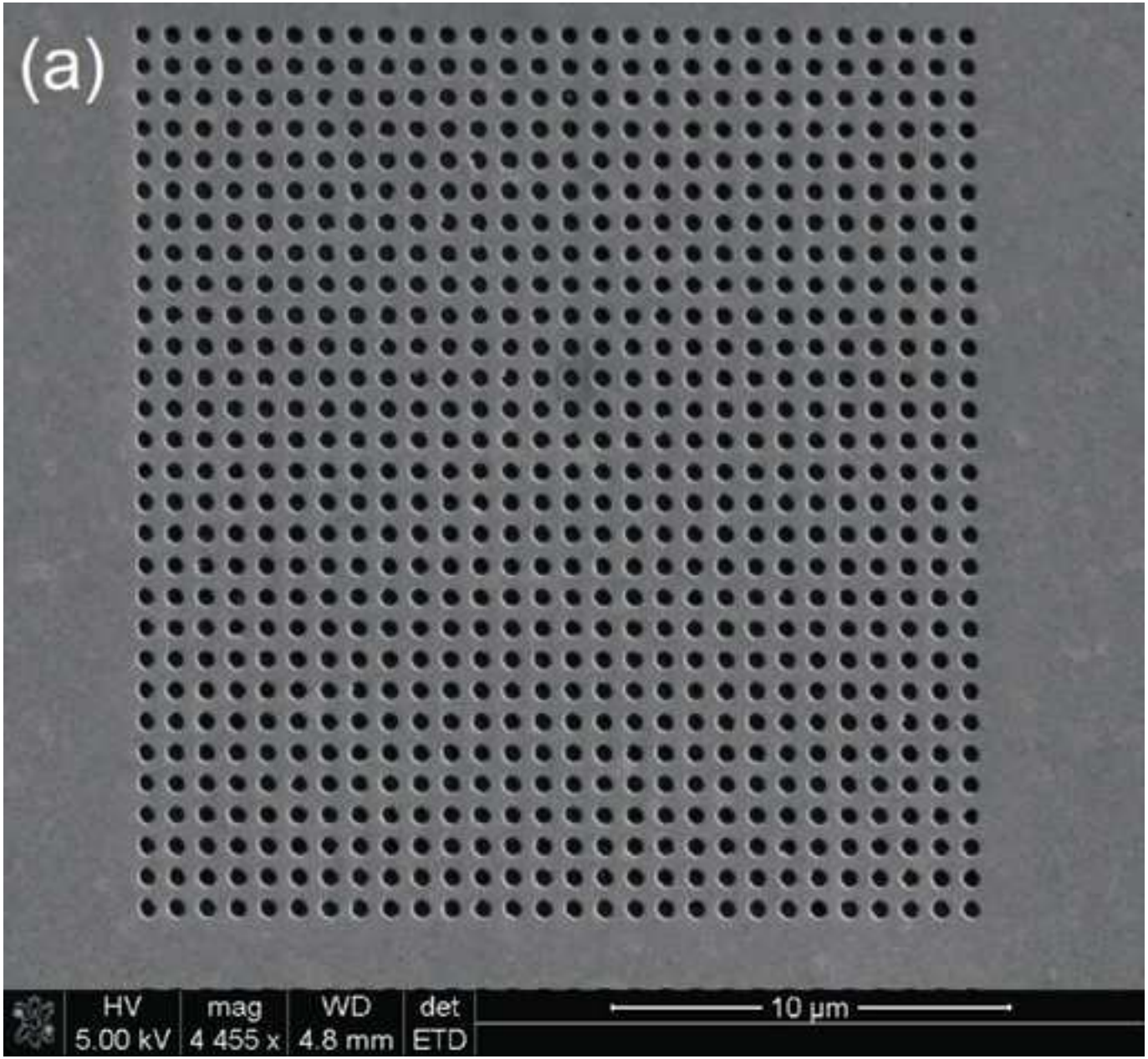
