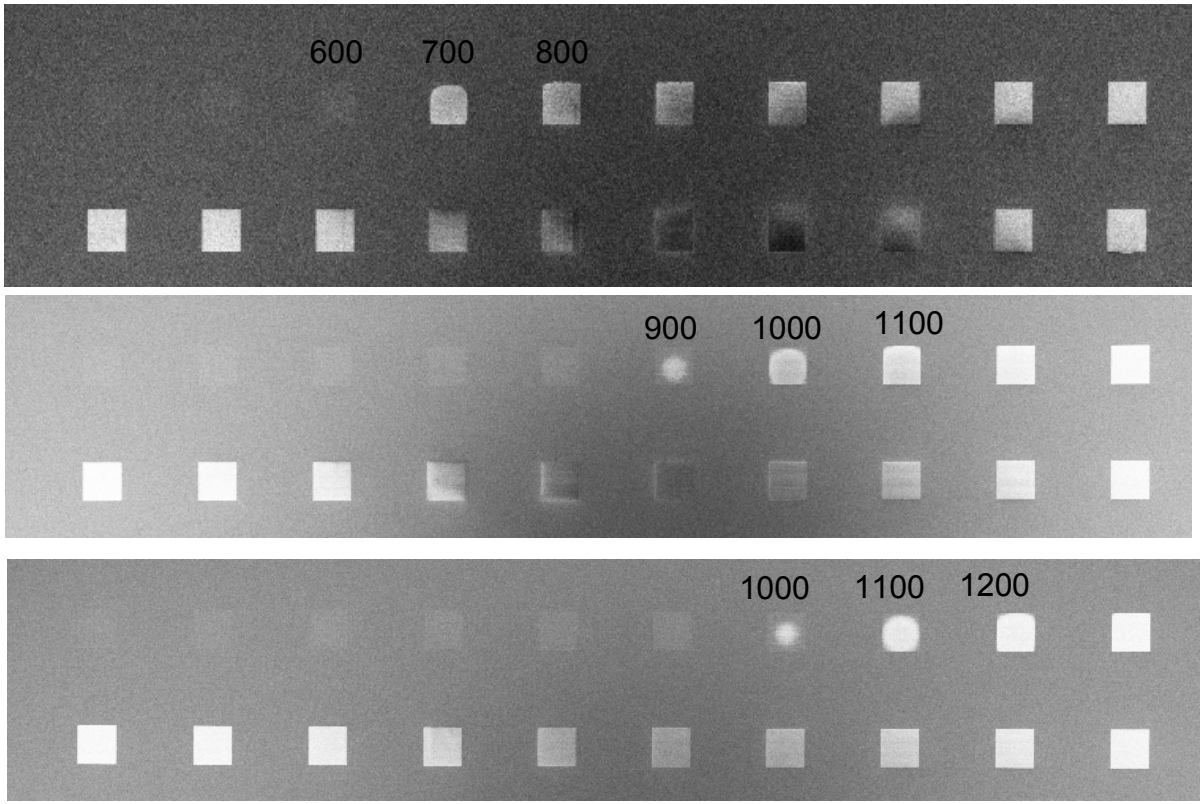


thickness vs. dose



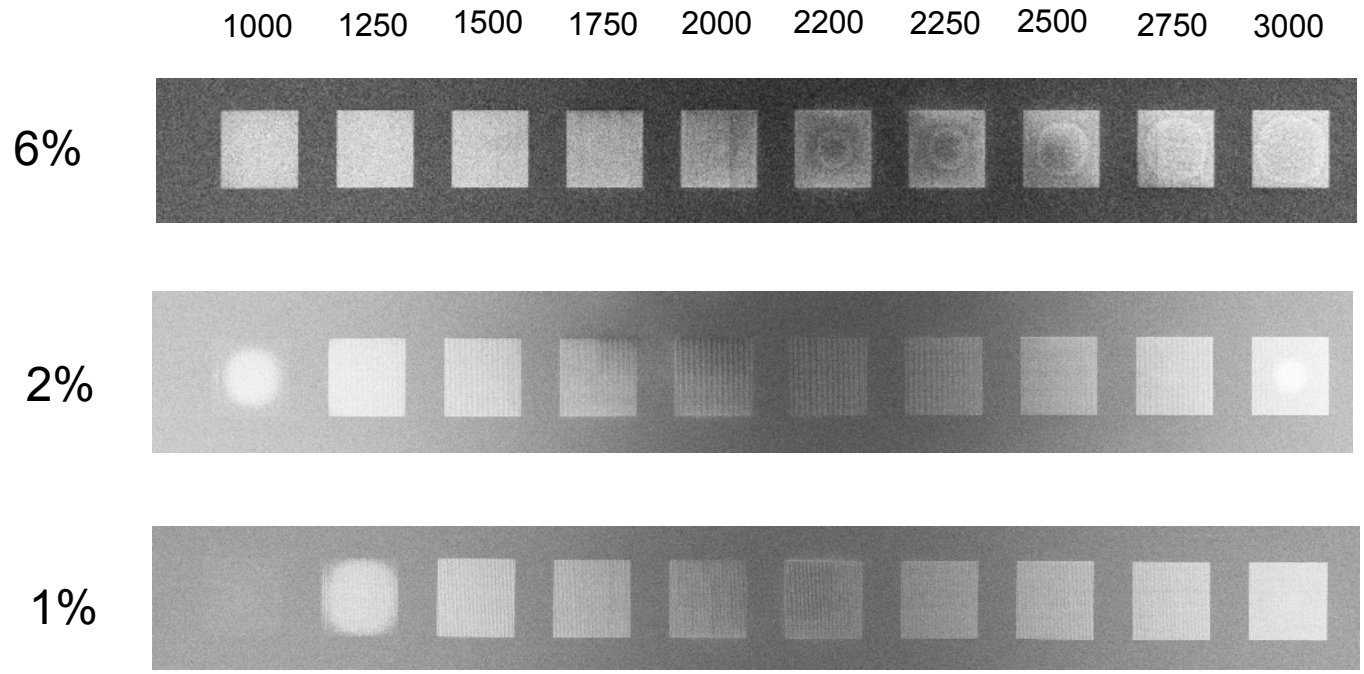
- thickness measured by reflectometry on 50 x 50 um squares
- HSQ contrast is low, difficult to say where base dose is exactly
- 2% has higher onset dose
- 6% base dose possibly 1500 uC/cm2
- 2% base dose possibly 1700 uC/cm2
- 1% cannot be measured because it cannot be seen optically

