

NANOFABRICATION FACILITY

ADVANCED SCIENCE RESEARCH CENTER



ELIONIX

Using WecaS for Elionix EBL CAD File Conversion

And Considerations for Choosing Write Parameters

Samantha Roberts

Acknowledgements

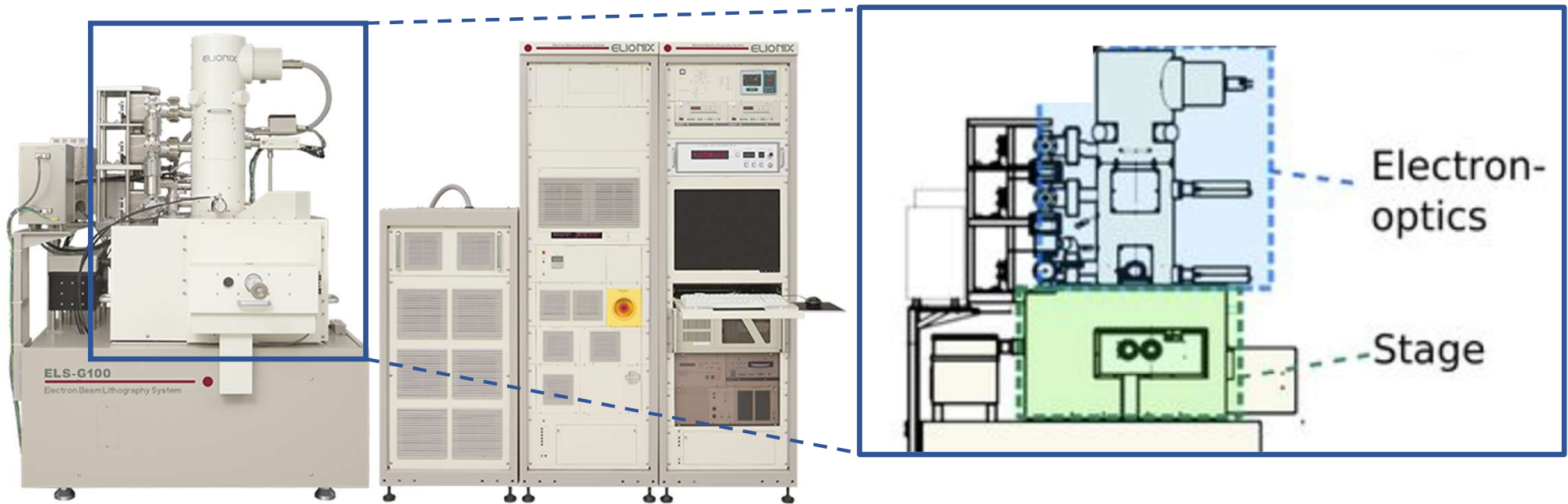