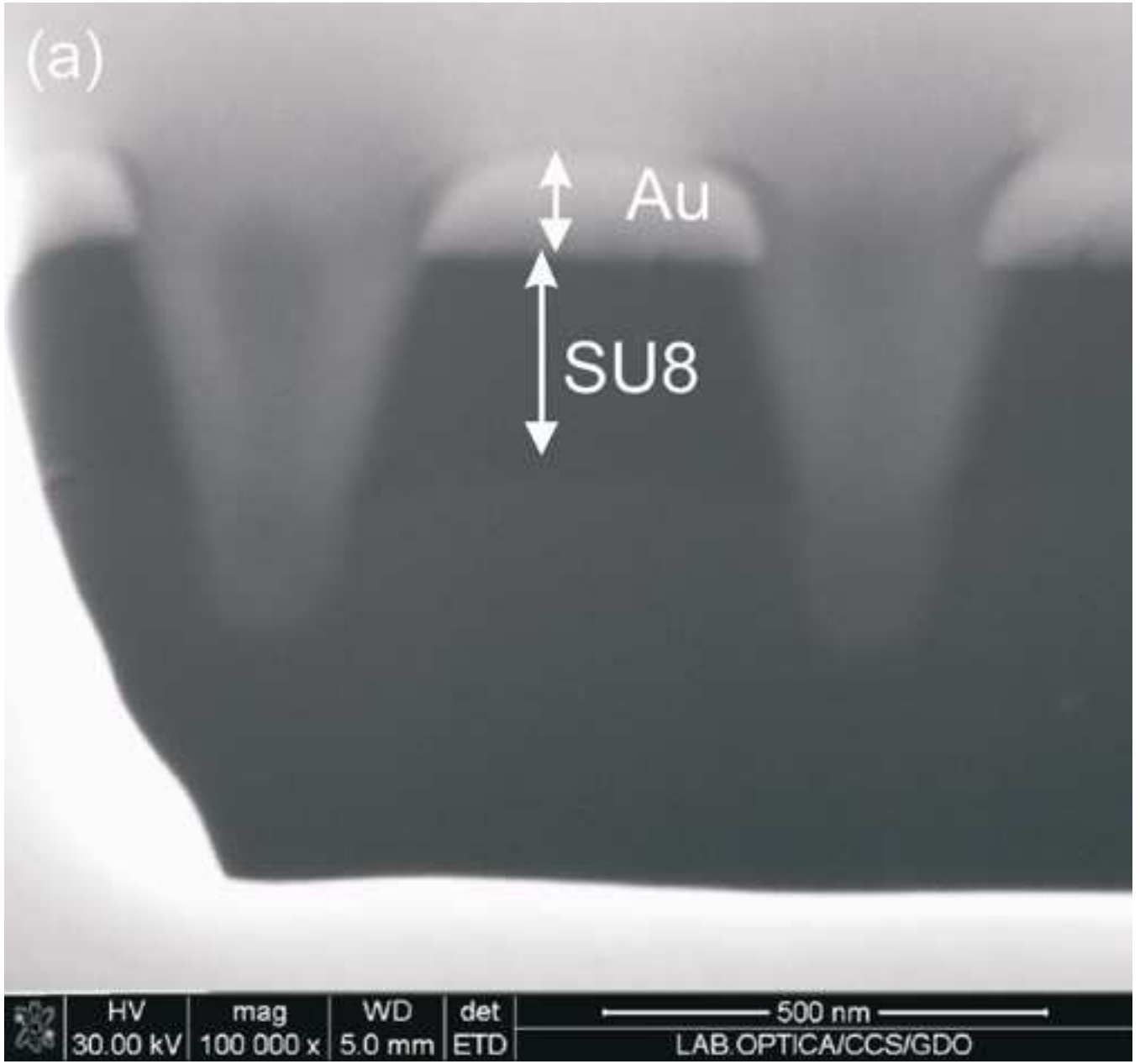
