NANOFABRICATION FACILITY

ADVANCED SCIENCE RESEARCH CENTER

ELIONIX

Using WecaS for Elionix EBL CAD File Conversion

And Considerations for Choosing Write Parameters

Samantha Roberts

Acknowledgements

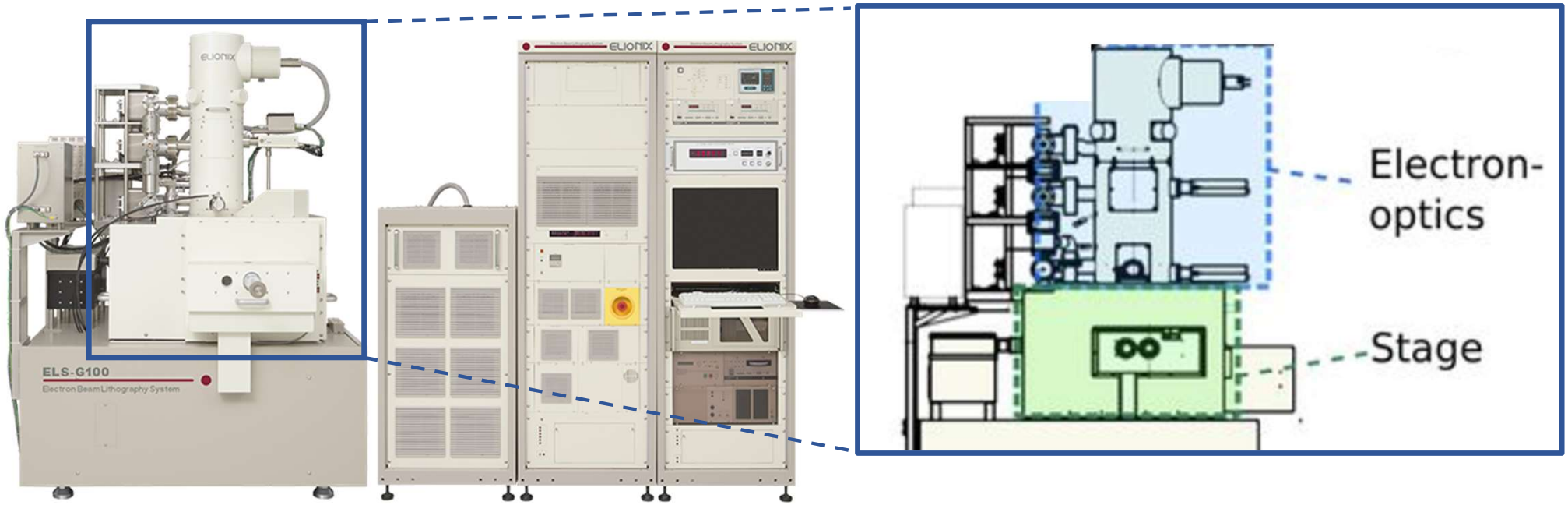
Sky on Sky: https://vonoff.com/

ELIONIX
株式会社 エリオニクス

ECA WIN

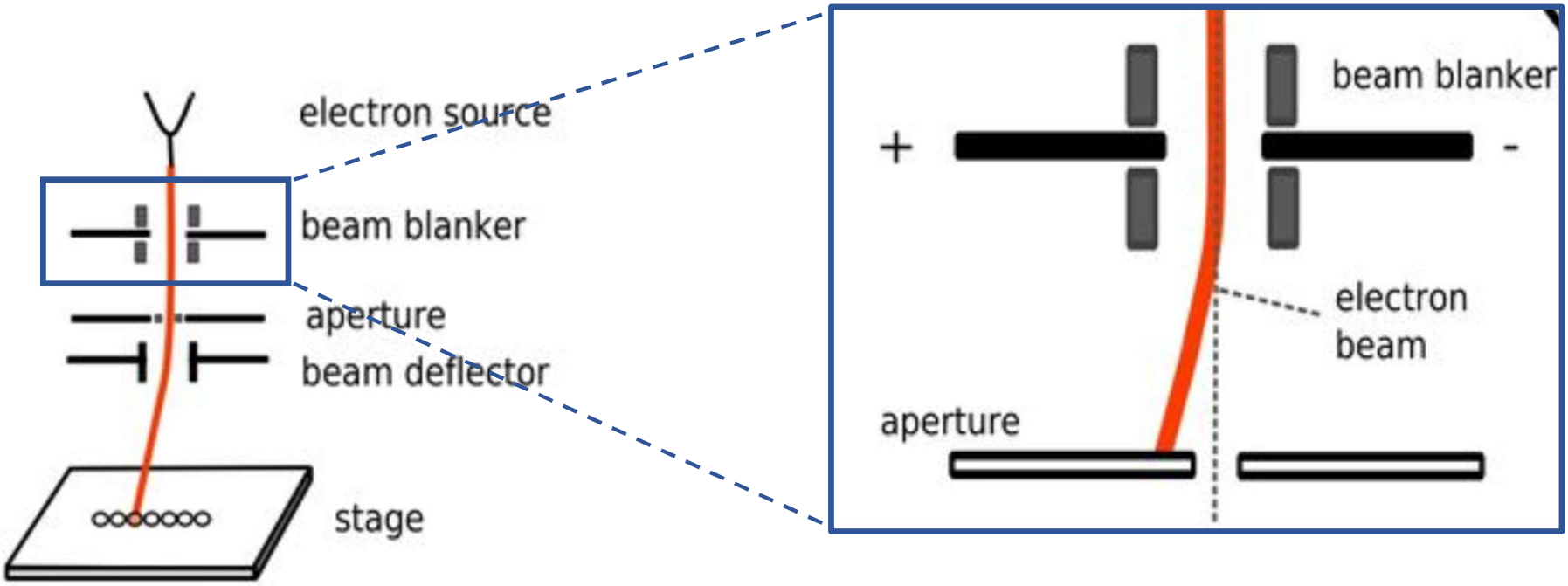
ELIONIX

Electron Optics Column and Stage

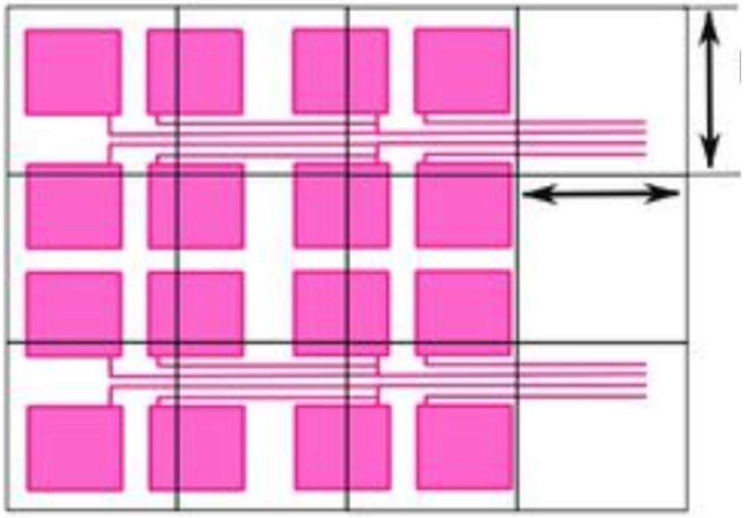


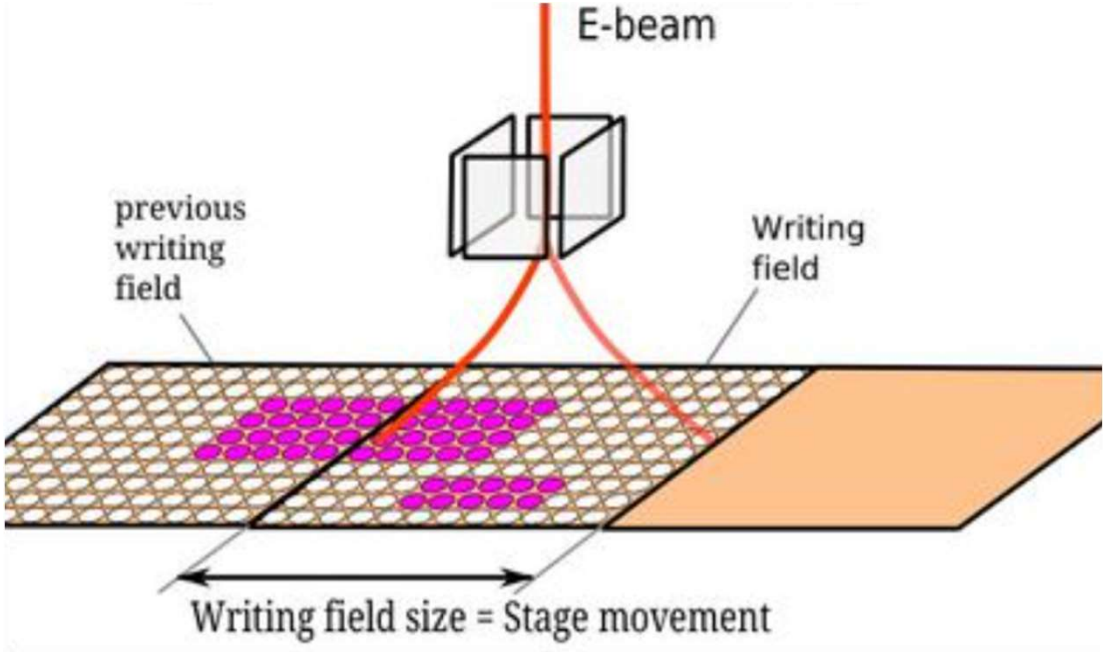
Beam Deflector and Beam Blanker

100MHz Clock → 10ns (Minimum dose time)

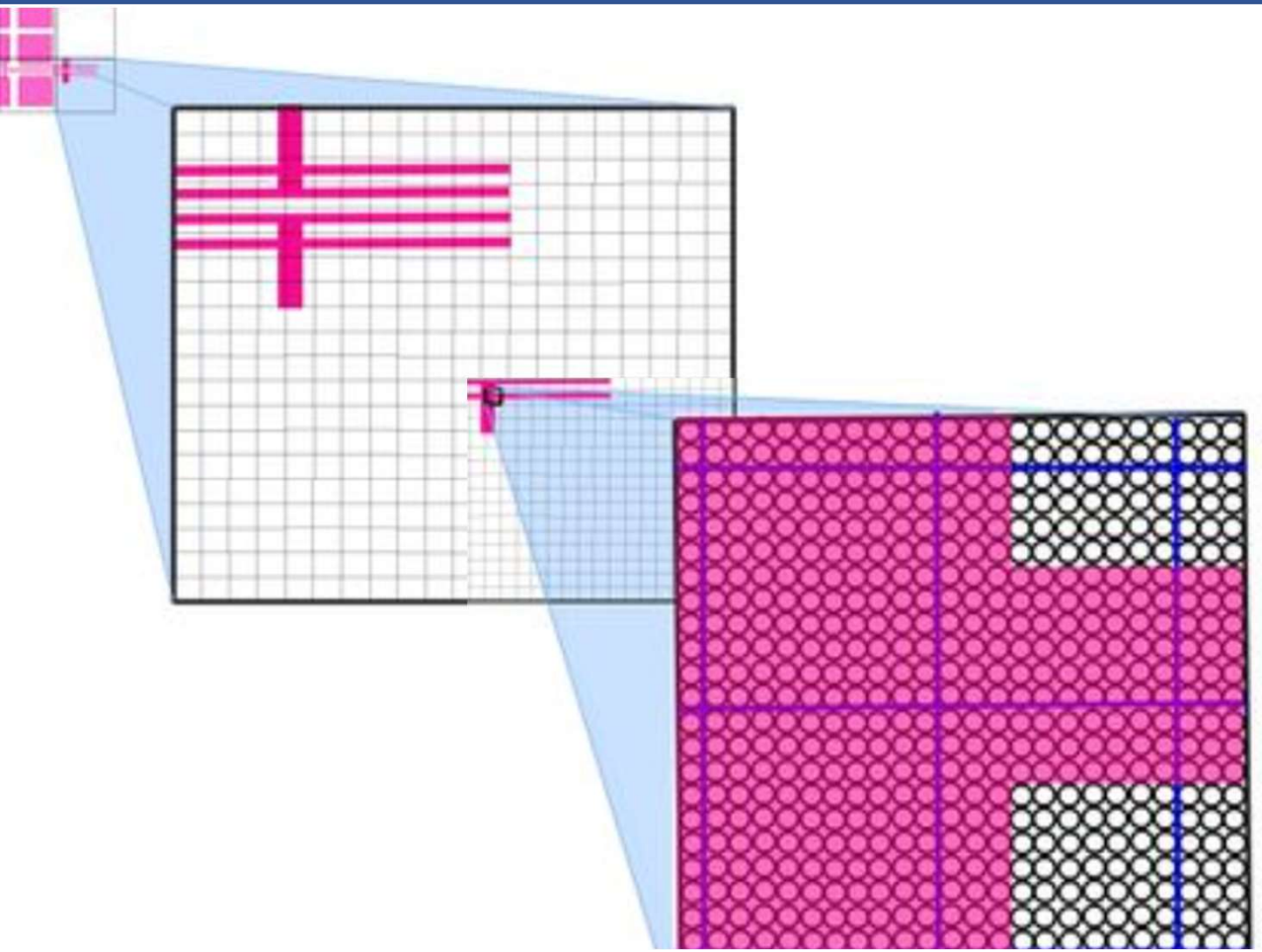


Elionix Breaks the CAD into Fields





Fields – Subfields – Polygons and E-Beam Spots

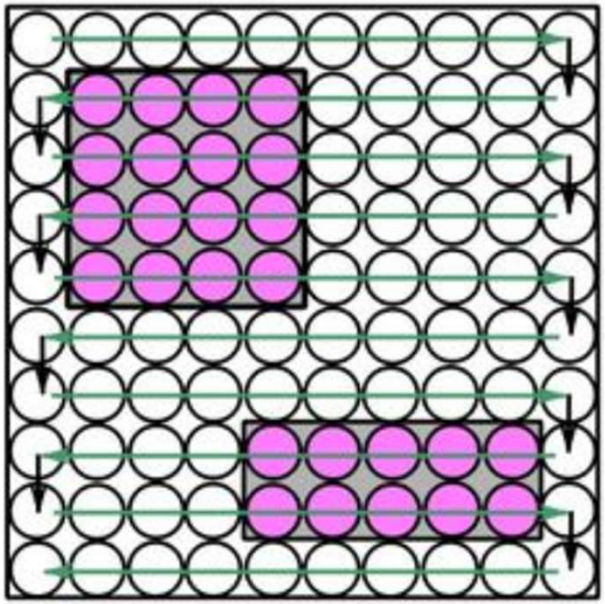


- Each field is broken into 20 subfields
- Each subfield is broken into trapazoids
- Each trapazoid is filled by E-beam shots