Sky on Sky: <https://vonoff.com/>

ELIONIX
株式会社 エリオニクス

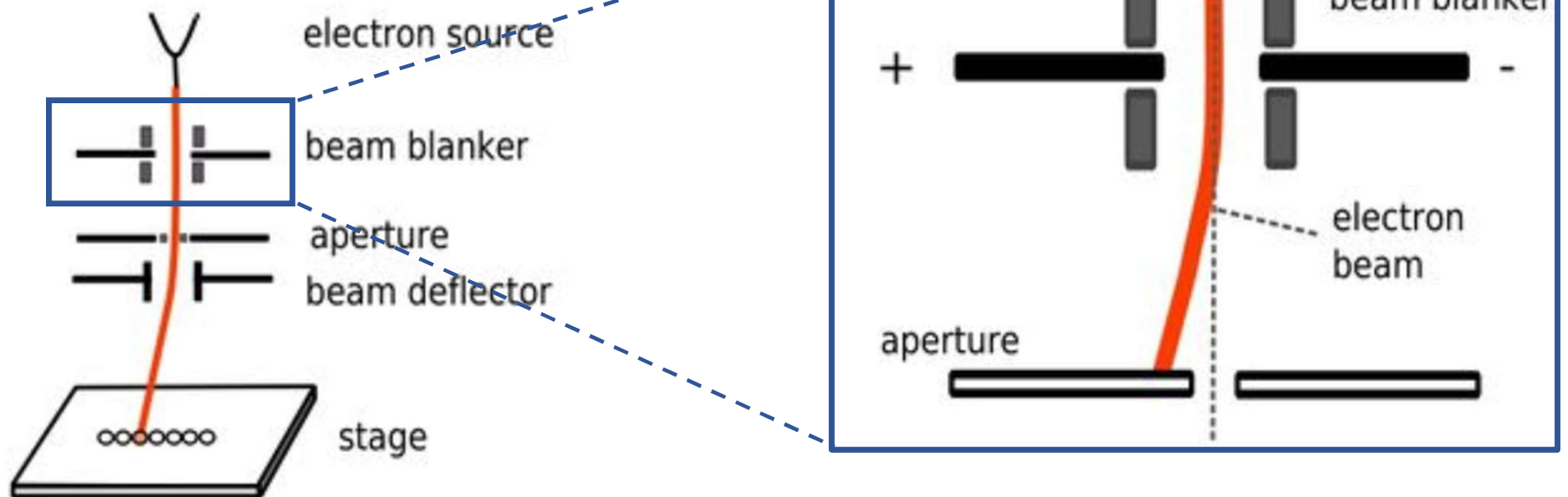


Electron Optics Column and Stage

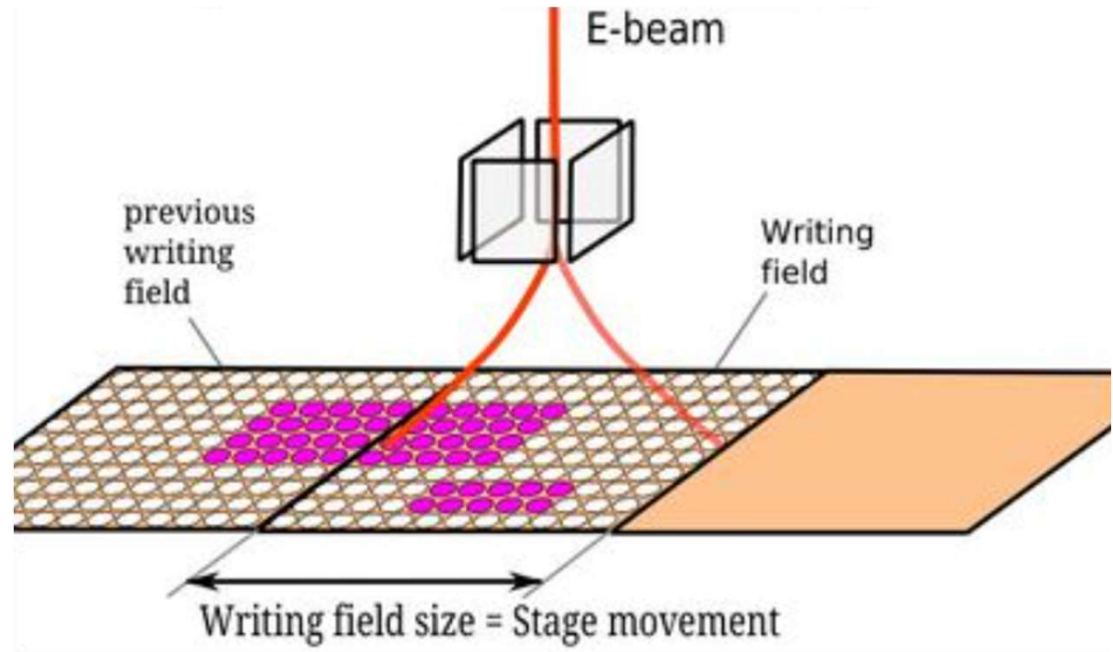
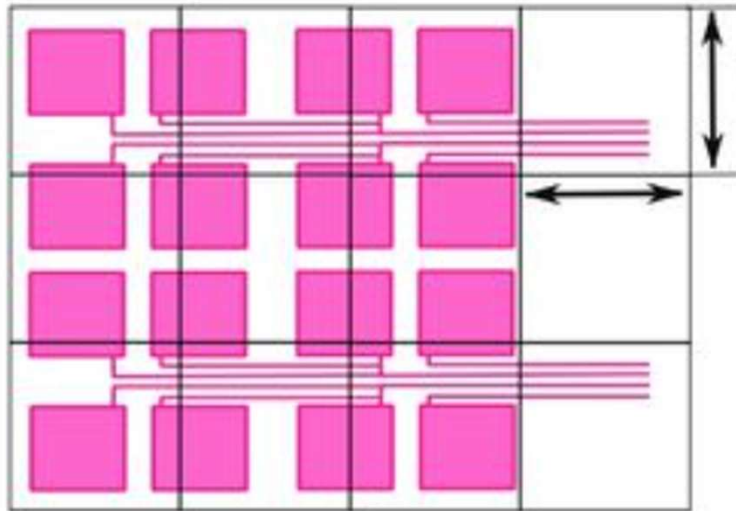