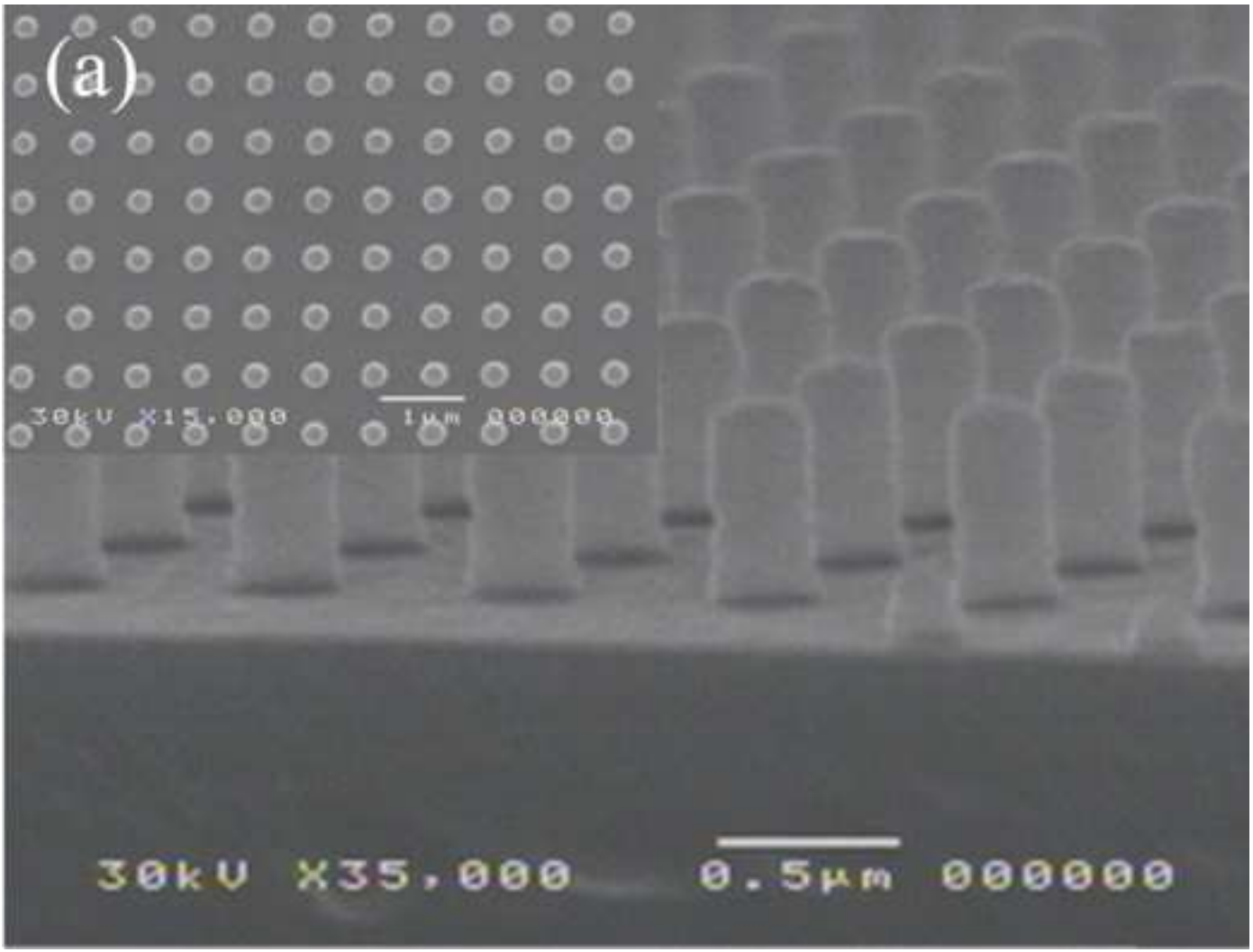
CAMTEC