Rastor Scanning

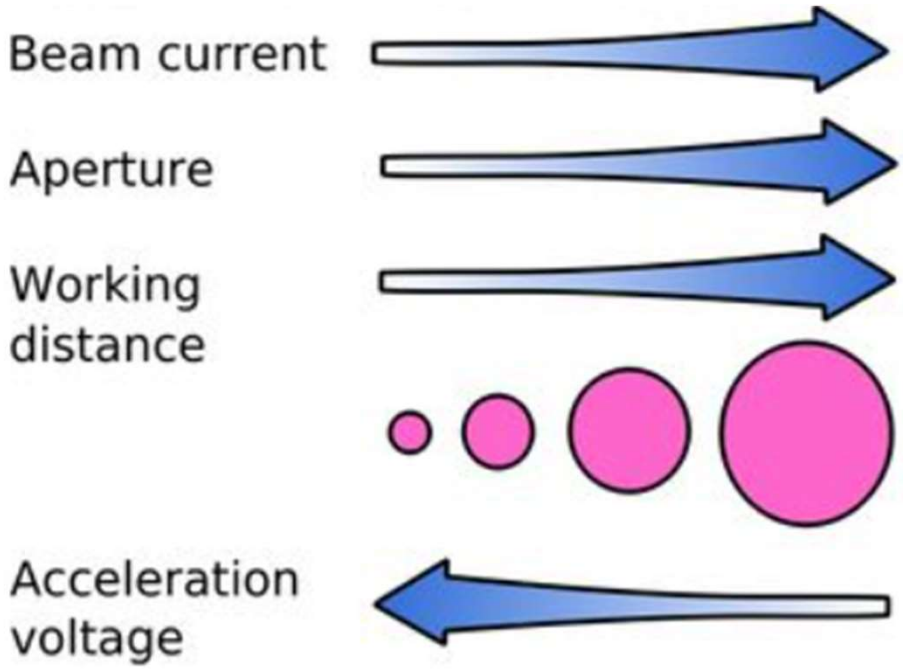
Raster scan

The beam is scanned over all surface area, while turning on/off the beam according to the presence or absence of a pattern

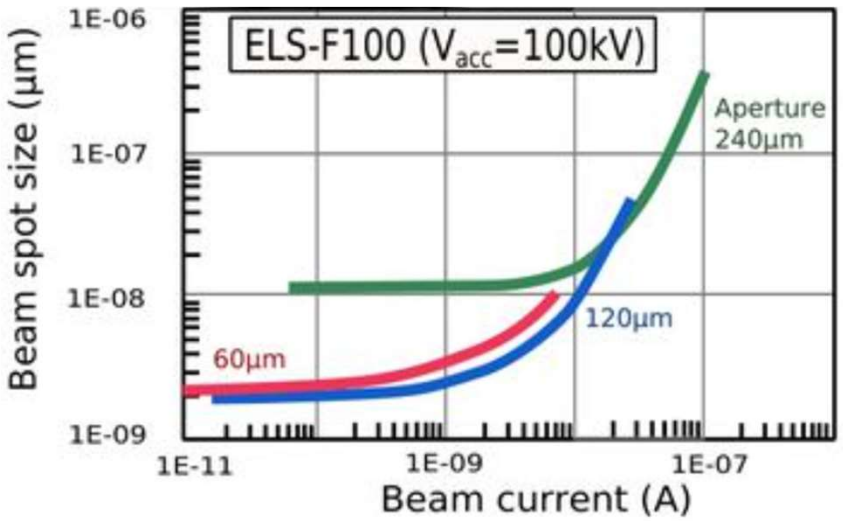


Beam OFF Beam ON

Factors Affecting the Beam Spot Size

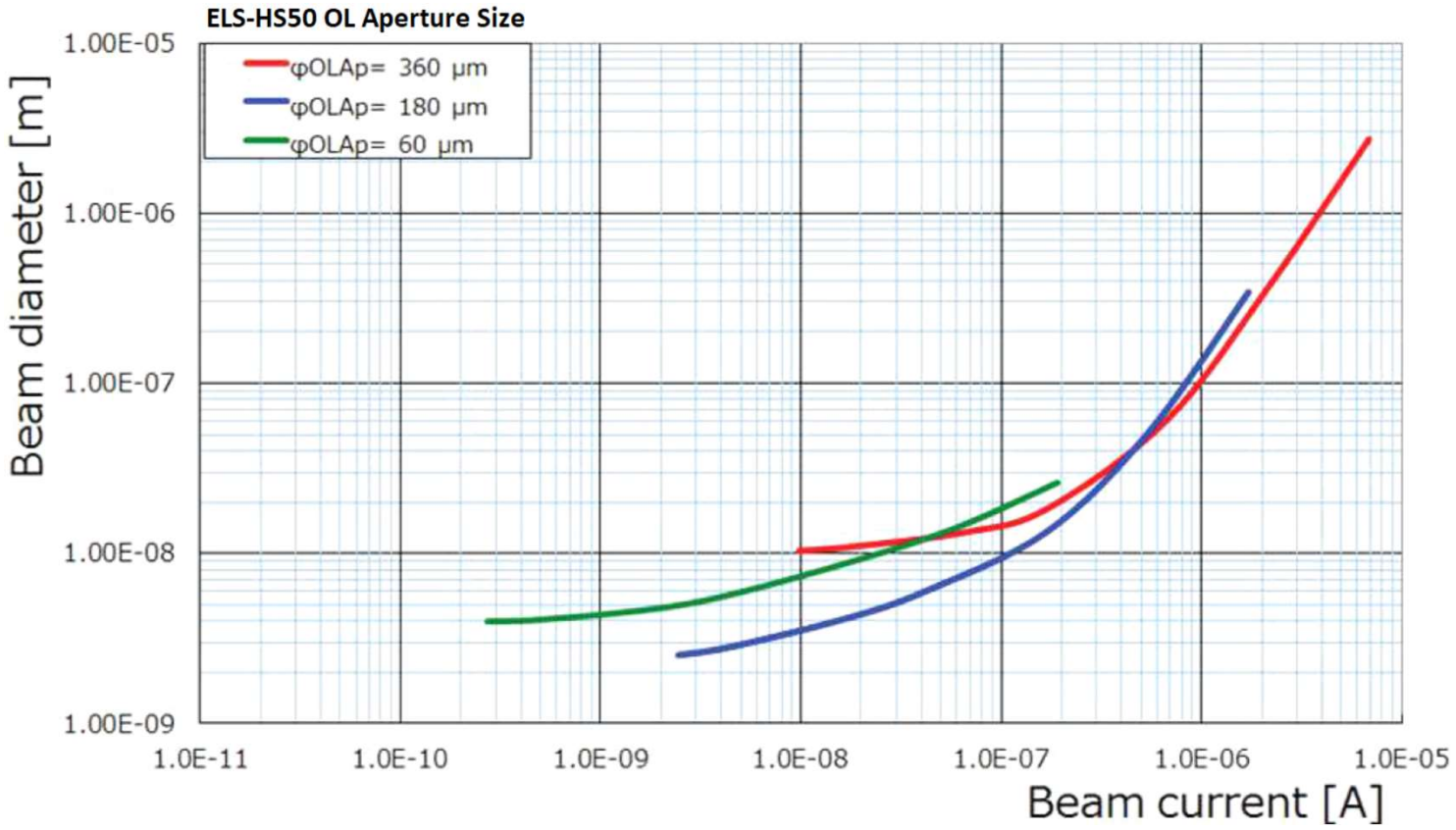


Beam Spot Size for the 100keV Elionix

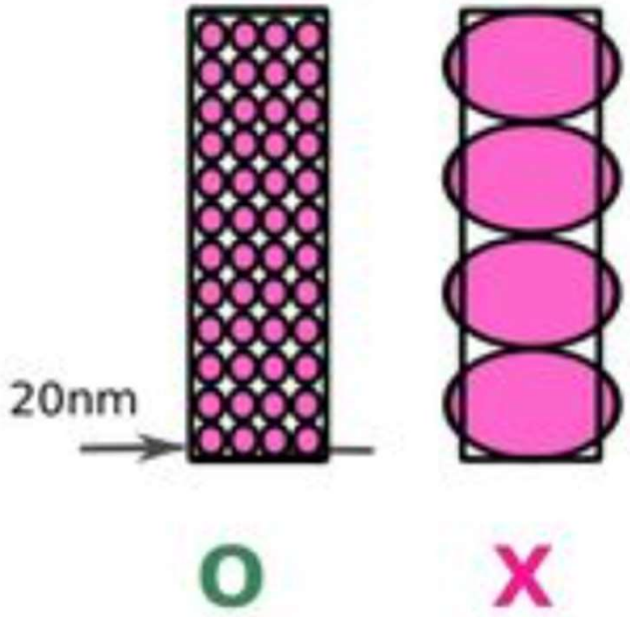


Beam Current	OLAP	Beam Diameter
100pA	120um	1.8nm
200pA	120um	2nm
500pA	120um	2.1nm
1nA	120um	2.3nm
2nA	120um	3nm
5nA	120um	5nm
10nA	120um	10nm
10nA	240um	15nm
20nA	240um	25nm
50nA	240um	90nm
100nA	240um	300nm

Beam Spot Size for the 50keV Elionix

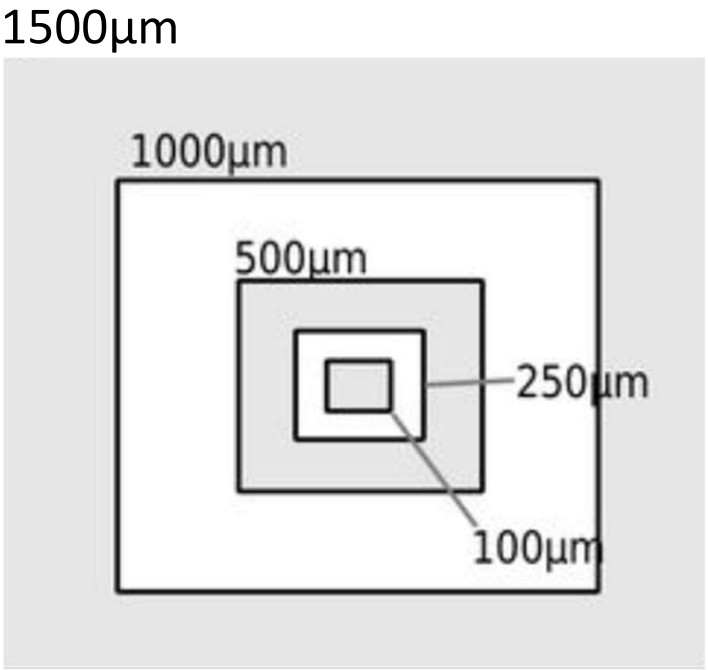


Step 1. Choose the Beam Current and Aperture



- How small you need to go depends on your minimum feature size
- Larger beam currents mean shorter write times

Step 2. Choose a Field Size



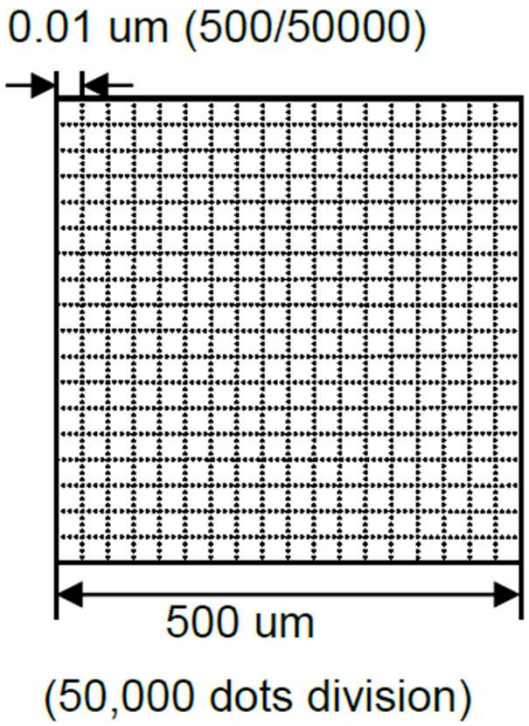
Maximum Field Sizes:

- 100keV = 1000 µm
- 50keV = 1500 µm

Field size can be critical – more to follow

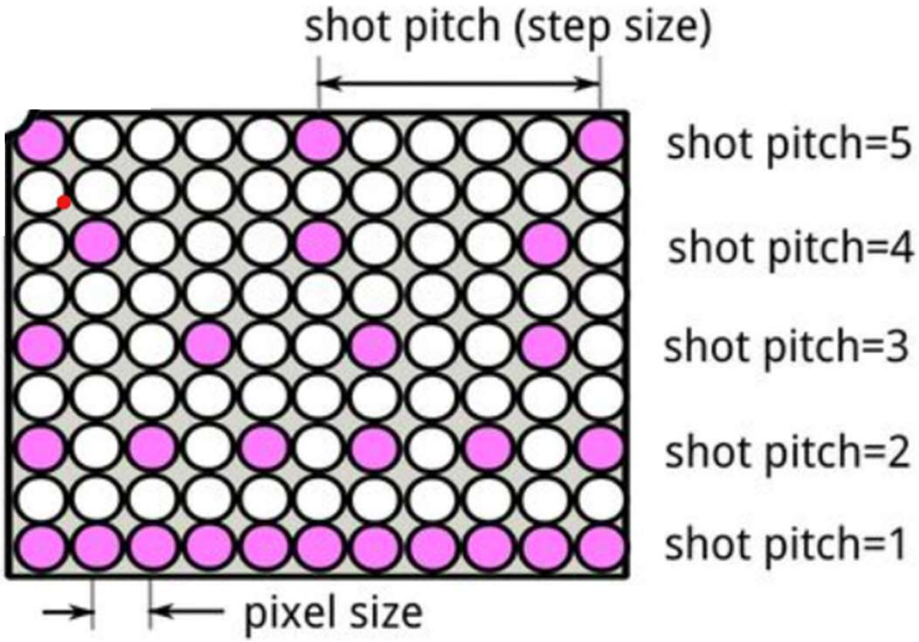
Step 3. Define CAD Grid (Dot Number)

Beam Position Resolution = Field Size / Dot Number

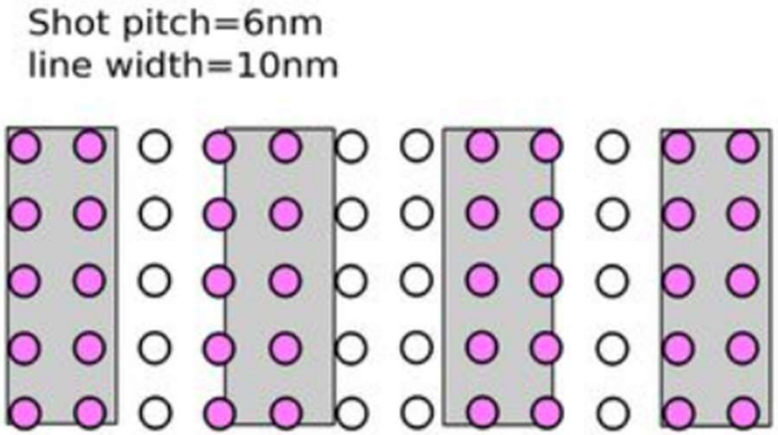


		Dot Number			
		50,000	200,000	500,000	1,000,000
Field Size	100um	**2nm**	**0.5nm**	**0.2nm**	**0.1nm**
	250um	**5nm**	**1.25nm**	**0.5nm**	**0.25nm**
	500um	**10nm**	**2.5nm**	**1nm**	**0.5nm**
	1000um	**20nm**	**5nm**	**2nm**	**1nm**