Beam Deflector and Beam Blanker

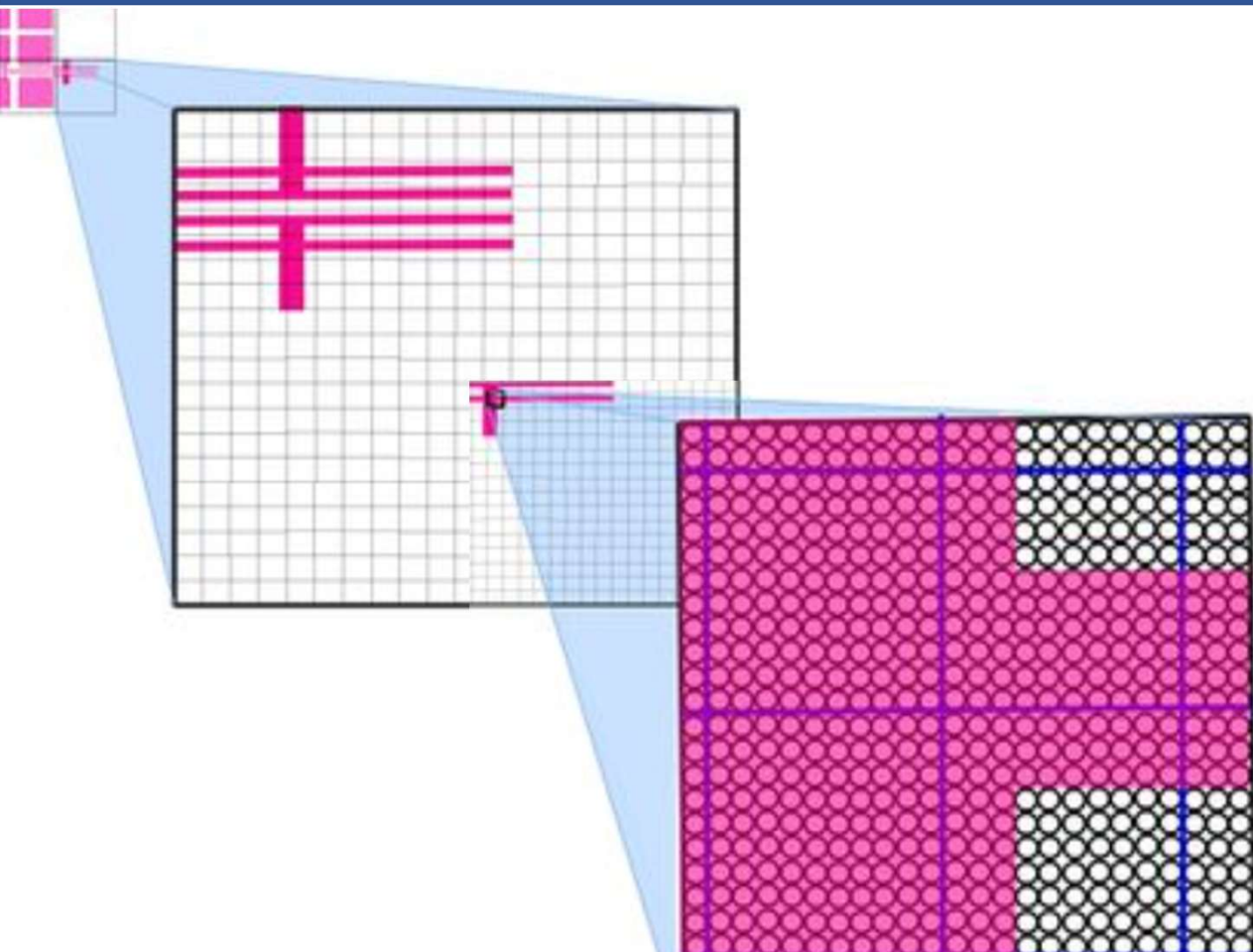
100MHz Clock \rightarrow 10ns (Minimum dose time)



Elionix Breaks the CAD into Fields



Fields – Subfields – Polygons and E-Beam Spots

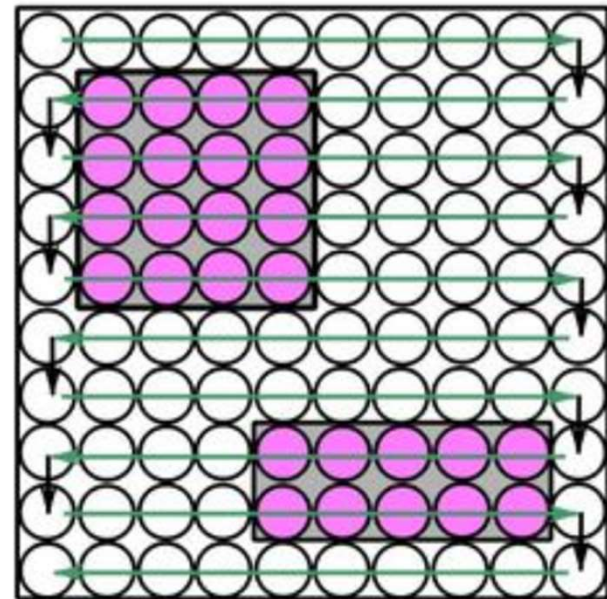


- Each field is broken into 20 subfields
- Each subfield is broken into trapezoids
- Each trapezoid is filled by E-beam shots