Factors influencing the sidewall profiles of the developed e-beam resists

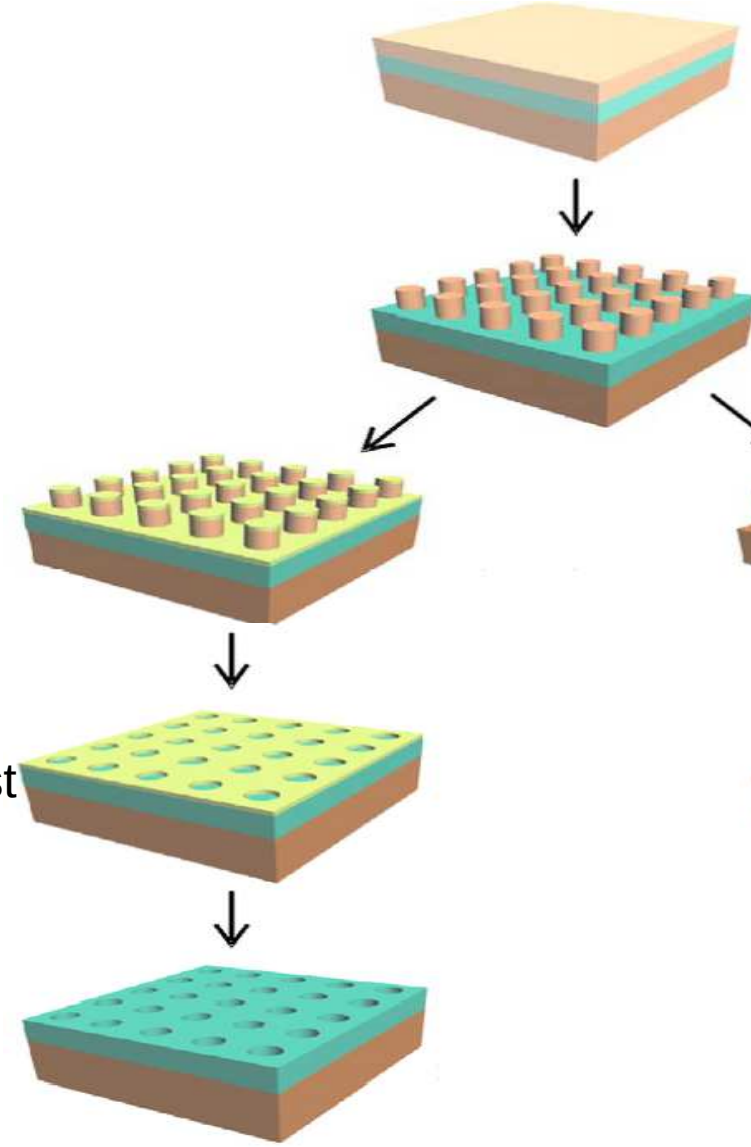
Jacson Menezes


(a)
HV
5.00 kV
mag
4 455 x
WD
4.8 mm
det
ETD
10 µm


(a)
Au
SU8
HV
30.00 kV
mag
100 000 x
WD
5.0 mm
det
ETD
500 nm
LAB.OPTICA/CCS/GDO


(a)
30kV X15,000 1µm 000000
30kV X35,000 0.5µm 000000

Standard steps of the fabrication process



- Deposition of the materials

- Structures recorded and developed

- Deposition of intermediate mask

- Etching using resist as mask

-Lift-off of the resist

- resulting pattern in the desired material

-Etch of the desired material

Substrate
resist
Intermediate mask
Desisred material

Parameters that determine the vertical sidewalls

- Voltage

-Current

- Dose

- development process

- Beam alignment

- beam drift (time)