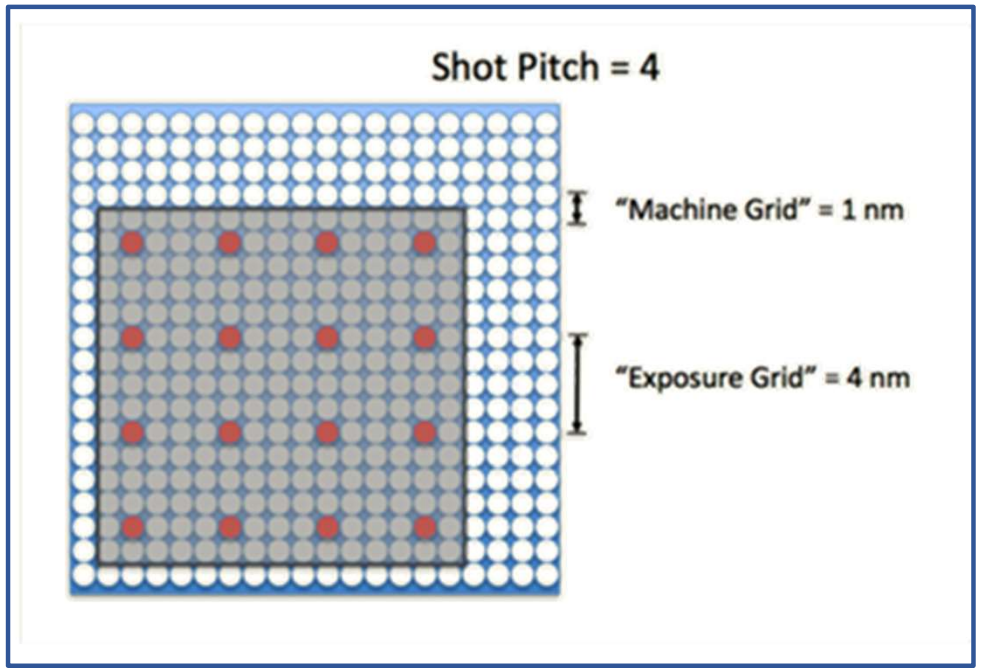
Step 4. Choose Scan and Feed Pitch

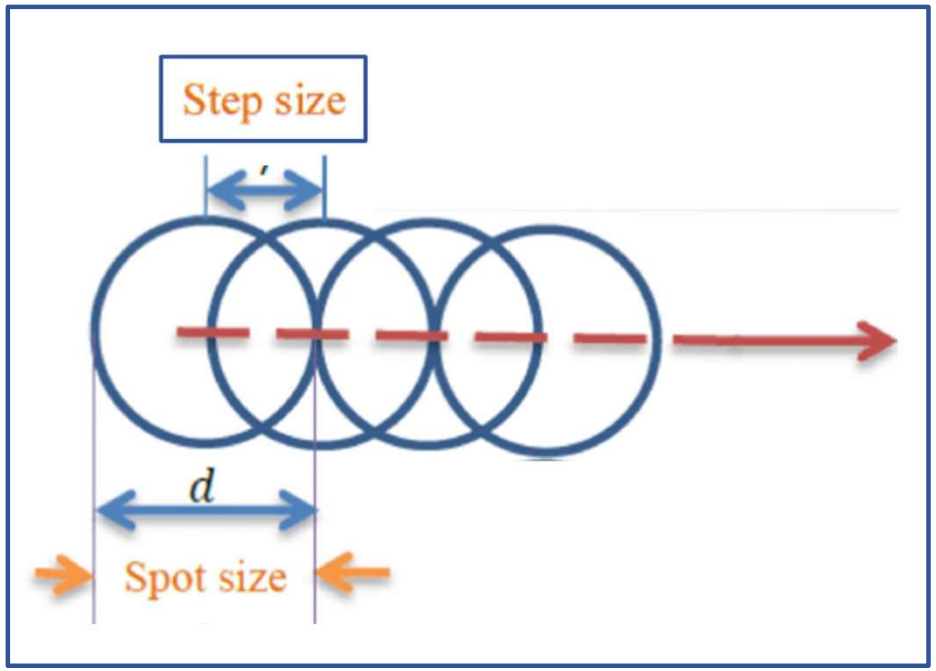


Considerations: Feature Size

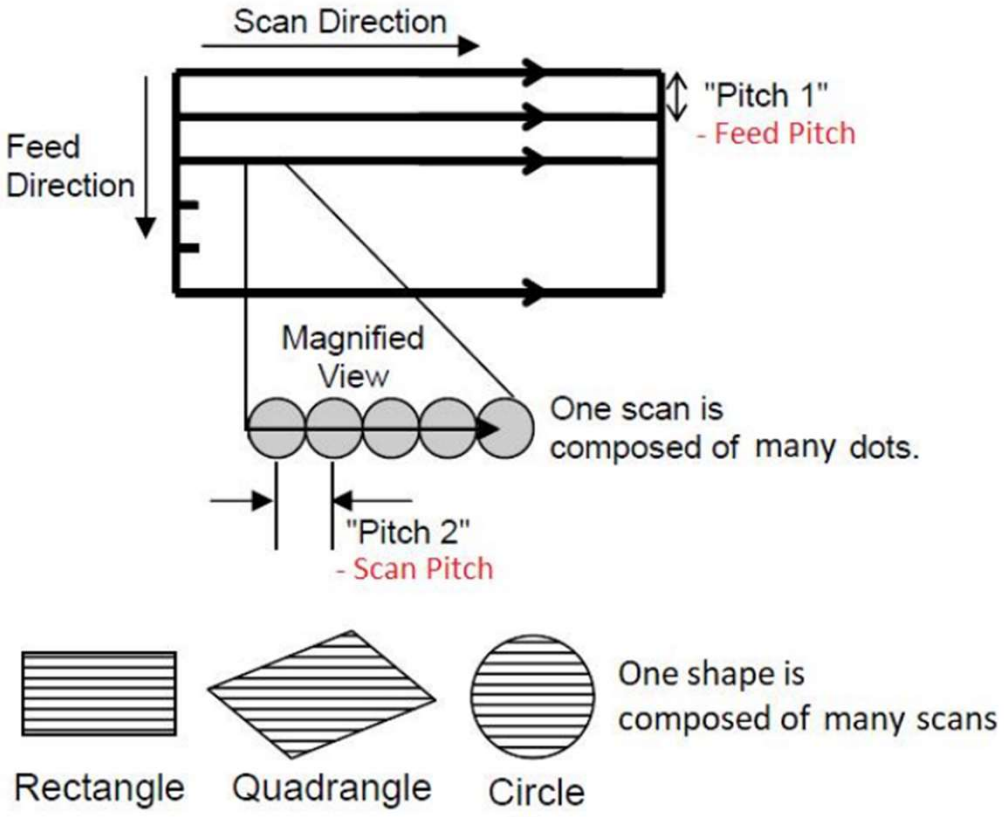


Examples with different shot pitch

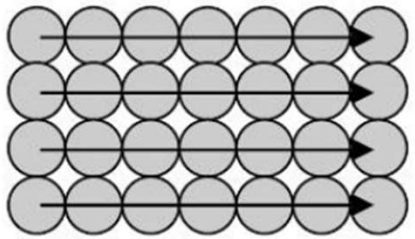




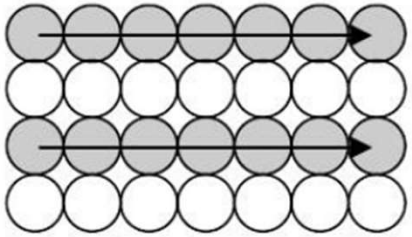
How a shape is written with E-Beam



"Pitch 1" = 1, "Pitch 2" = 1 (All-points Irradiation)



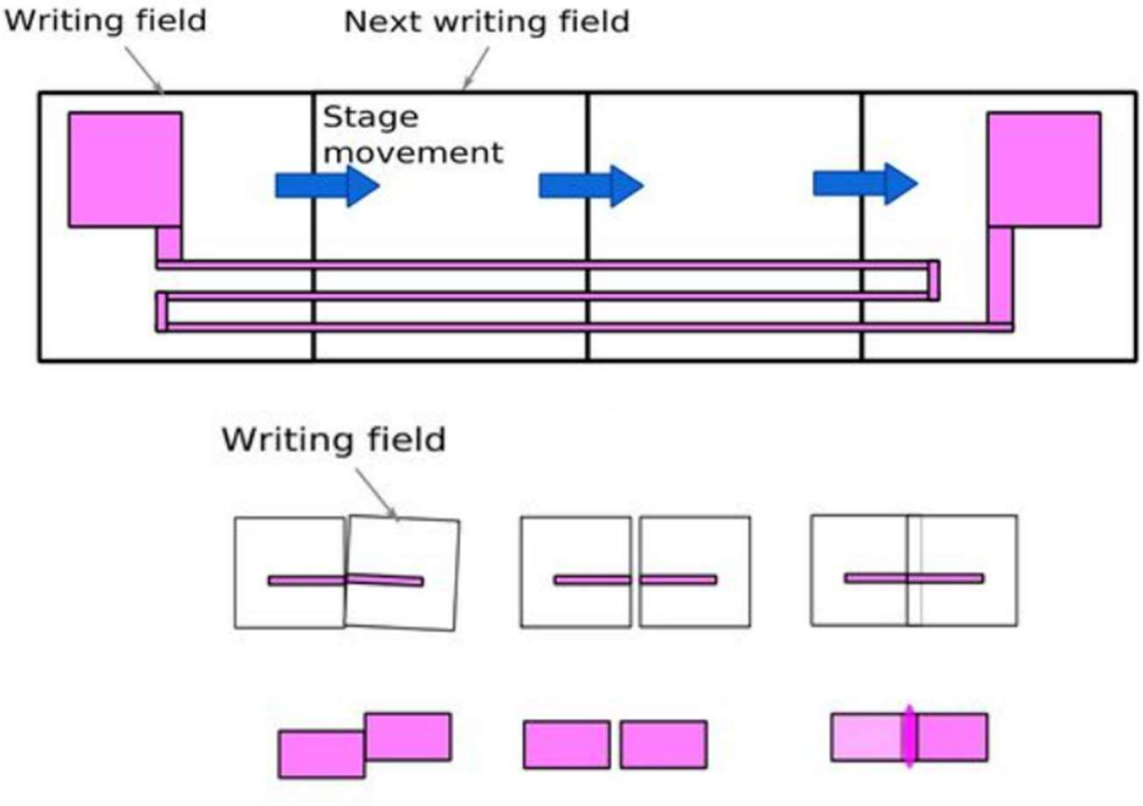
"Pitch 1" = 2, "Pitch 2" = 1 (Scan every other one)



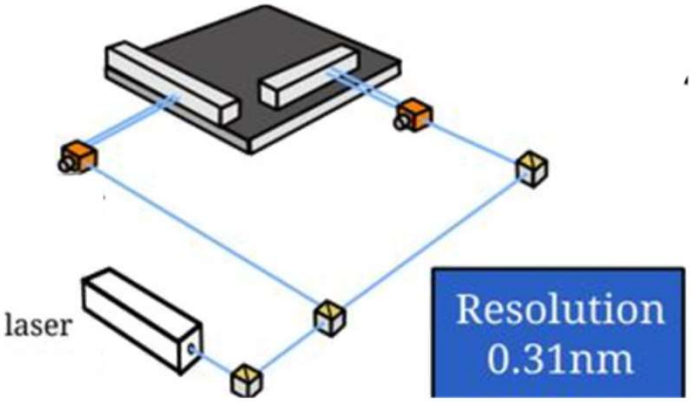
Dots that beams are irradiated to

Dots that beams are not irradiated to

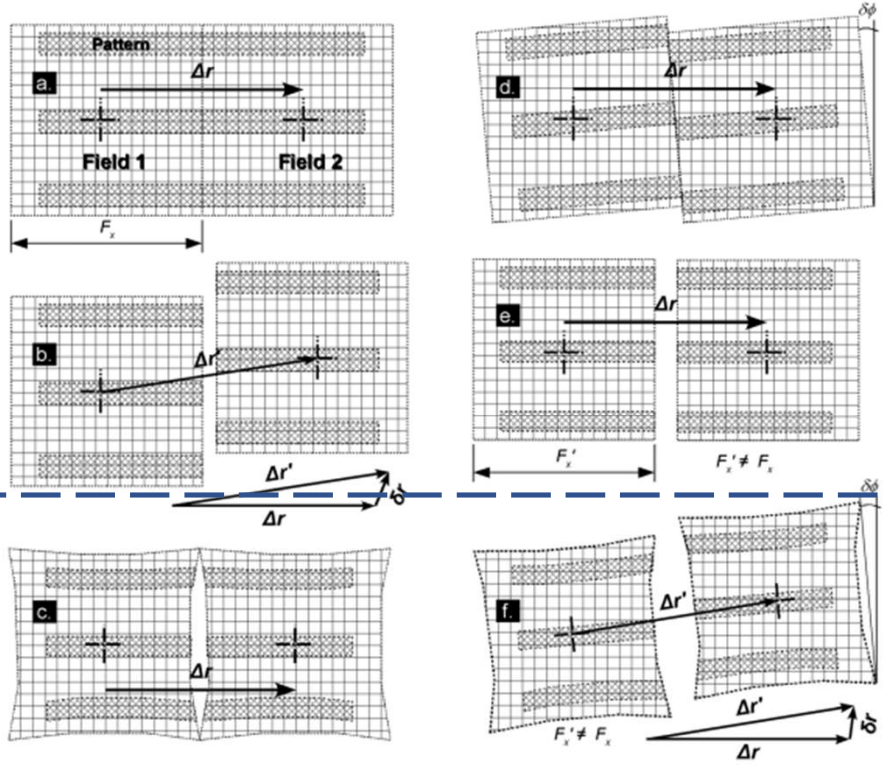
Issue: Stitching Errors at Field Boundaries