Raster Scanning

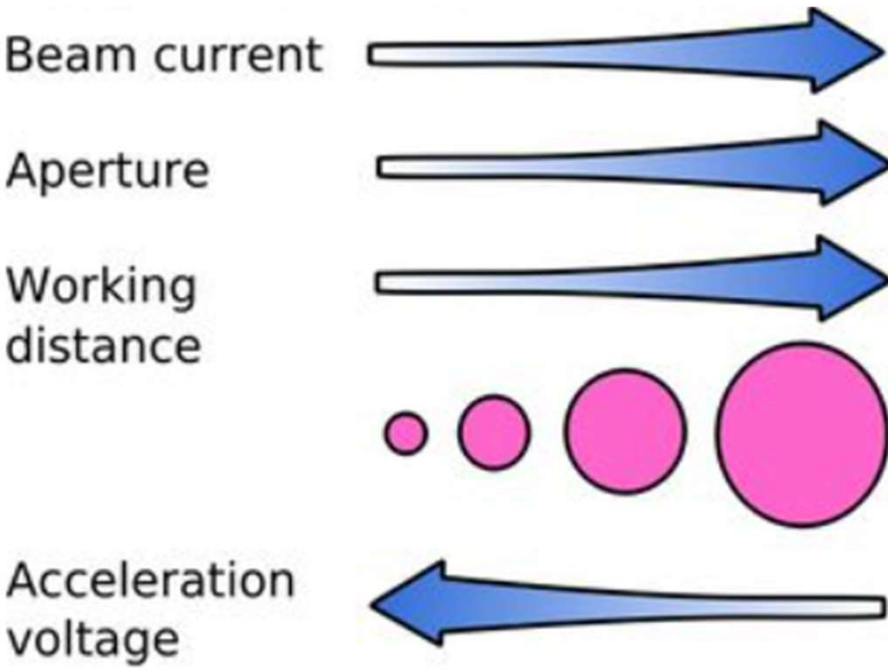
Raster scan

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

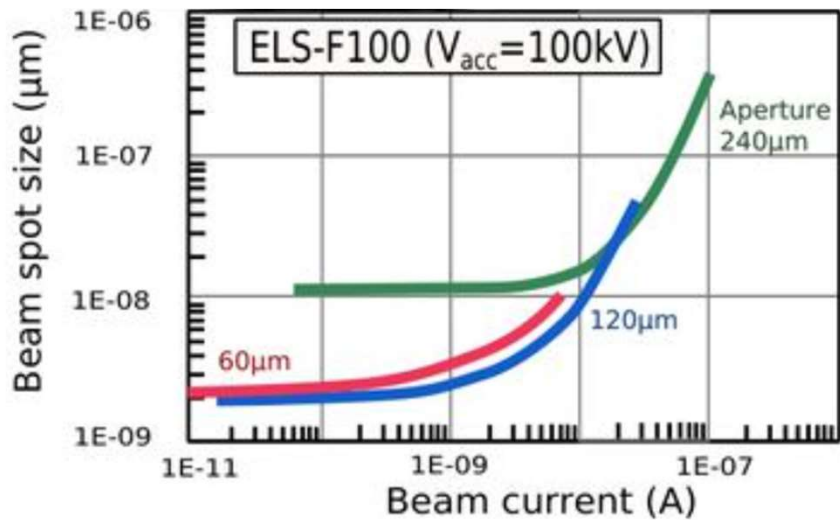


○ Beam OFF ● Beam ON

Factors Affecting the Beam Spot Size

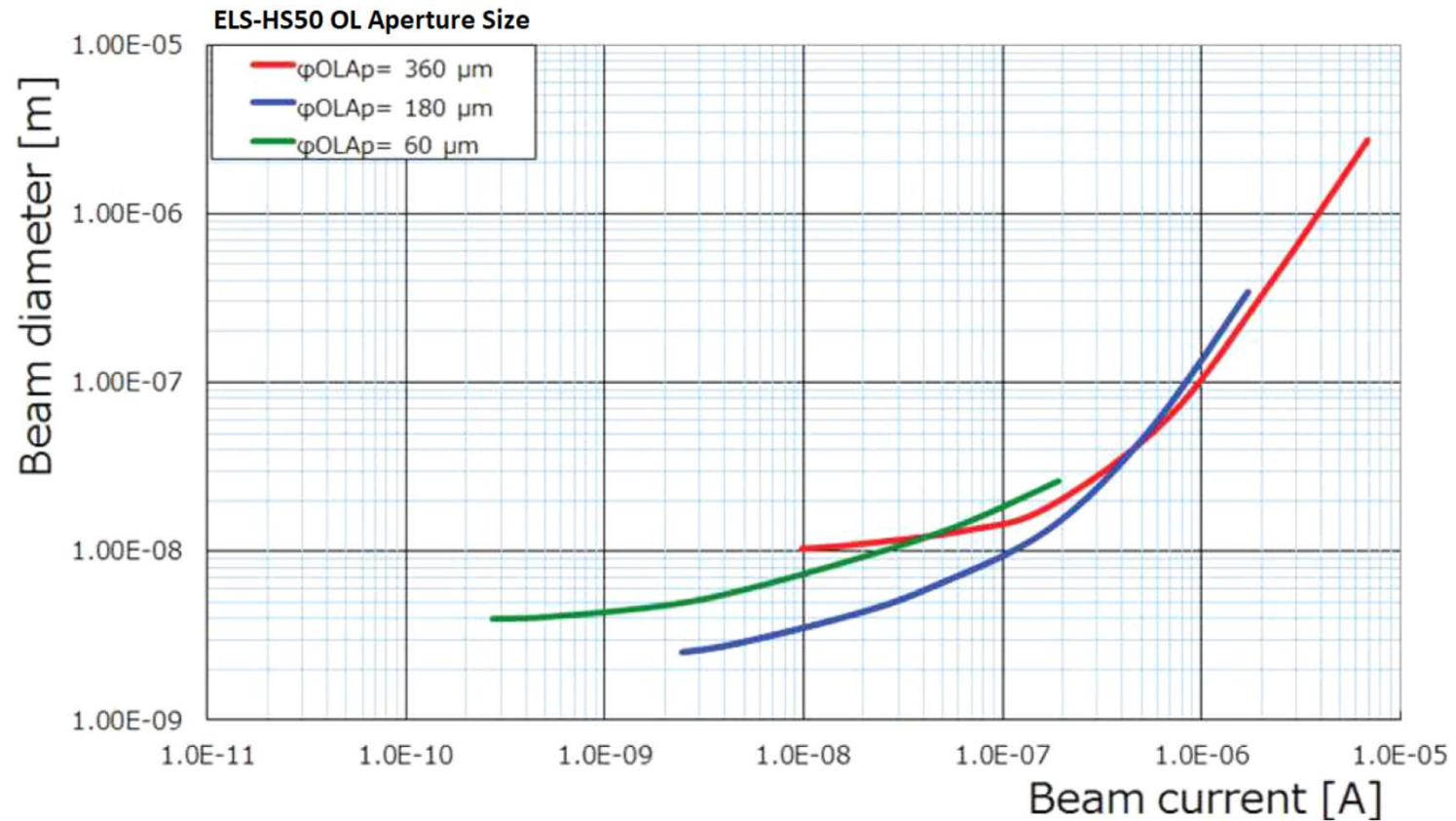