- resist

- dimensions of the desired pattern

- Thickness of the resist

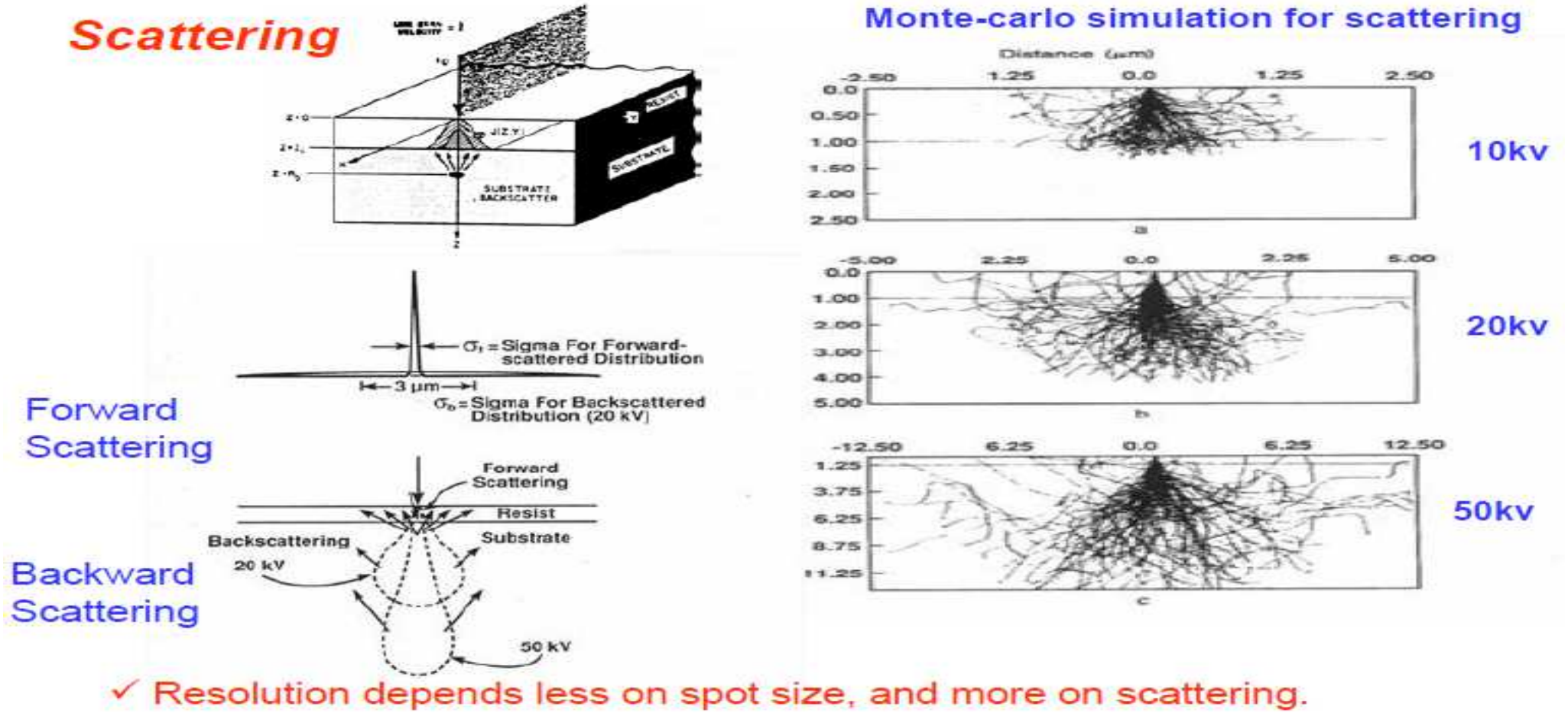
- etc

Voltage

When electrons strike a material, they lose energy from atomic collisions and are 'scattered'. The scattering of electrons may be backward, but it is often forward through small angles with respect to the original path.

This electron scattering has two major effects:

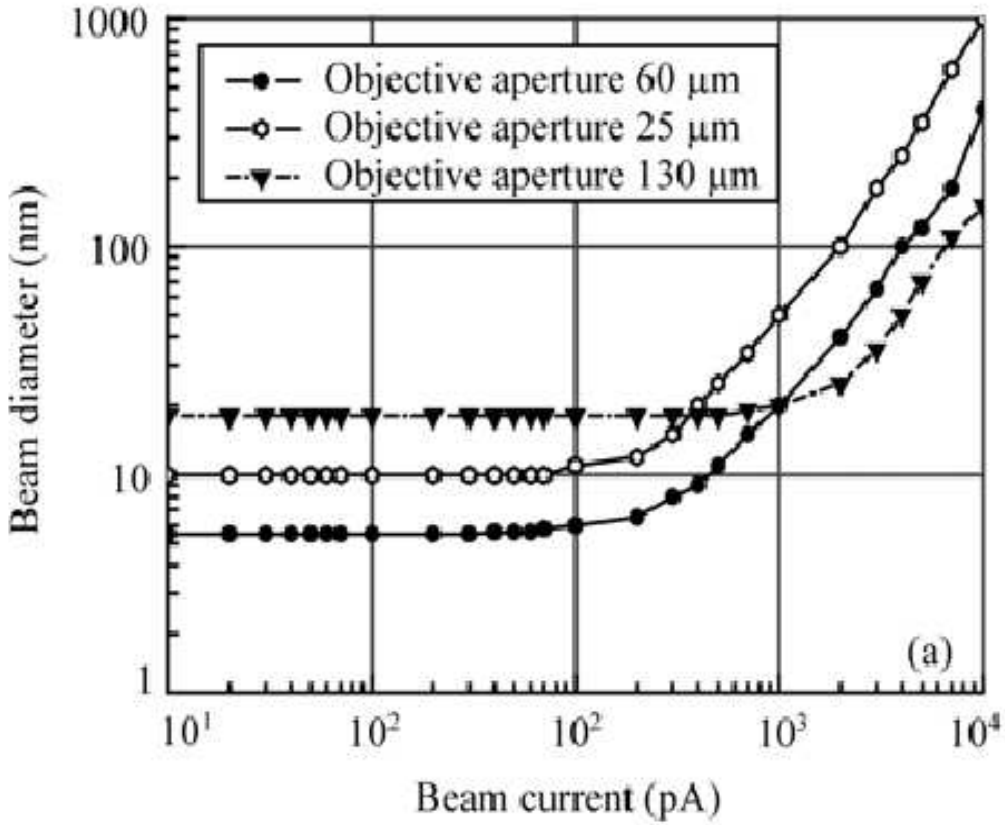
1) it broadens the diameter of the incident electron beam as it penetrates the resist and substrate; and
2) it gives the resist extra doses of electron exposure as back-scattered electrons from the substrate.