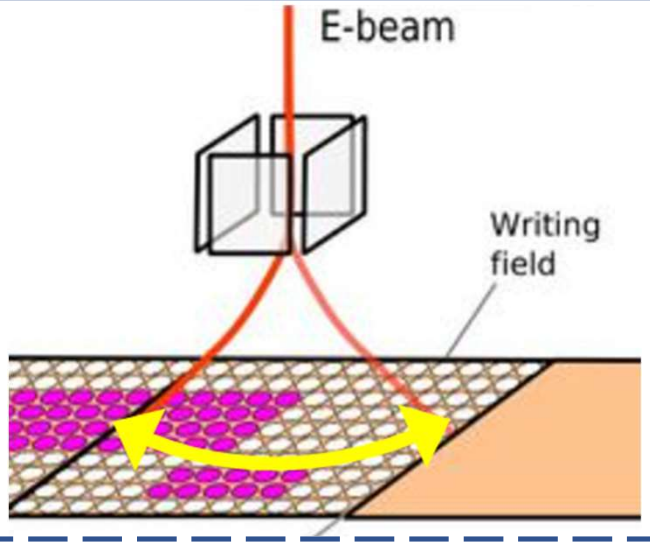


Stitching Accuracy:
~ 15-20 nm



Field Correction for Dynamic Focus Correction

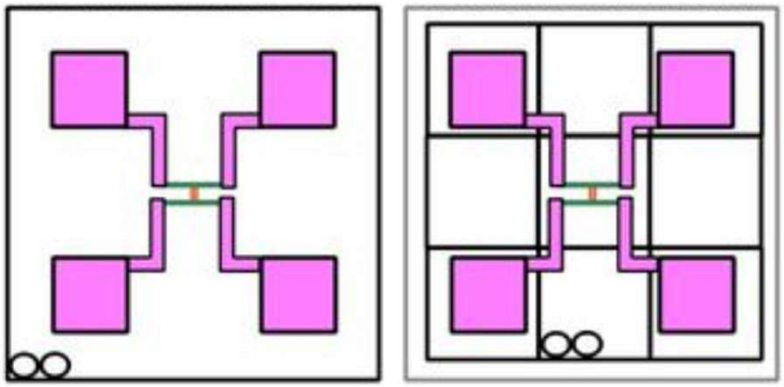




Deflection Scale Errors are handled with "Field Correction" in WecaS

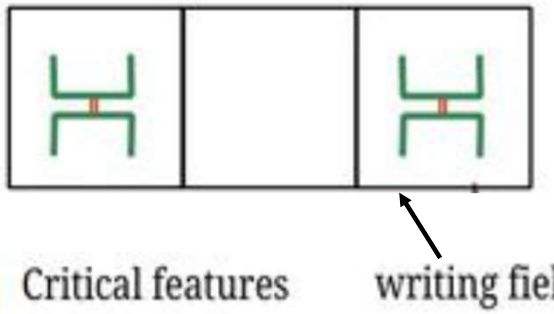
FIG. 1. Types of field stitching errors: (a) ideal case $|\Delta \mathbf{r}| = F_x$; (b) shift error, $|\Delta \mathbf{r}| \neq F_x$, $\Delta \mathbf{r}' = \Delta \mathbf{r} + \delta \mathbf{r}$; (c) field distortion, $\mathbf{S}' = \mathbf{S} + [\delta s_{ij}]$; (d) field rotation, $\delta \mathbf{r}_{rot} = ((y - y_0)\delta\varphi, (x_0 - x)\delta\varphi)$; (e) deflector scale error, $F_x' \neq F_x$; (f) combined error, $3\sigma = 20$–100 nm.

Choosing Best Field Size and Placement

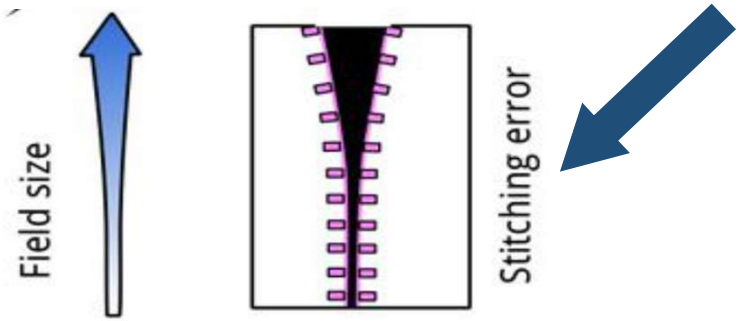


1. Increase/Change Field Size

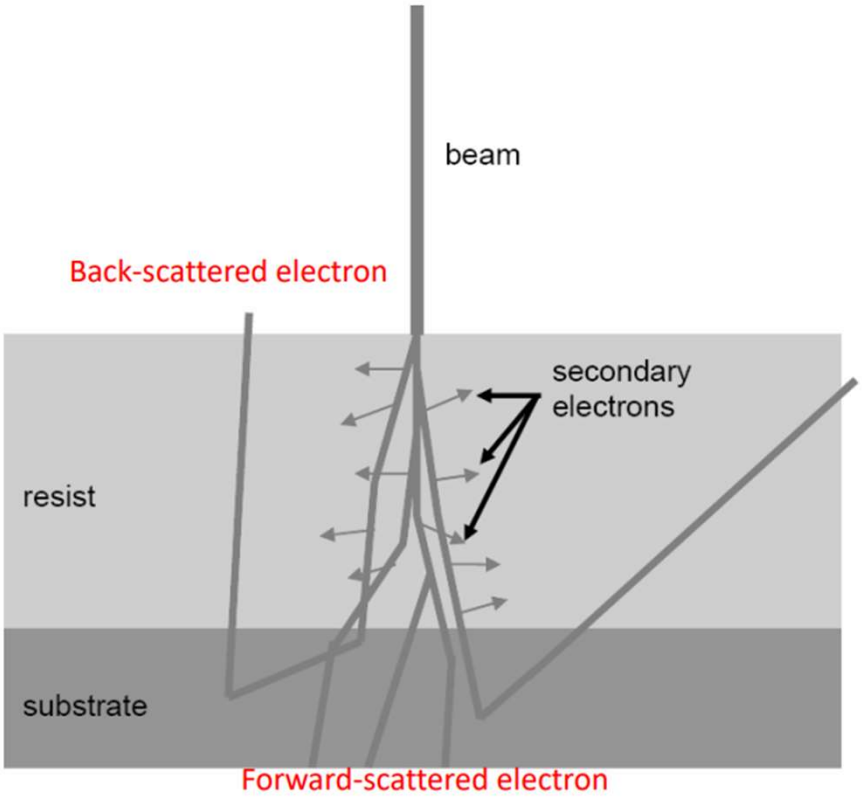
2. Put critical features in the center of the field



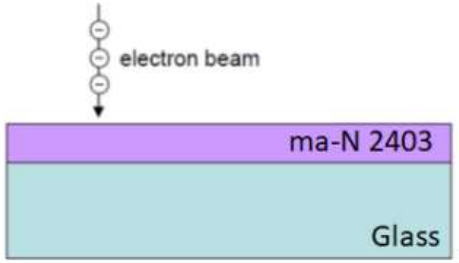
3. Errors at the Boundary Increase with field size

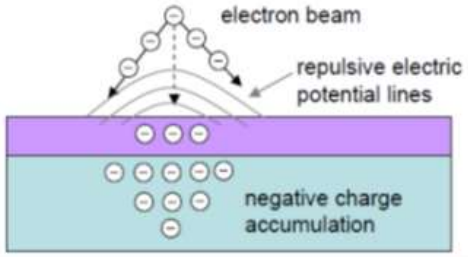


Electron Scattering in the resist helps - PSF



Charging Issues





Ti/Au/Ti under resist
ESpacer < 1 hour
front side Au

GOOD
(no charging)

ESpacer > 24 hours

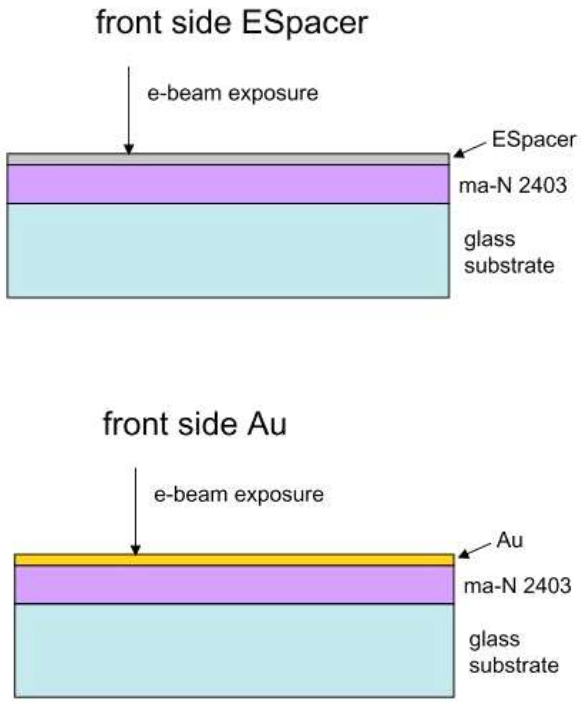
BAD
(moderate charging)

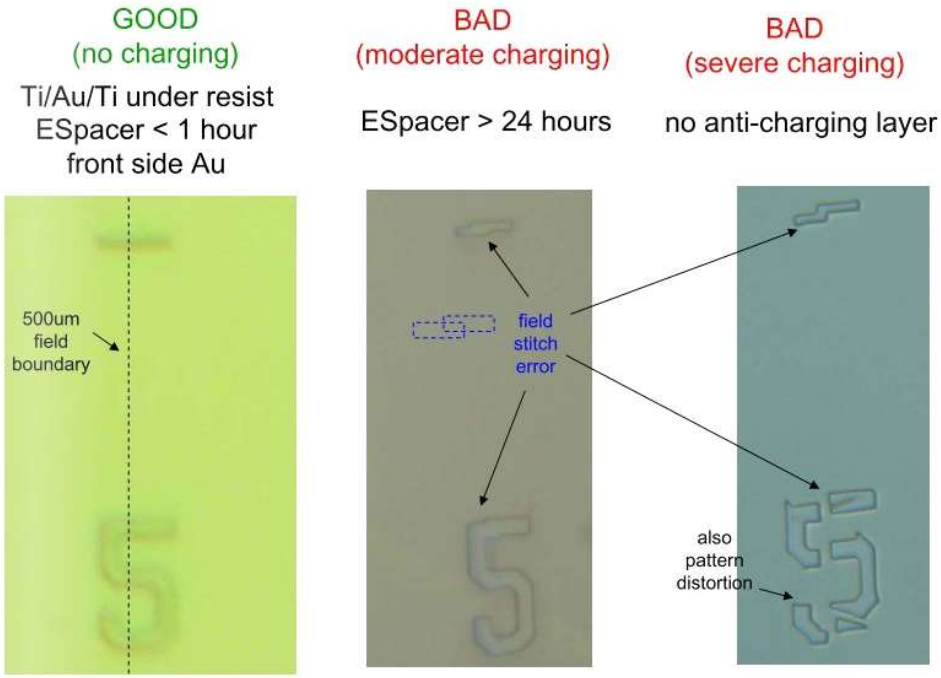
no anti-charging layer

BAD
(severe charging)