Beam Spot Size for the 100keV Elionix

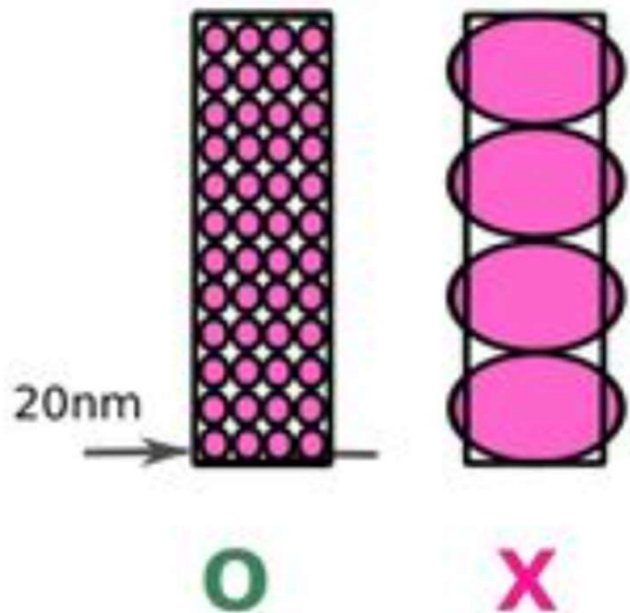


Beam Current	OLAP	Beam Diameter
100pA	120 μm	1.8nm
200pA	120 μm	2nm
500pA	120 μm	2.1nm
1nA	120 μm	2.3nm
2nA	120 μm	3nm
5nA	120 μm	5nm
10nA	120 μm	10nm
10nA	240 μm	15nm
20nA	240 μm	25nm
50nA	240 μm	90nm
100nA	240 μm	300nm