SEM of solid squares

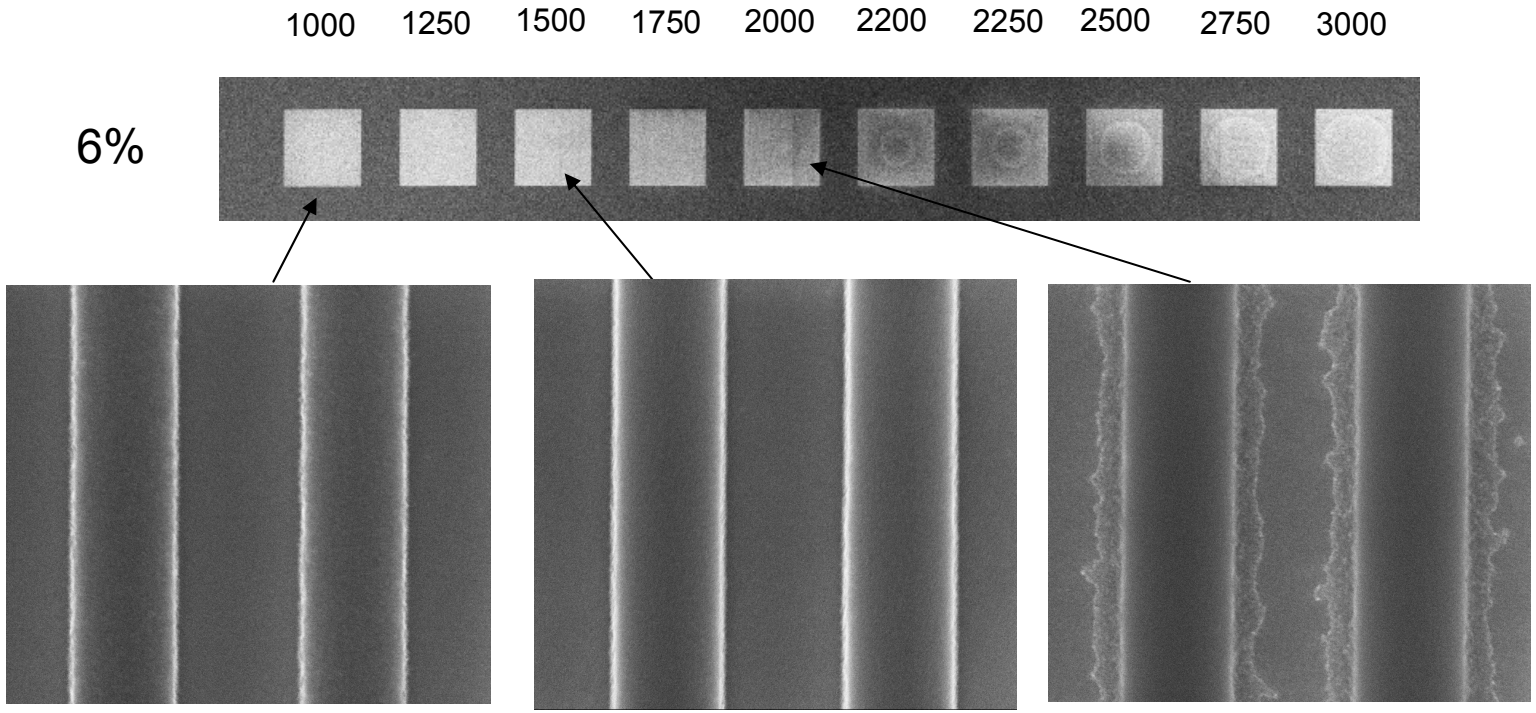


- onset doses of 2% and 6% agree with reflectometry measurements
- 1% onset dose is 100 uC/cm2 higher than 2%
- from this we can estimate 1% HSQ base dose is ~10% higher than 2% HSQ