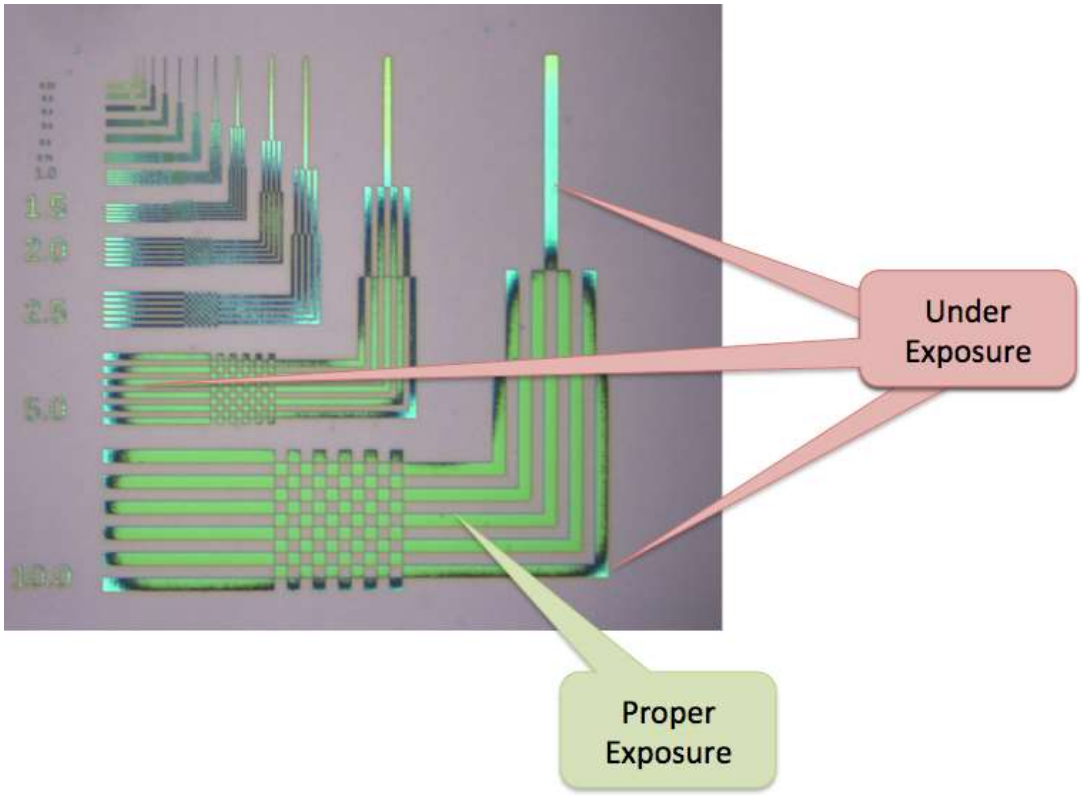
By Devin K. Brown, Georgia Tech

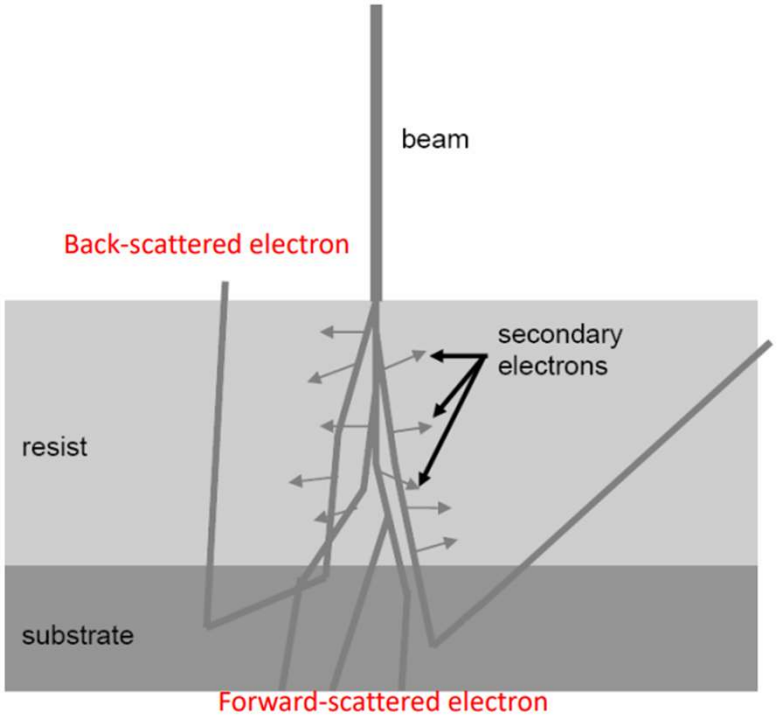
Charging Issues



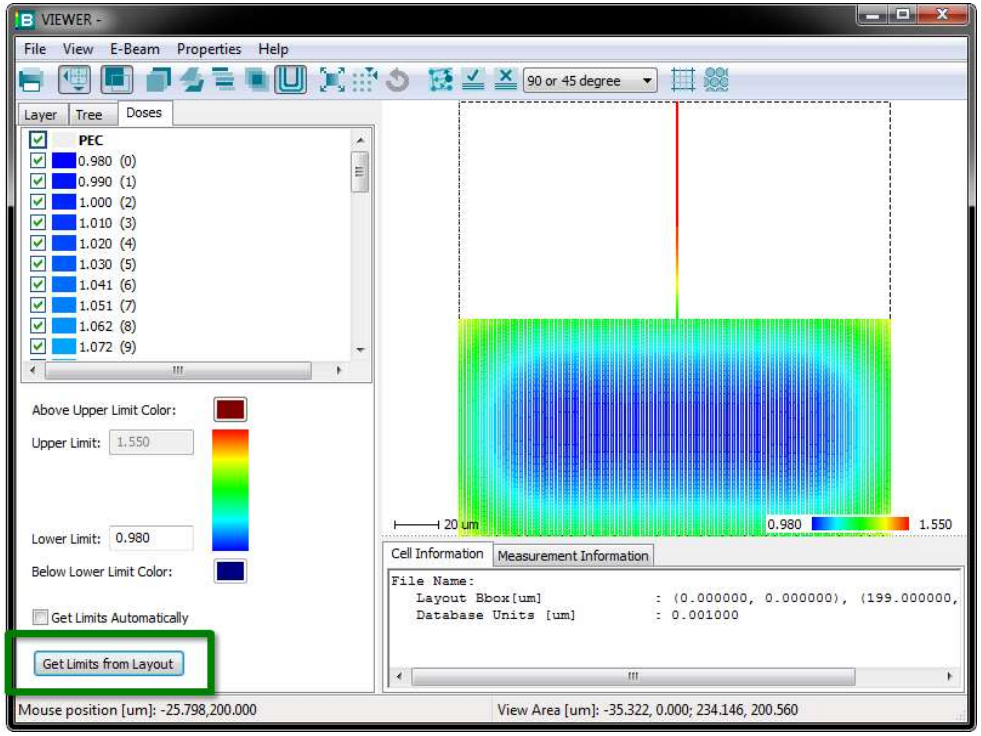


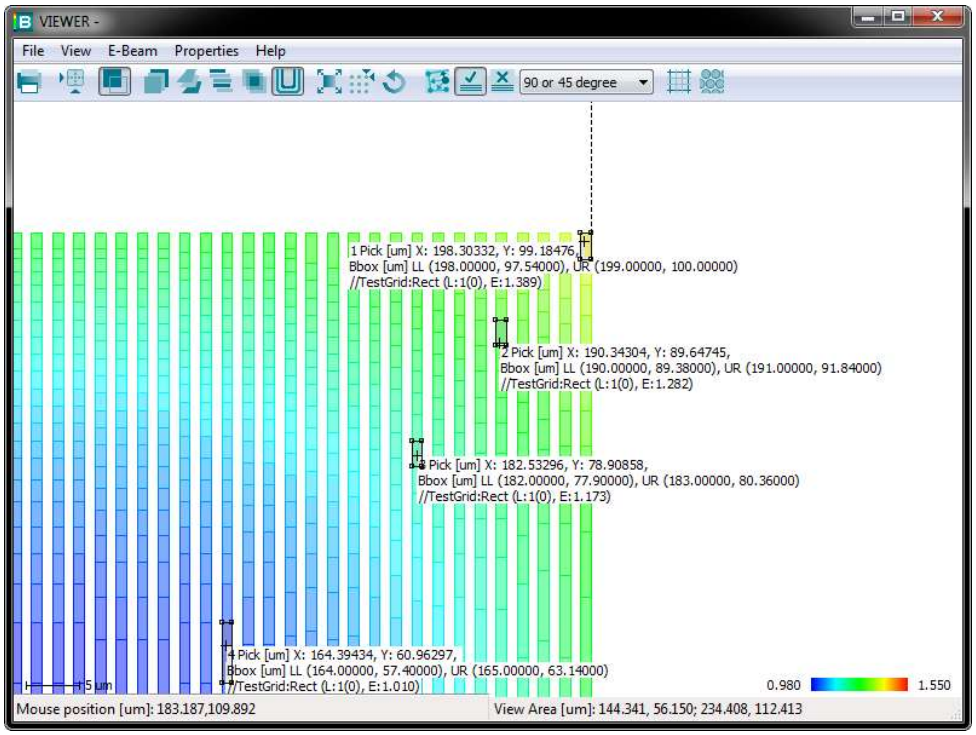
Proximity Effect Issues



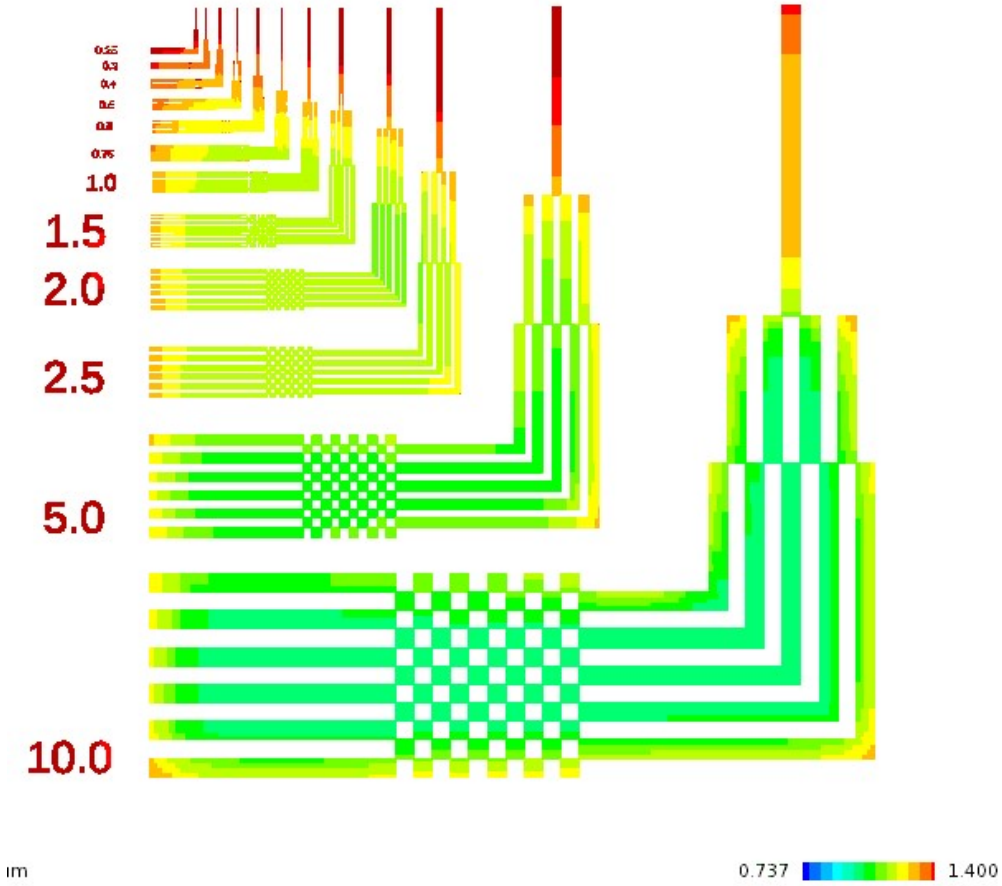


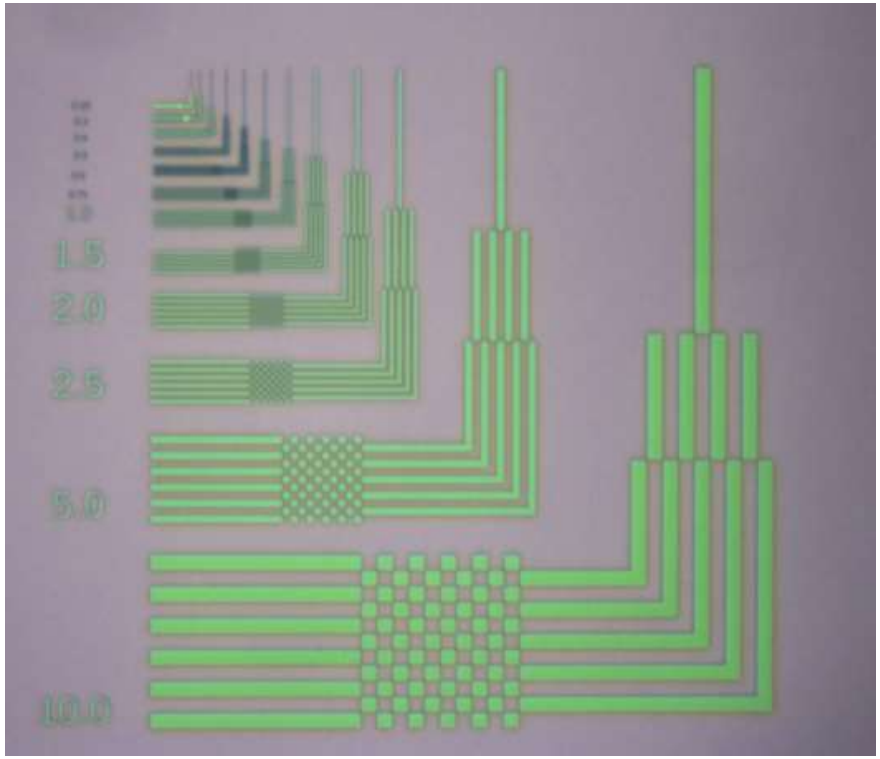
Proximity Effect solution: Dose Modulation -- Beamer





Proximity Effect (Solved)





Resists and Exposure Doses (μC/cm^2)

Some common E-Beam resists

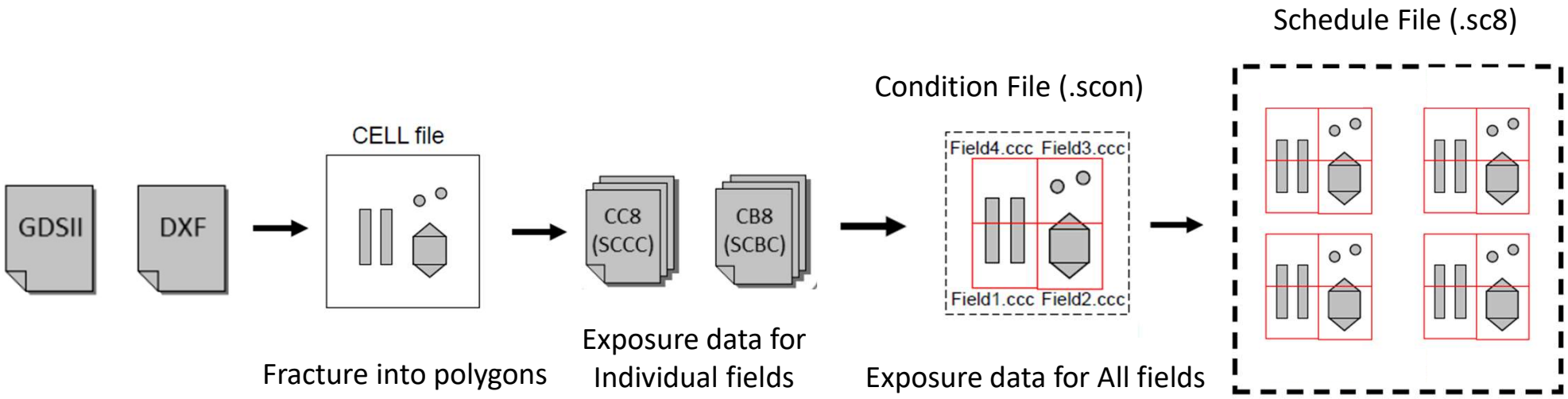
- PMMA – Positive E-beam / DUV Resist (ASRC)
- Ma-N – Negative DUV / E-beam Resist (ASRC)
- SU-8 – Negative DUV resist
- HSQ – (Hydrogen Silsesquioxane) Negative “Spin-on-glass” (USER)
- ZEP – Positive Resist (USER – but could be purchased through the ASRC)

Anti-Charging Agents for Insulating Substrates

- Espacer (User owned)
- DisCharge (DisChem Inc) (User owned)
- Gold Sputter Tool (inside cleanroom)