✓ Resolution depends less on spot size, and more on scattering.

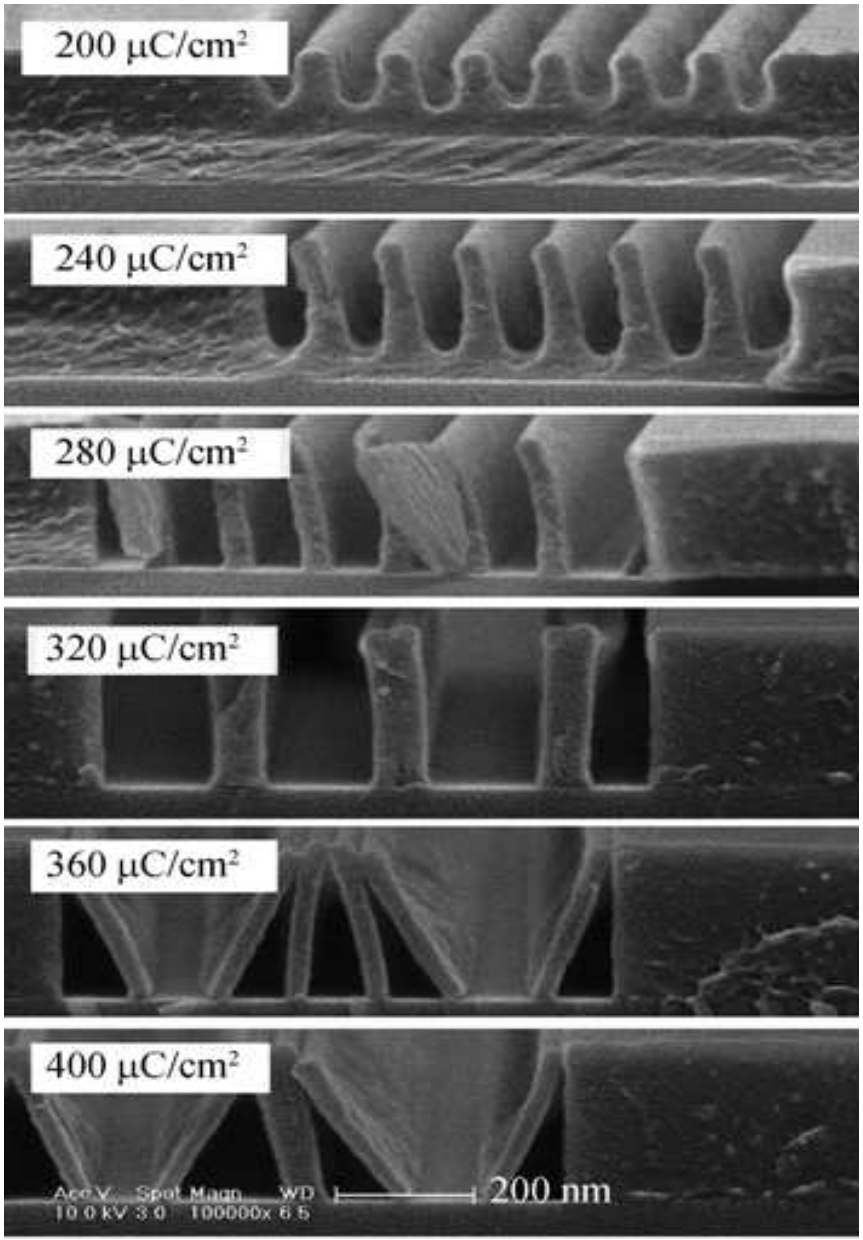
Current

Increasing the current, the beam size increase. The result is related to line-width (dimension of the recorded structure)



The beam size determines the minimum line-width, which is typically at least 3 times the beam diameter.