SEM of 500 nm line/space



SEM of 500 nm line/space
6% HSQ

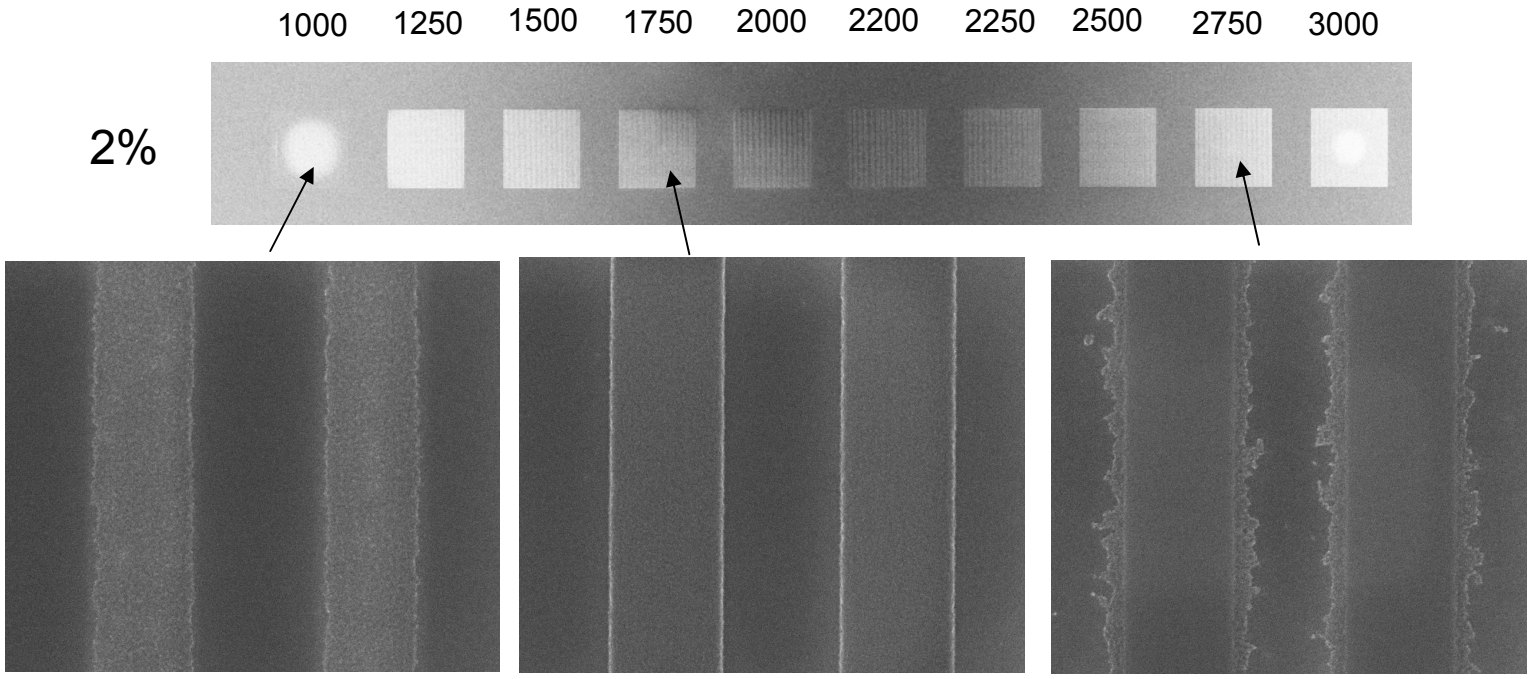


1000 uC/cm2
avg line width = 466 nm

1500 uC/cm2
avg line width = 496 nm

2000 uC/cm2
overexposed/residue

SEM of 500 nm line/space
2% HSQ

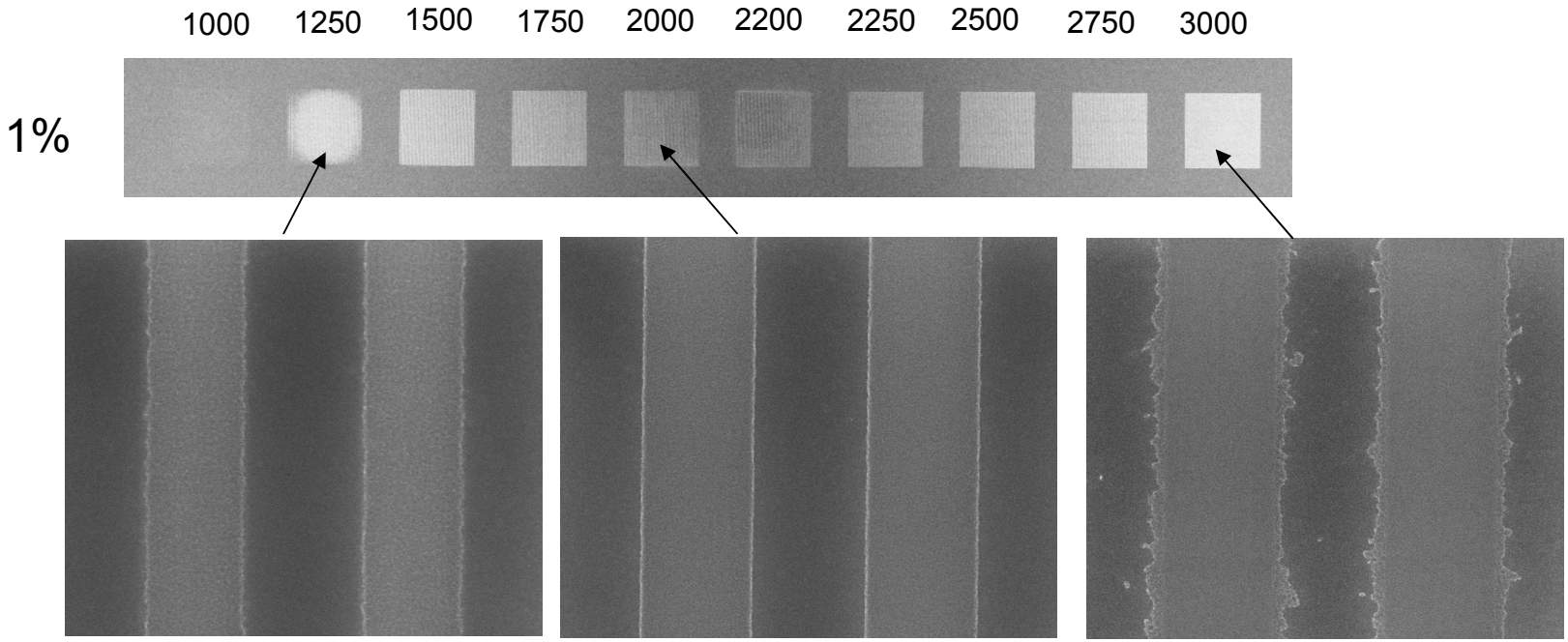


1000 uC/cm2