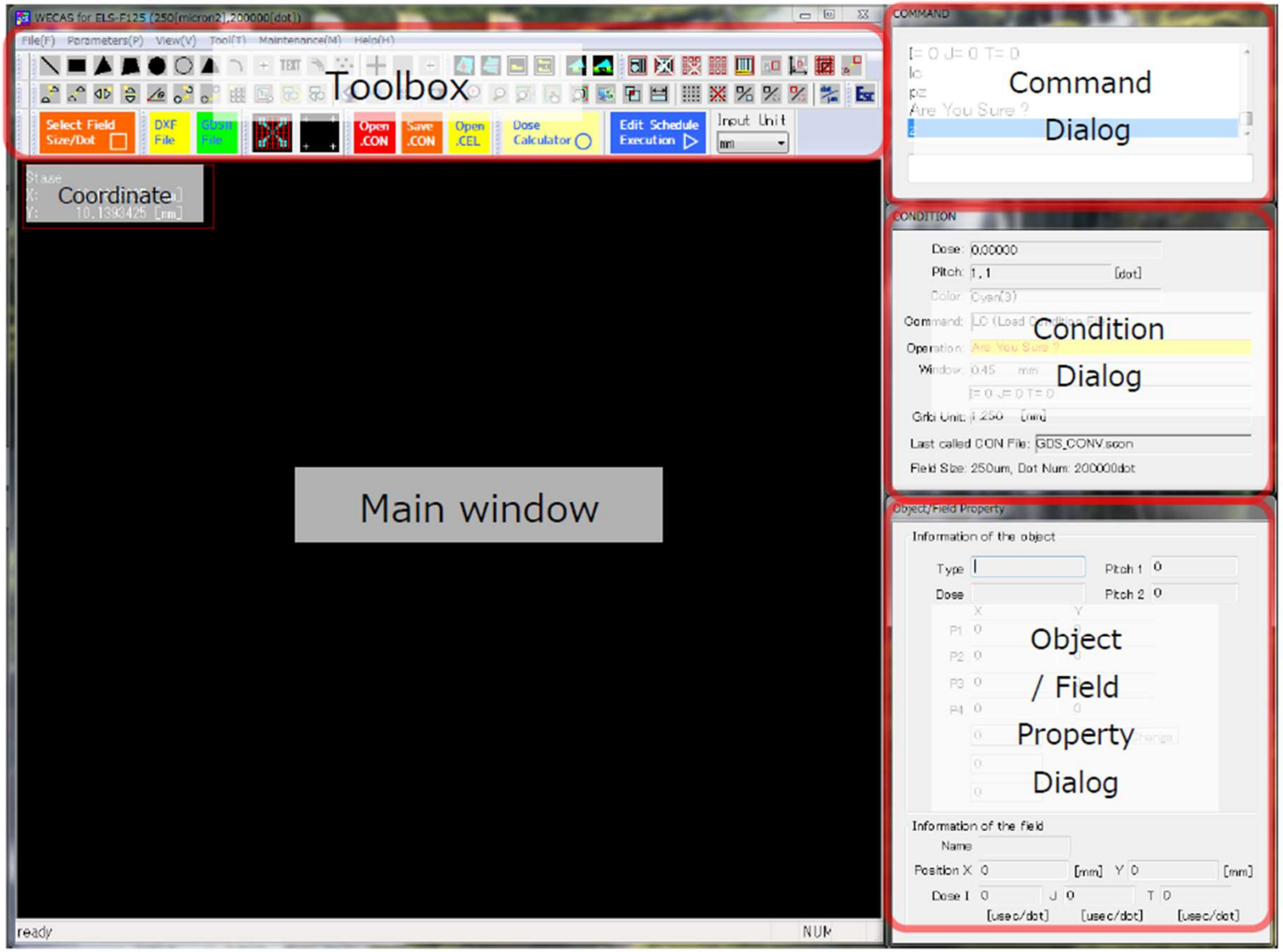
WecaS

Data structure / Files created



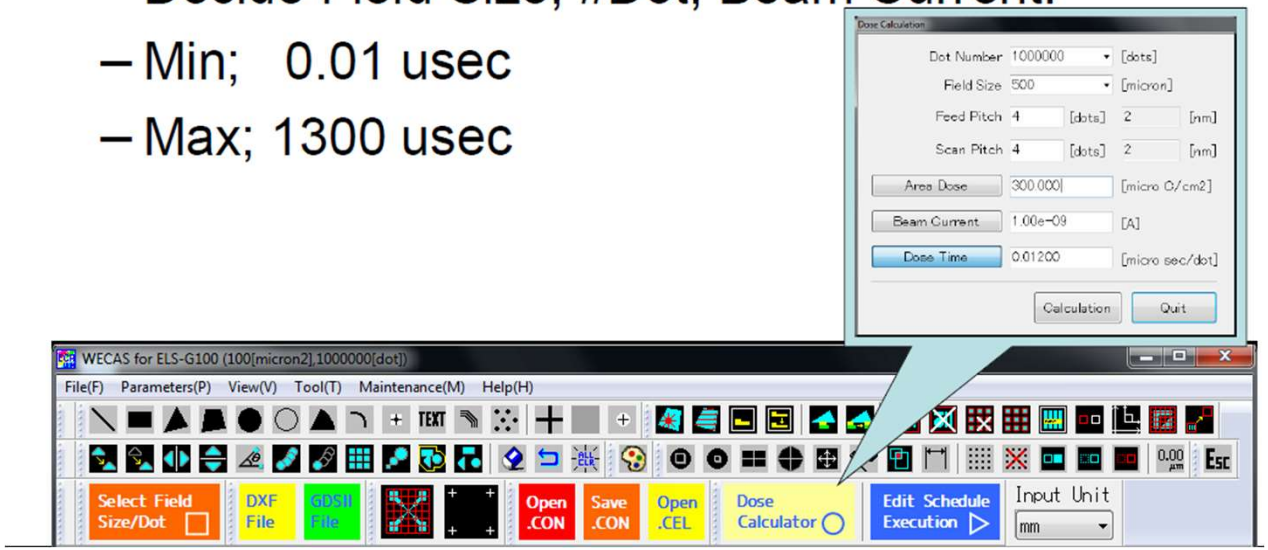
WecaS

1) Calculate the dose time (µs/dot)
2) Define CAD Grid (Field, Dots)
3) GDS/DXF Conversion → into CELL file
4) Set Pitch/Dose
5) Place / Compute Fields
6) Save CON File
7) Edit Schedule Execution
   a. Dose Assignment
   b. Set Options

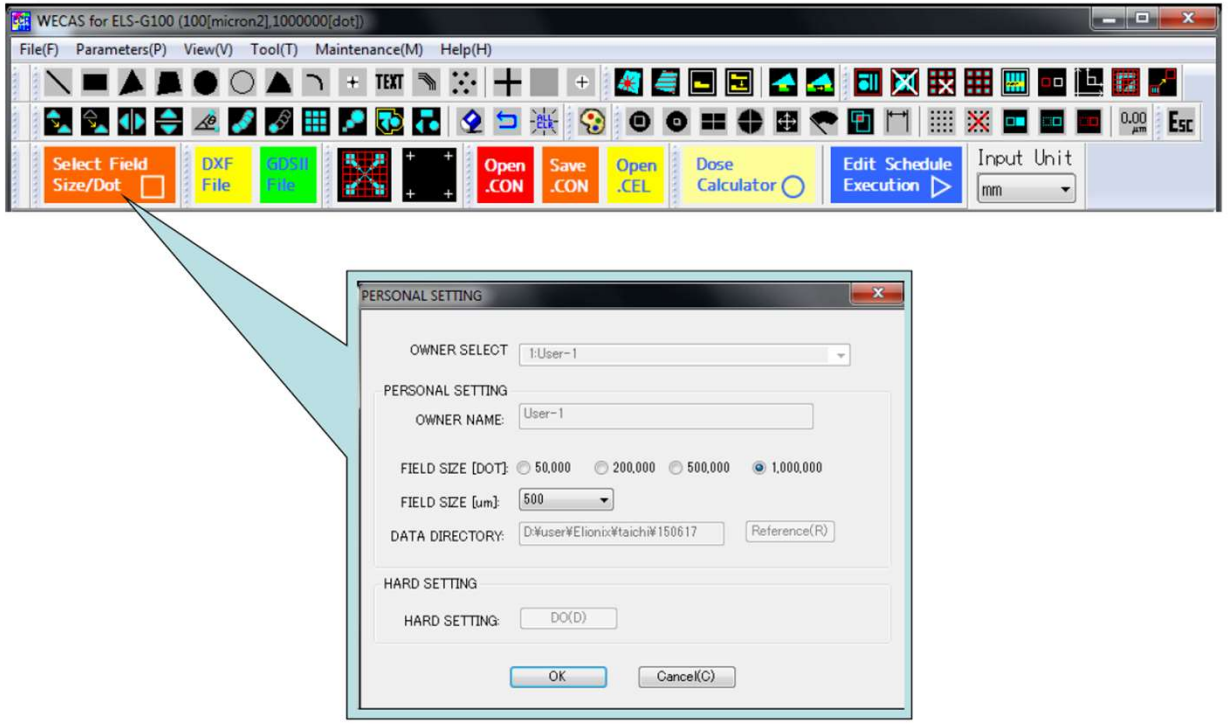

Toolbox
Coordinate
Main window
Command
Dialog
Condition
Dialog
Object
/ Field
Property
Dialog

(1) Estimate Dose

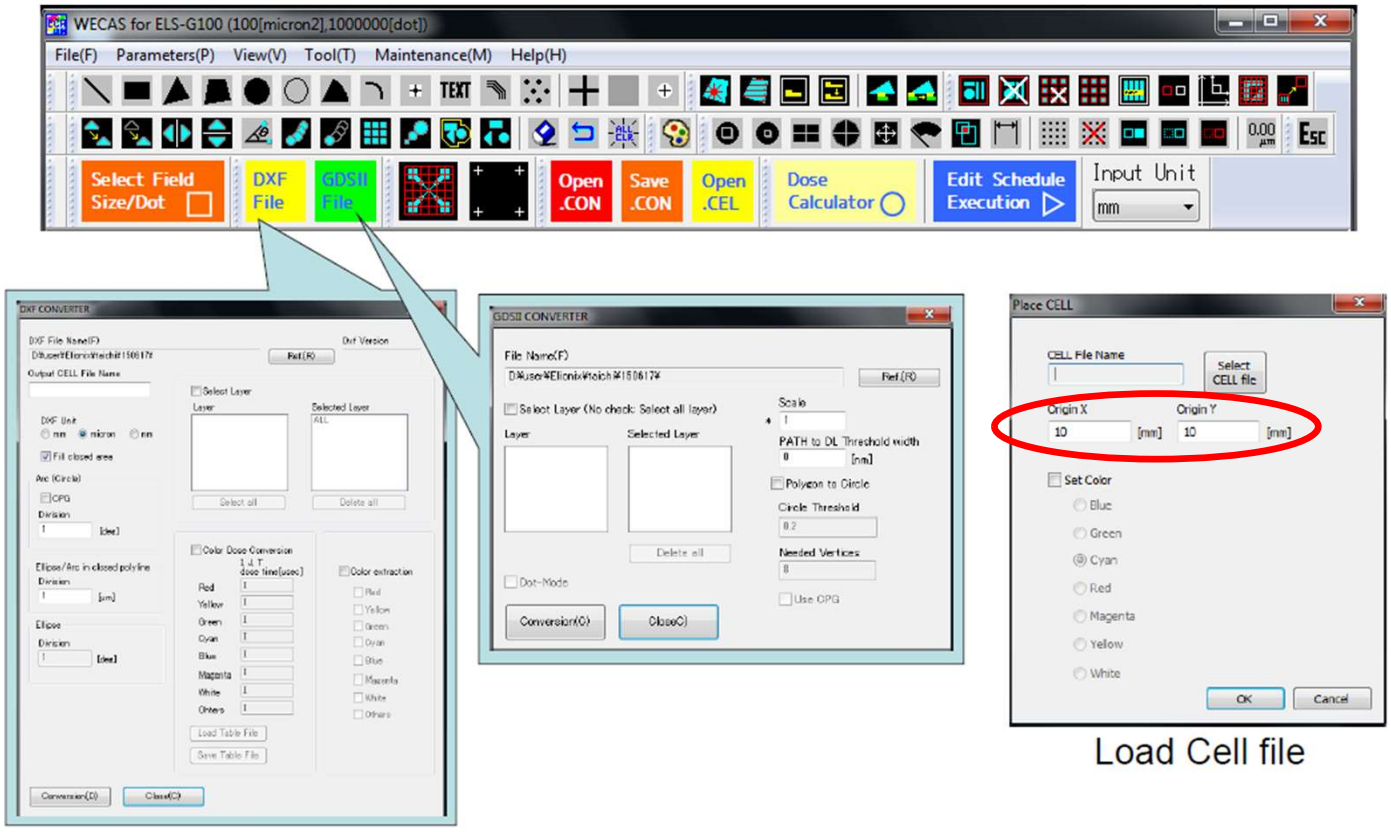
- Estimate Area Dose [uC/cm2]
  - Depends on Resist, Developer, Vacc, etc.
- Calculate Dose Time [usec]
  - Decide Field Size, #Dot, Beam Current.
  - Min; 0.01 usec
  - Max; 1300 usec