Dose : related with the exposure time (current)

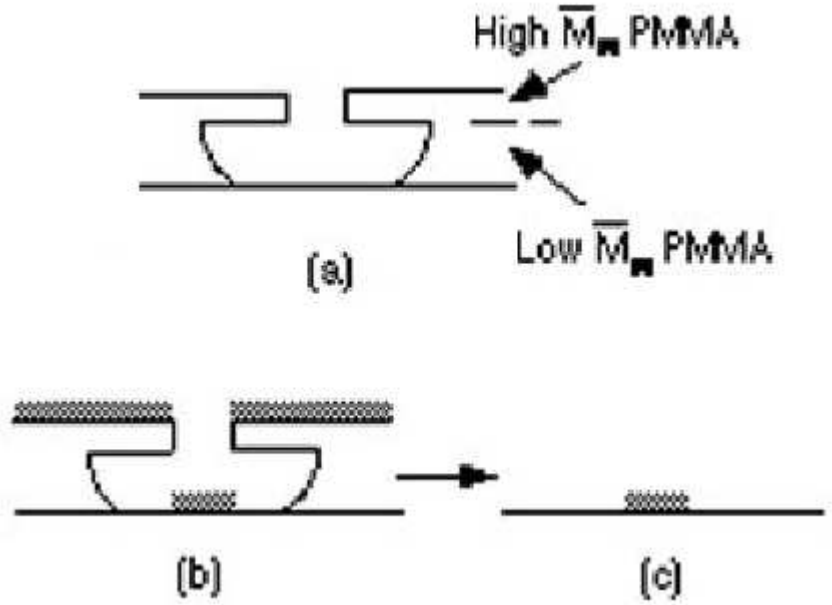


If the exposure dose is too low, the exposed resist will not be completely dissolved by the developer

The higher the electron energy, the smaller the side wall angle

larger exposure dose leads to a reserved resist structure that is too narrow and easily collapses after developing

Effects of the developer on sidewall: Developer control



Bilayer e-beam resist structures.
A high molecular weight PMMA is spun on top of a slightly more sensitive bottom layer of low molecular weight PMMA.

↓

Undercut profile

↓

Good to lift-off process

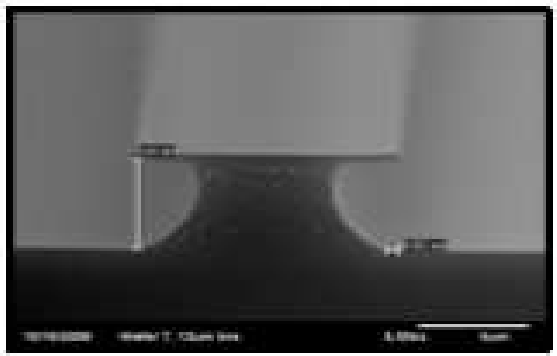
acceleration voltage constant and equal to 50KeV

Development process can be controlled using several different parameters:

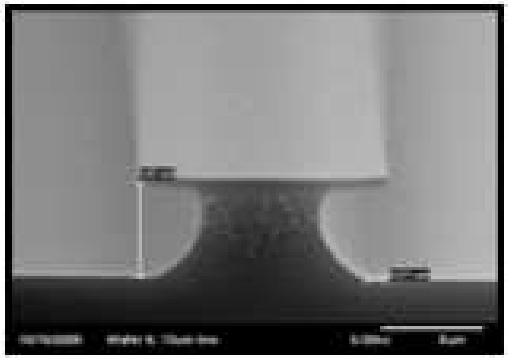
- **wafer spin-speed (agitation)**
- **development time,**
- developer strength,
- developer type.

Experimental variables tested

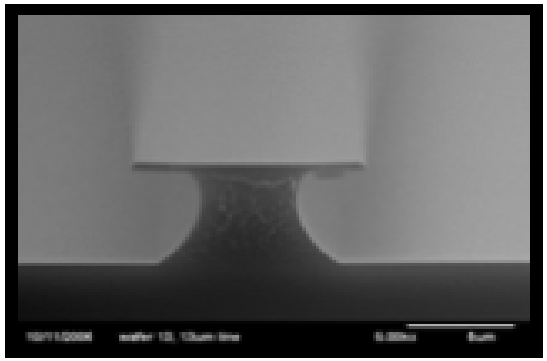
1- Wafer spin-speed: Figure shows the effect of wafer spin-speed on the amount of undercut for a 60 second development time.