Beam Spot Size for the 50keV Elionix



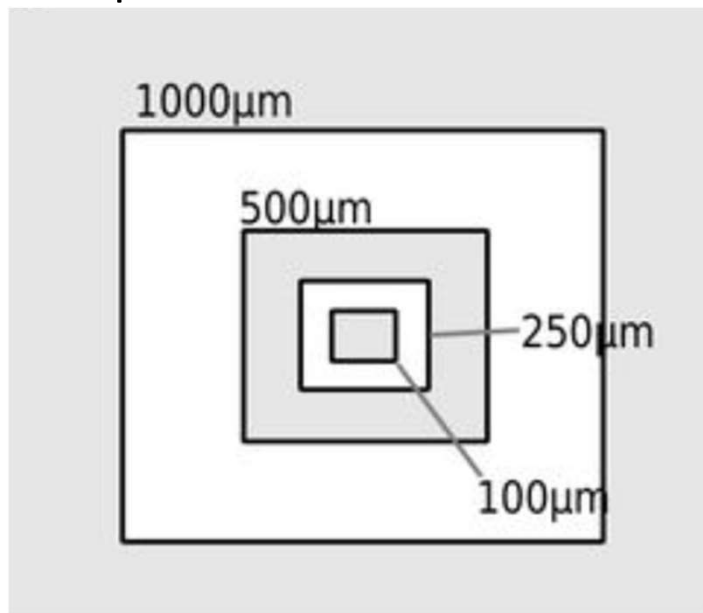
Step 1. Choose the Beam Current and Aperture



- 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

1500 μm



Maximum Field Sizes:

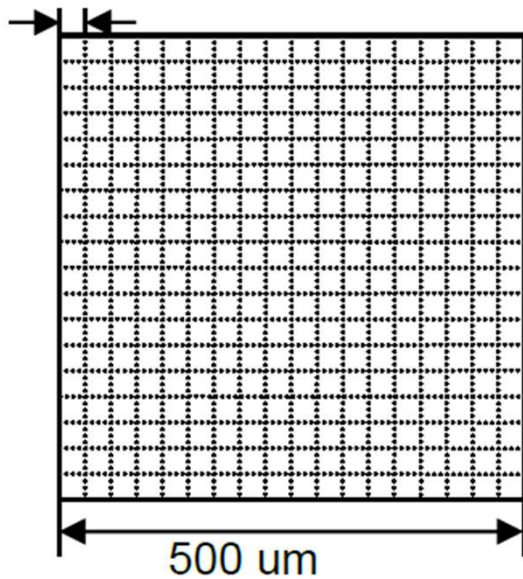
- 100keV = 1000 μm
- 50keV = 1500 μm

Field size can be critical – more to follow

Step 3. Define CAD Grid (Dot Number)

$$\text{Beam Position Resolution} = \text{Field Size} / \text{Dot Number}$$

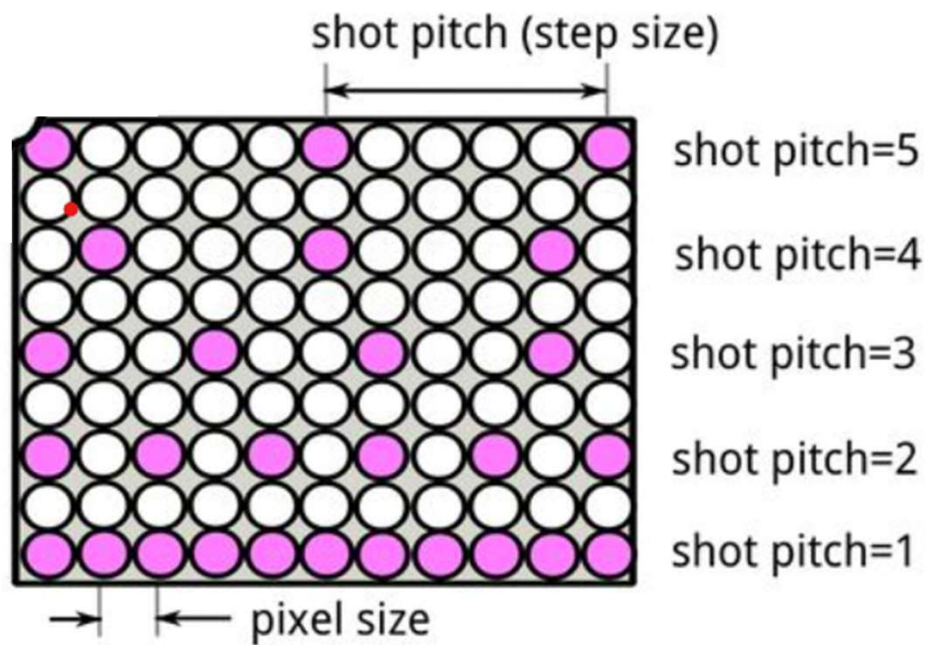
0.01 μm (500/50000)