avg line width = 416 nm

1750 uC/cm2
avg line width = 499 nm

2750 uC/cm2
overexposed/residue

SEM of 500 nm line/space
1% HSQ

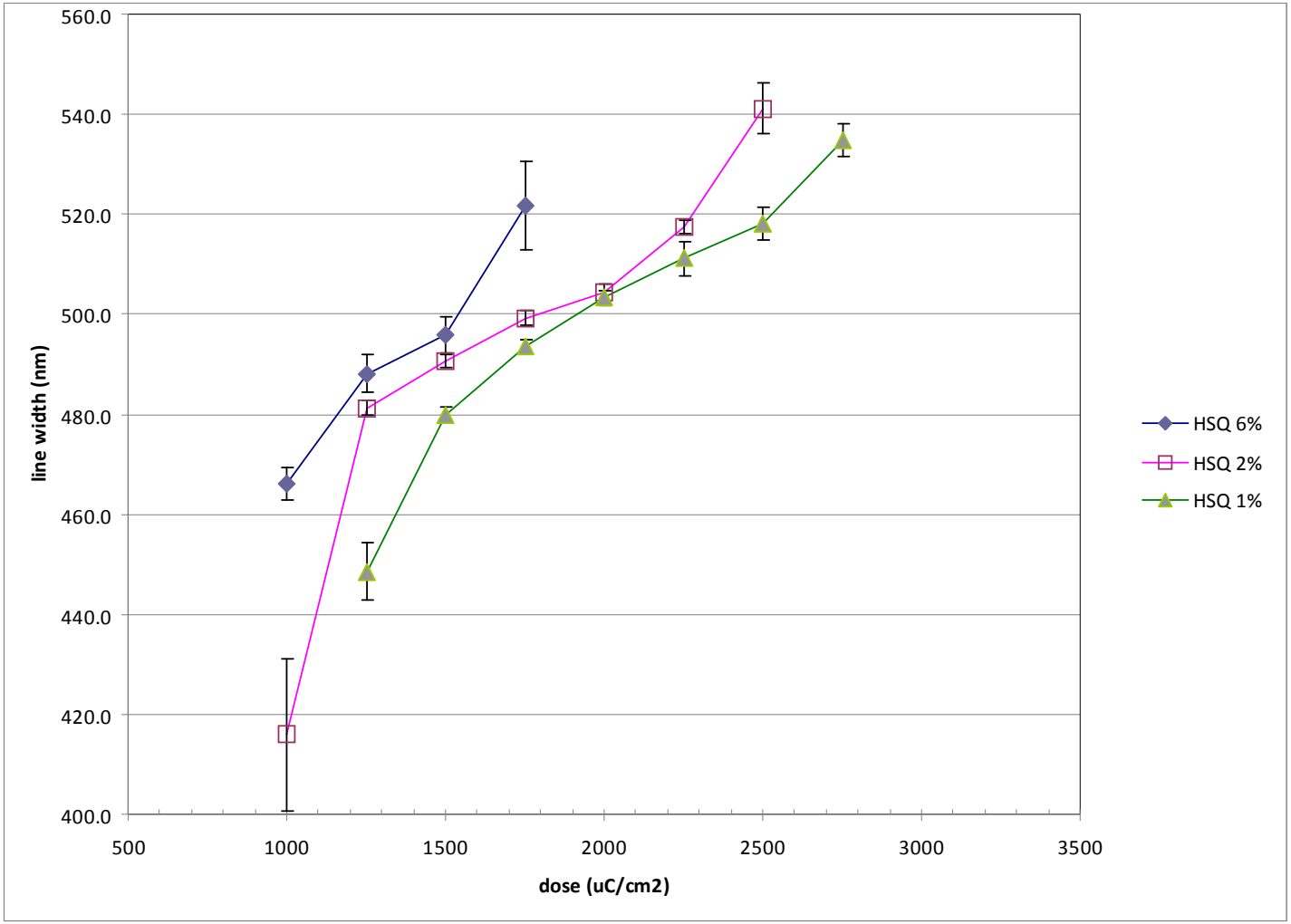


1250 uC/cm2
avg line width = 449 nm

2000 uC/cm2
avg line width = 503 nm

3000 uC/cm2
overexposed/residue

linewidth vs. dose for 500 nm line/space pattern



- 6% base dose ~ 1550 uC/cm2
- 2% base dose ~ 1800 uC/cm2
- 1% base dose ~ 1900 uC/cm2

conclusions

- HSQ base dose determination (100kV, 25% TMAH)
  - 6% base dose ~ 1550 uC/cm2
  - 2% base dose ~ 1800 uC/cm2 (+16%)
  - 1% base dose ~ 1900 uC/cm2 (+23%)