150 rpm



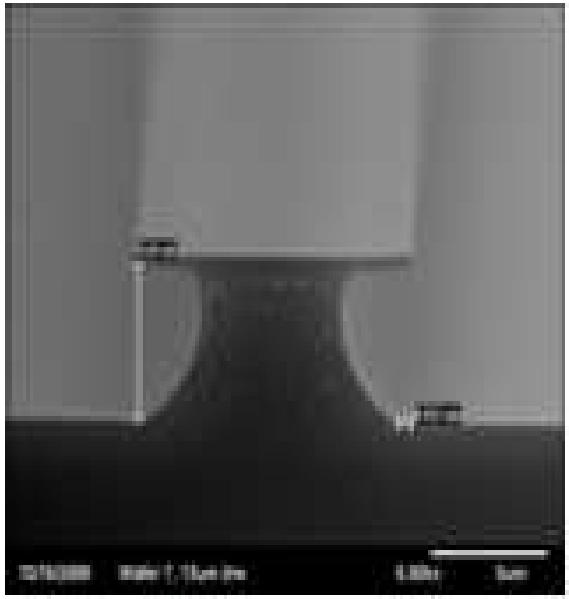
200 rpm



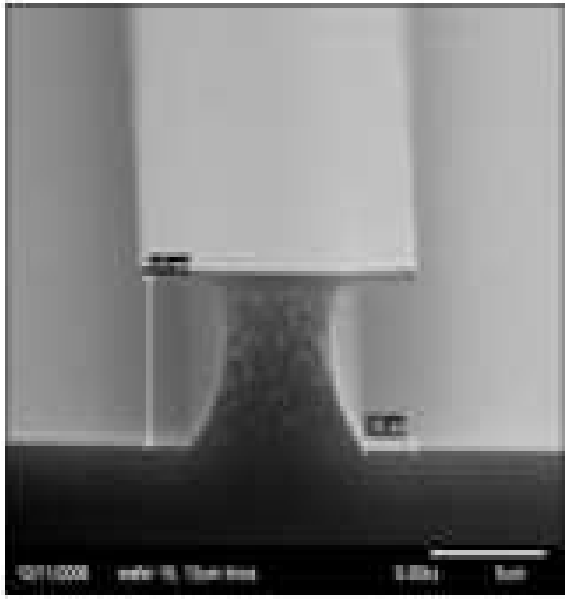
300 rpm

Increasing the spin-speed during development, not only does the amount of undercut change, but also the undercut profile become more vertical.

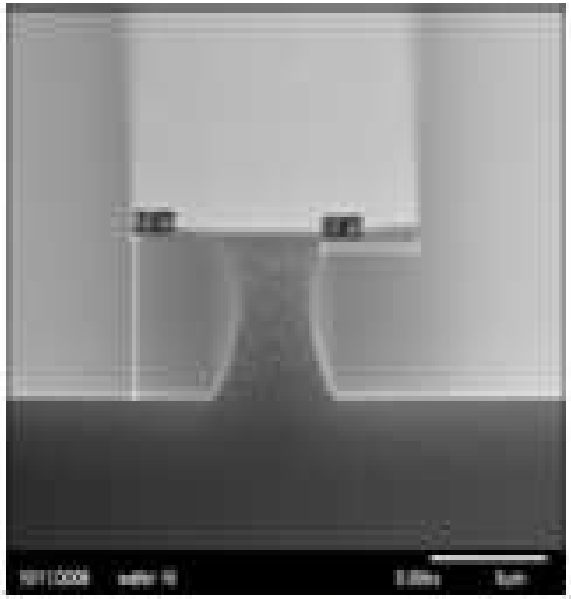
2- Effect of the development time keeping constant the spin-speed (150 RPM)



60 seconds



70 seconds



80 seconds

CONCLUSION

1- current: the bigger the current the bigger the beam size, affecting the original design.

2- Voltage: The smaller the voltage the bigger is the scattering at the surface, resulting in a change of the sidewall profile.

3- Dose: Relation with the time of exposure that is related with the current. Wrong doses can change the profile of the sidewalls

4- Developer: the profile change with **wafer spin-speed (agitation) and development time**

Best combination of these four parameters need to be found for the desired resist and the pattern designed.