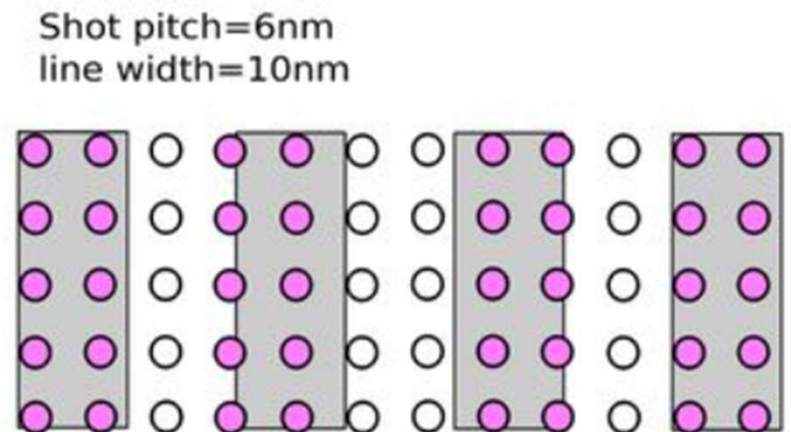
(50,000 dots division)

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

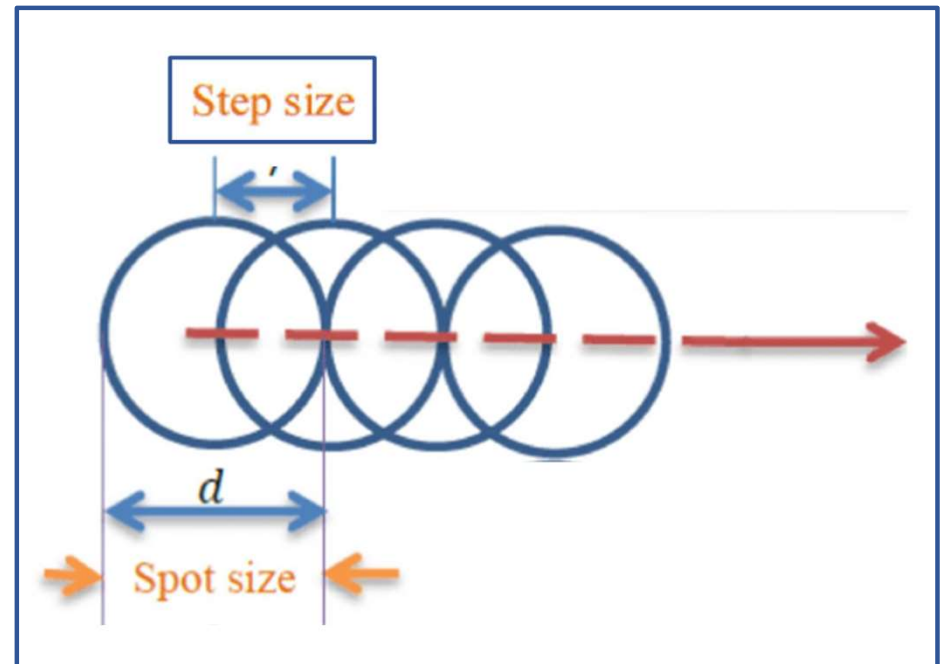
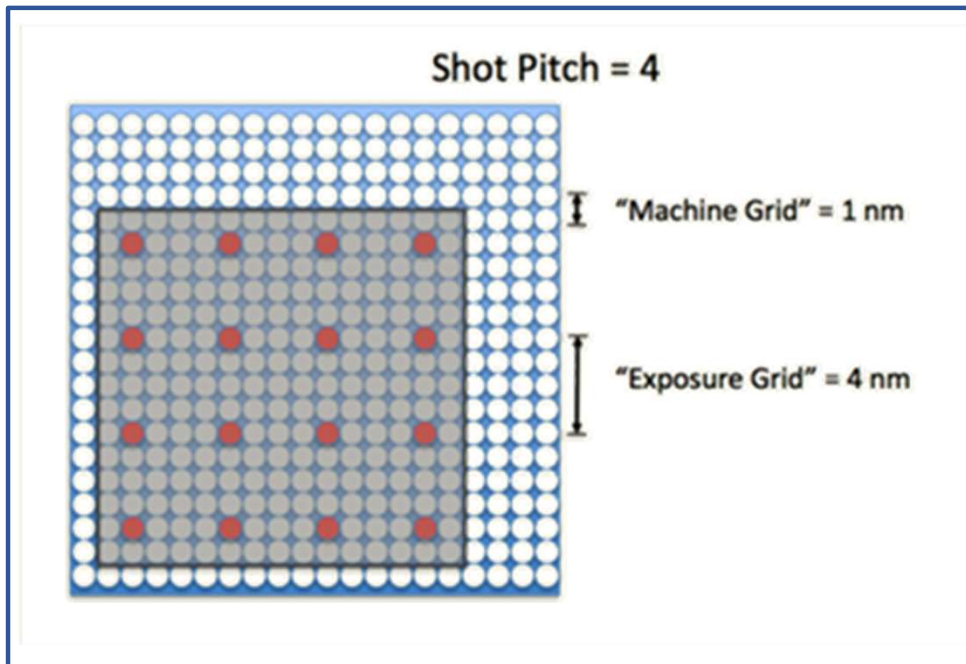
Step 4. Choose Scan and Feed Pitch