(2) Define the Field Size and the Grid

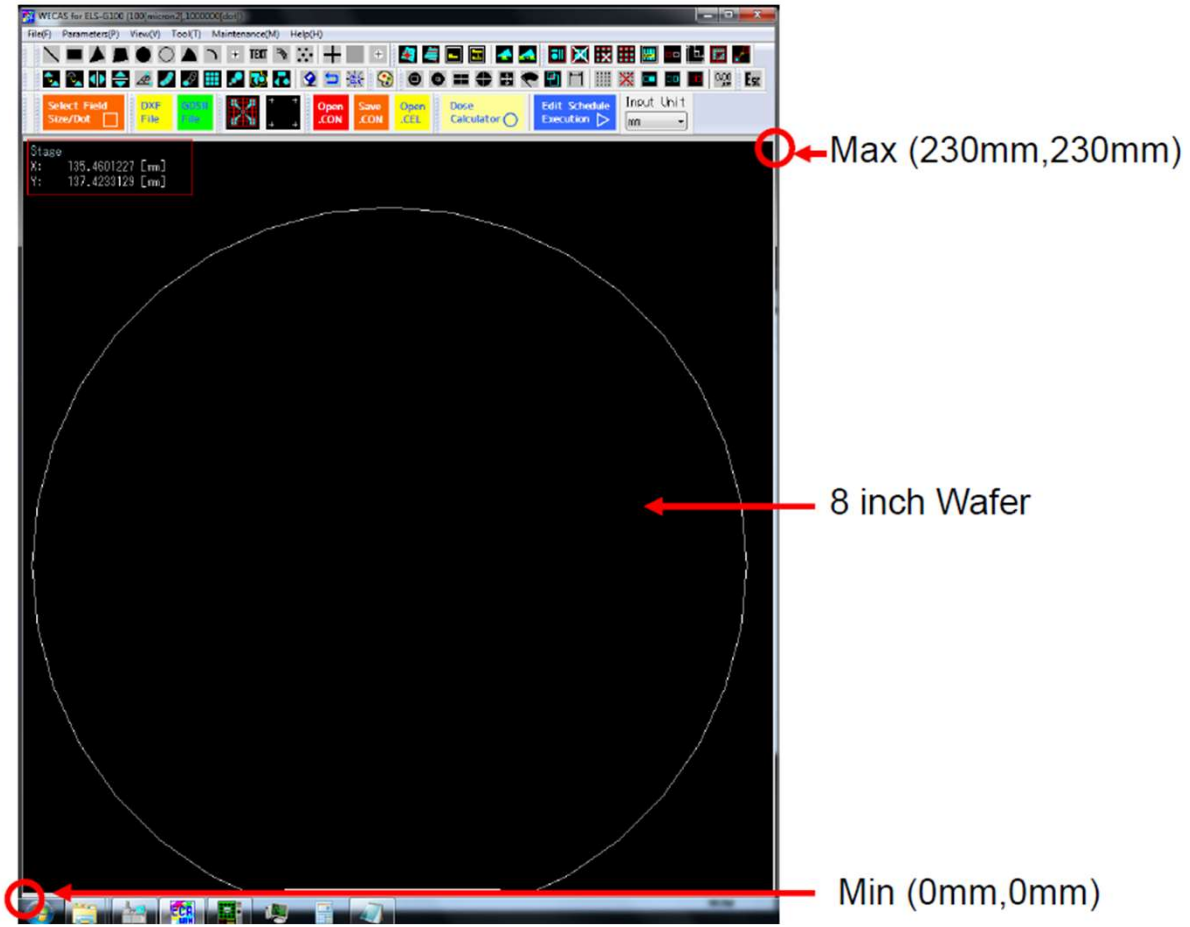


(3) Convert GDSII/DXF into Cell File

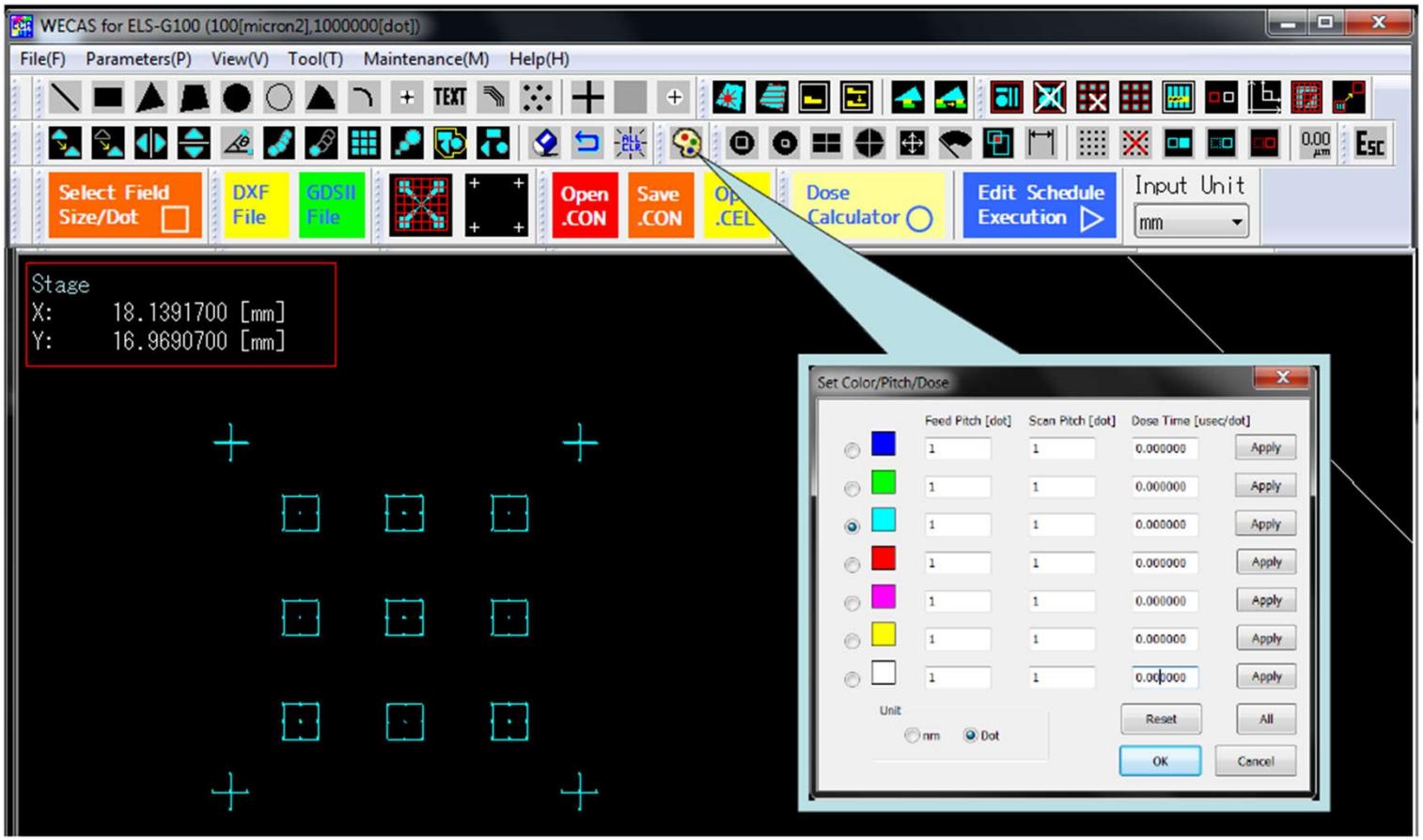


Load Cell file

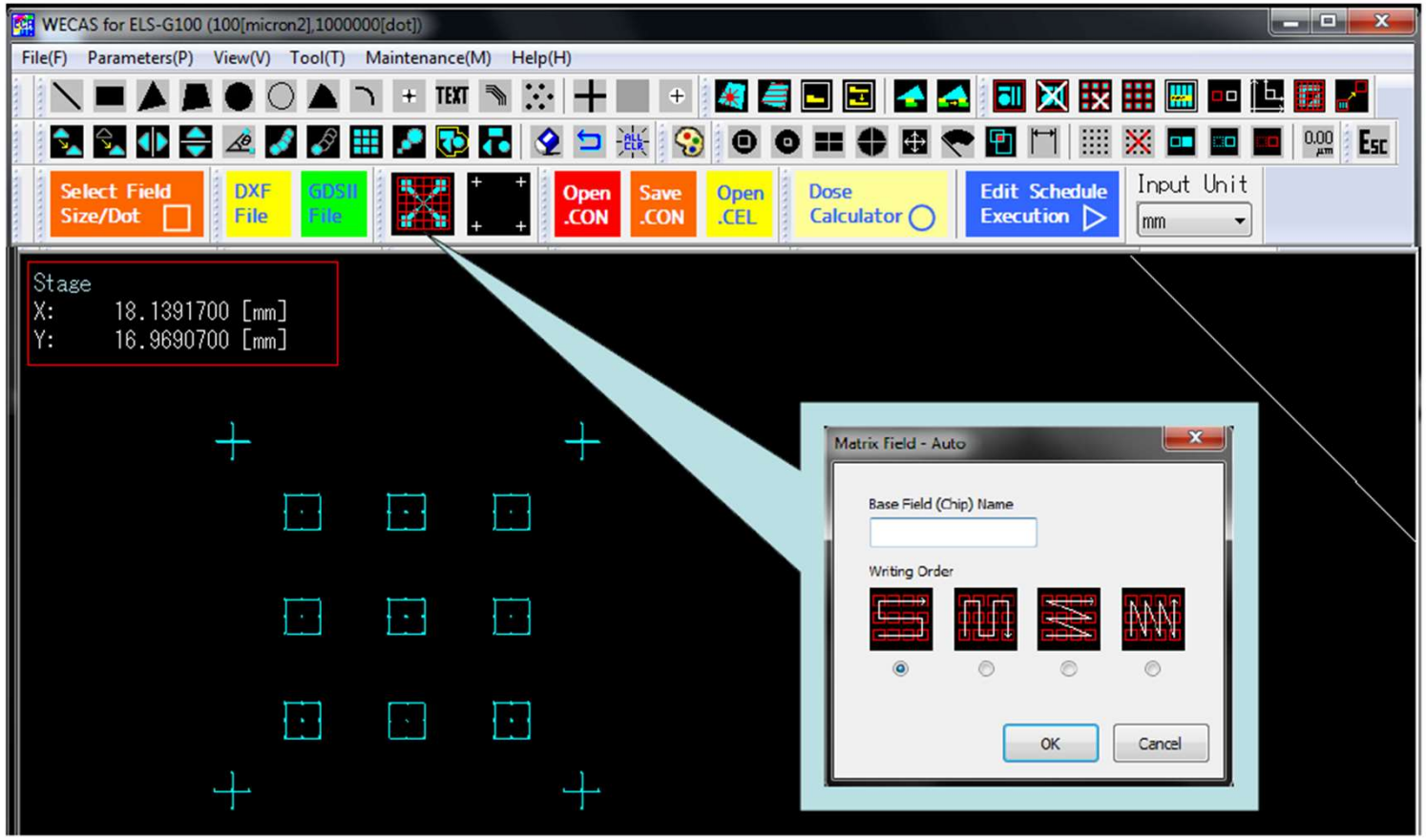
Note: Writing / CAD Area – 1st Quadrant Only



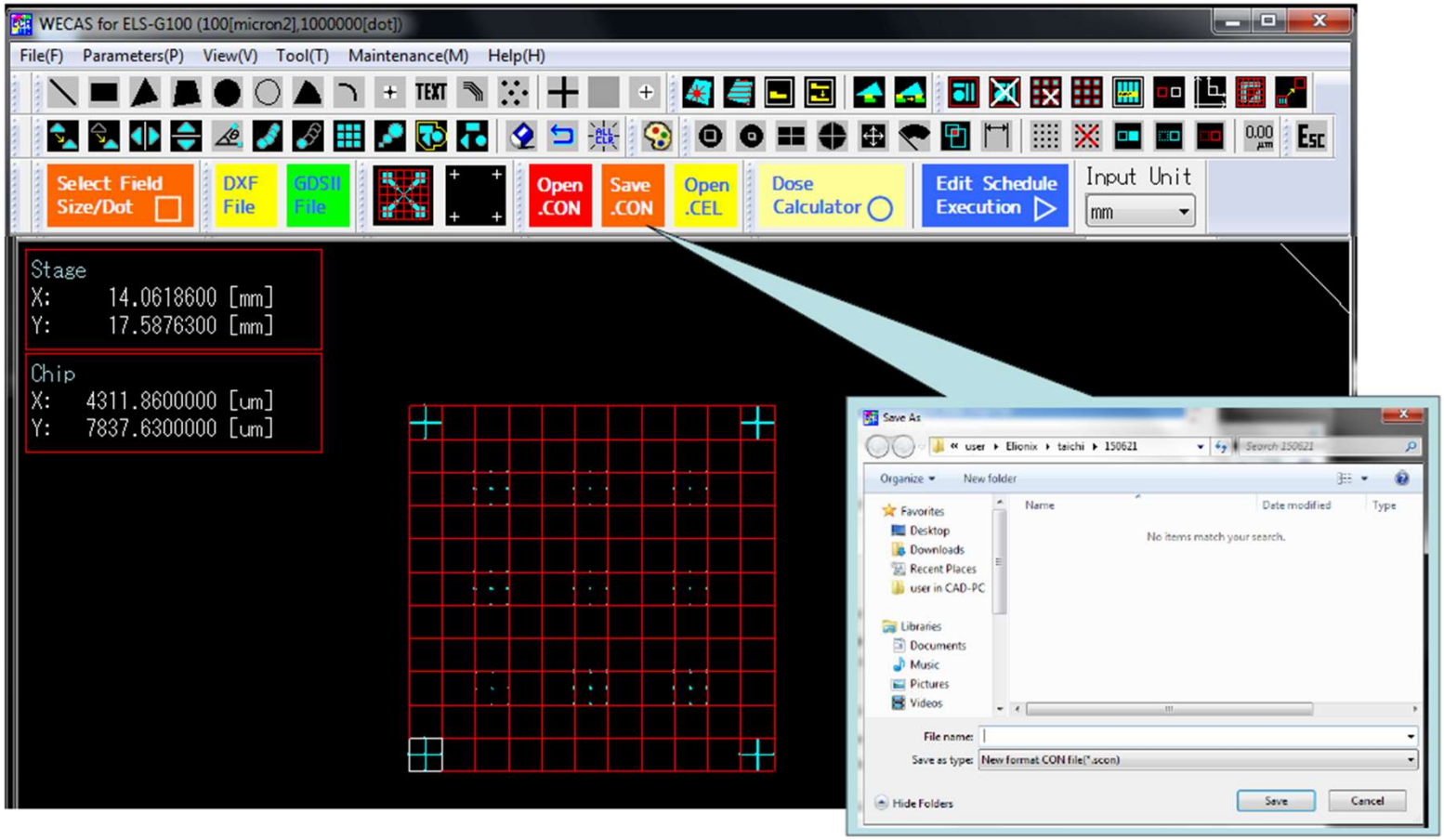
(4) Set Pitch and Dose



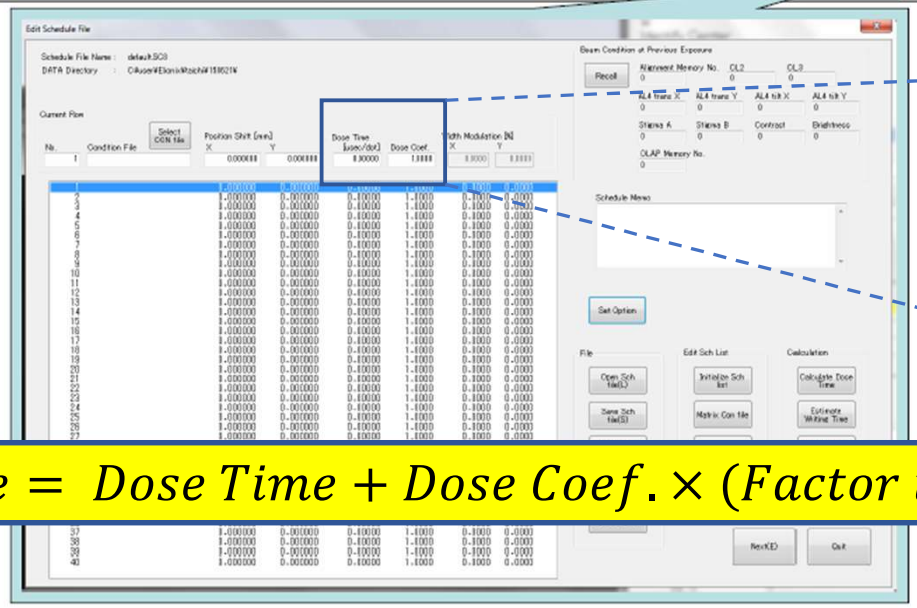
(5) Auto Placement of Fields

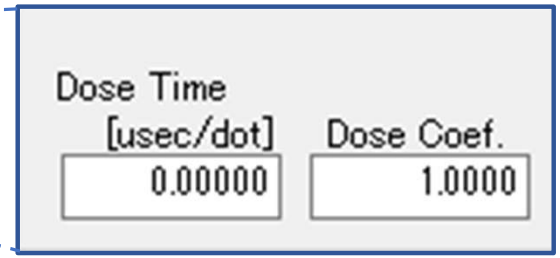


(6) Save .SCON File



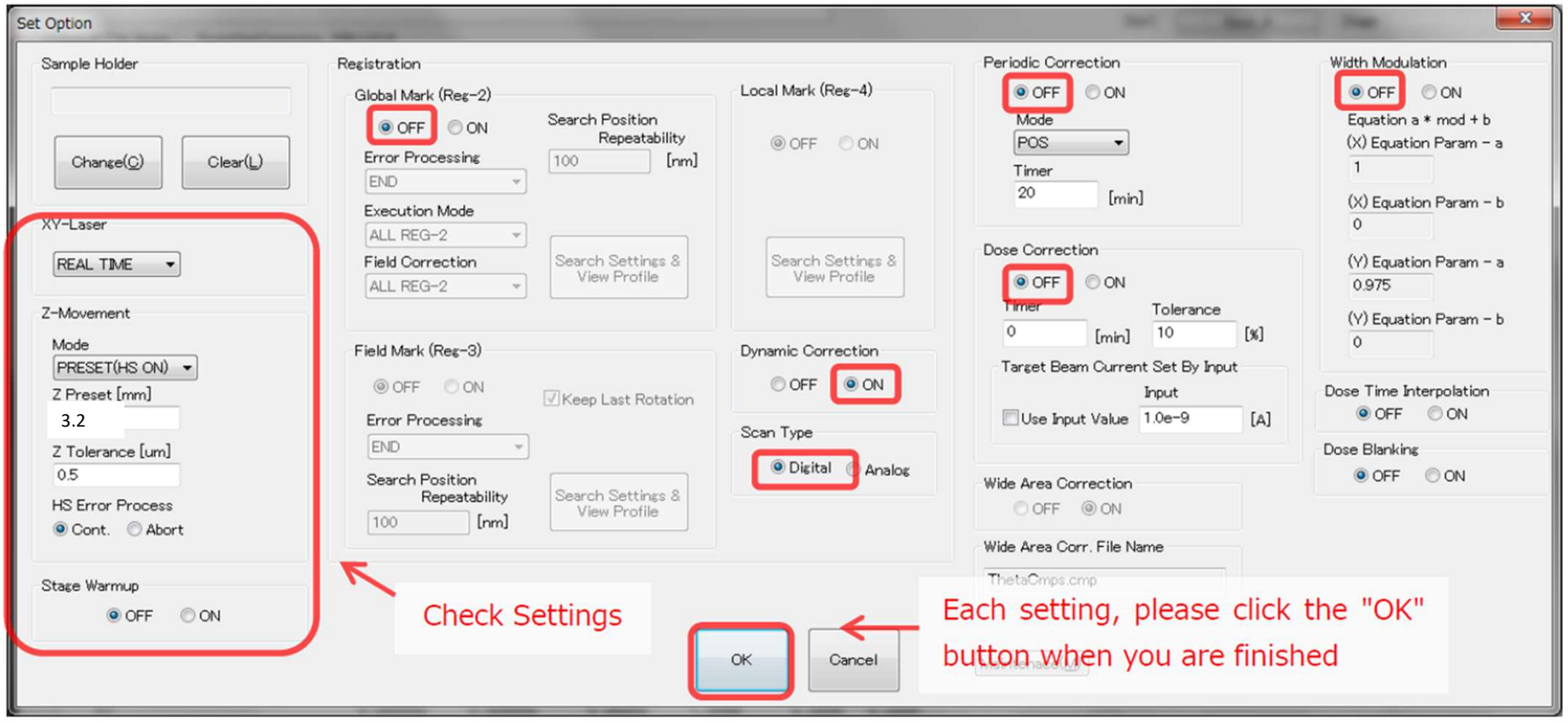
(7a) Create Schedule File – Dose Assignment



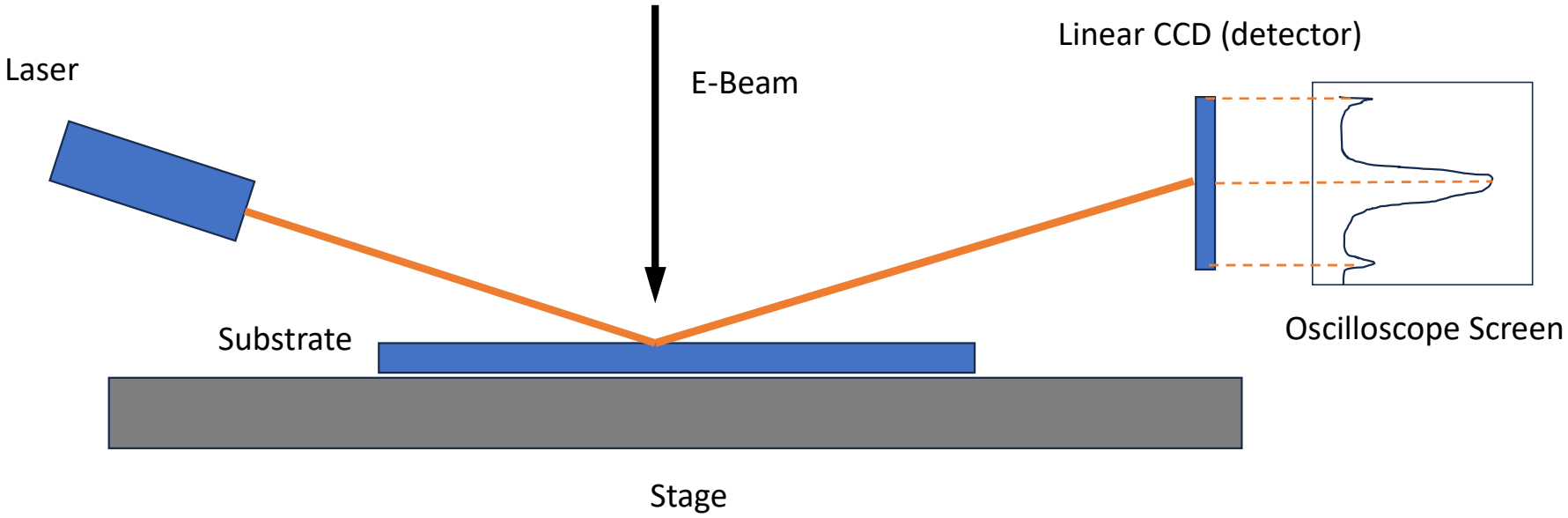


$$Total\ Dose\ Time = Dose\ Time + Dose\ Coef. \times (Factor\ in\ Converted\ File)$$

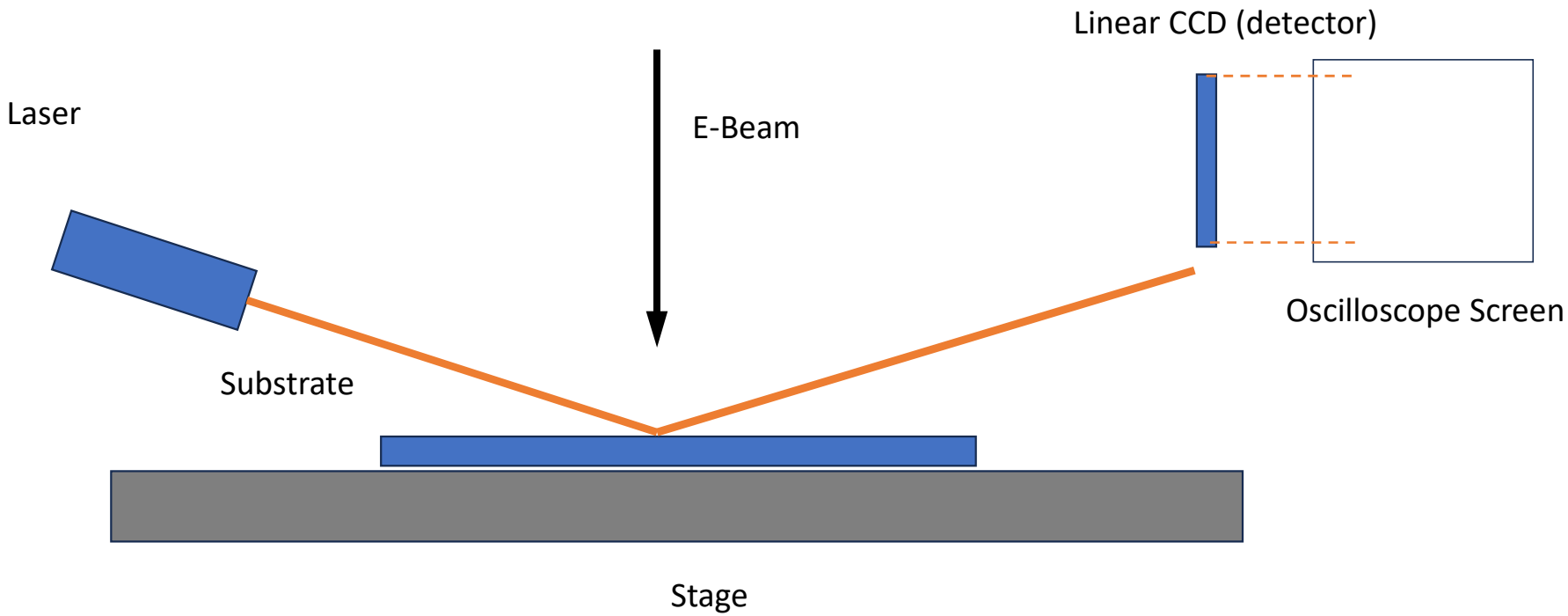
(7b) Schedule File – Set Option and Preset Height



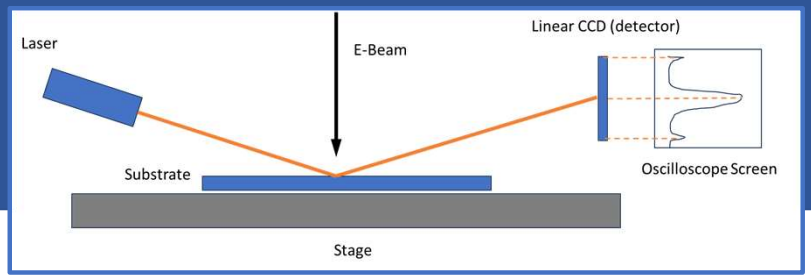
Preset Height and Height Sensor

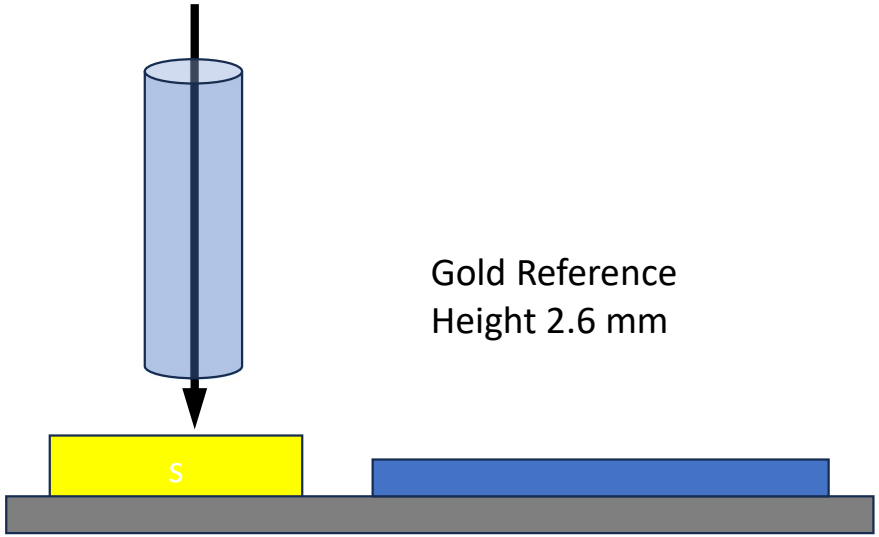


Preset Height and Height Sensor

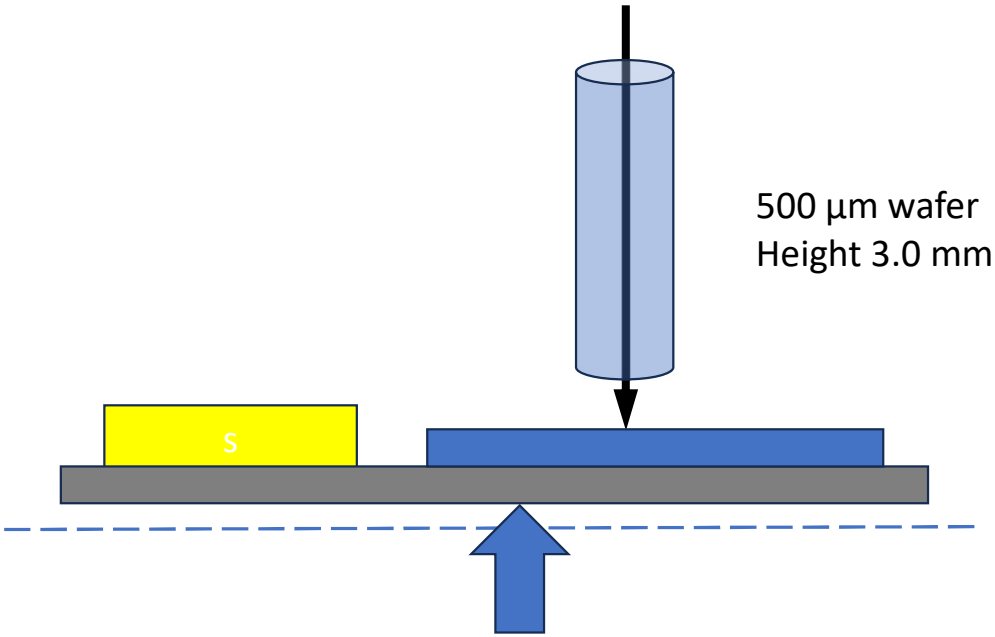


Preset Height (offset)



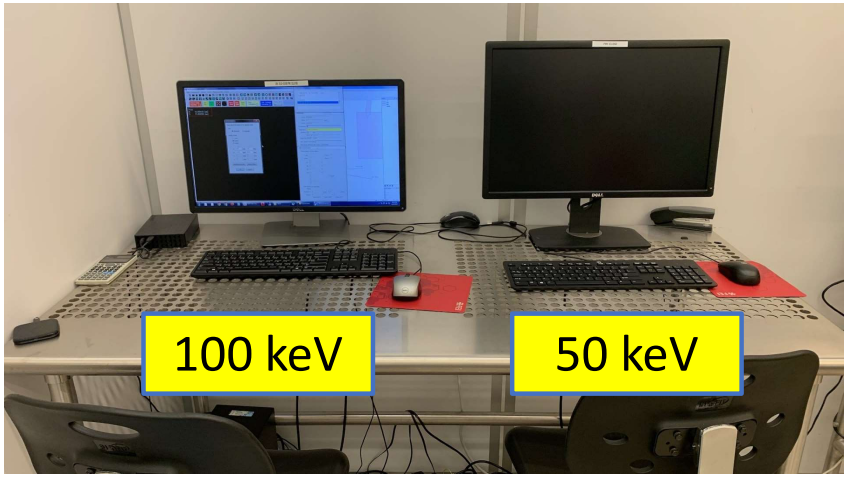


Gold Reference
Height 2.6 mm



500 µm wafer
Height 3.0 mm

CAD Conversion ONLY on CAD-PCs (!)



- Start the conversion process by creating a directory for this job
- Save entire folder on the CAD-PC (.cel, .sccc, .scbc, .scon, .sc8)
- Will transfer folder to the “Online PC” when at the tool
- Estimate your write time before reserving the tool!

Elionix Reservation Policies

- 10 Day Reservation Horizon for each tool
- No more than 3 reservations at a time
- No more than 1 prime time reservation at a time
- Number of reservations limited – NOT hours
- Reserve only the time that you need

Cancelation Policies

- Must cancel at least 24 hours before beginning of the reservation
- If reservation efficiency is below 80% you will receive warning – Thereafter will either be charged or loose reservation access or both

ELIONIX

Electron Beam Lithography