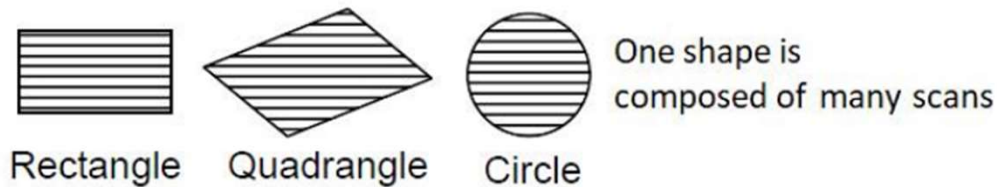
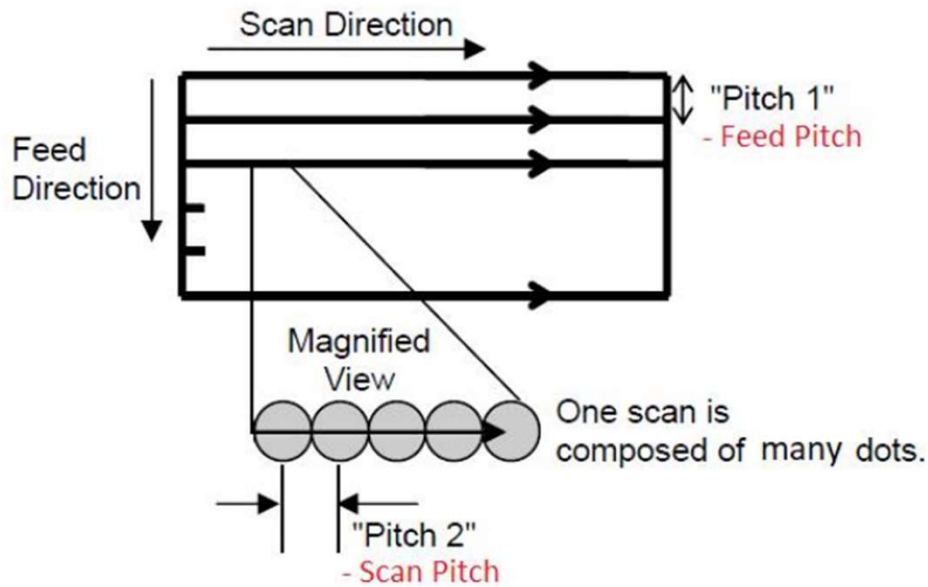
Considerations: Feature Size



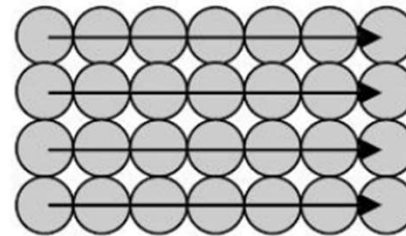
Examples with different shot pitch



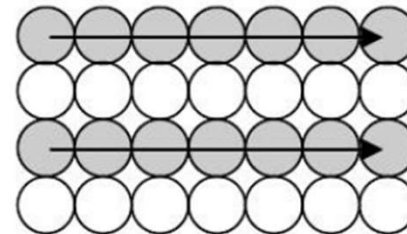
How a shape is written with E-Beam



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

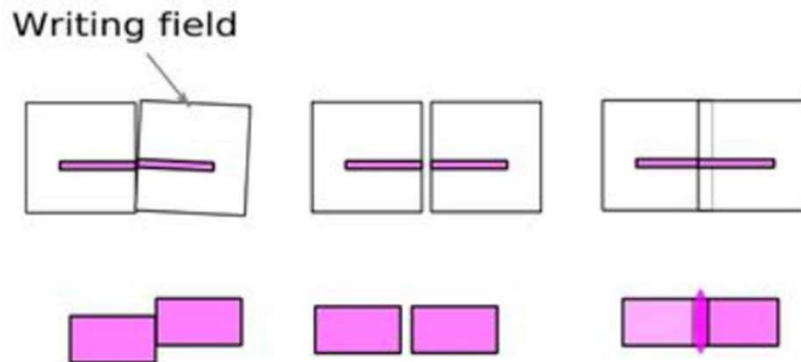
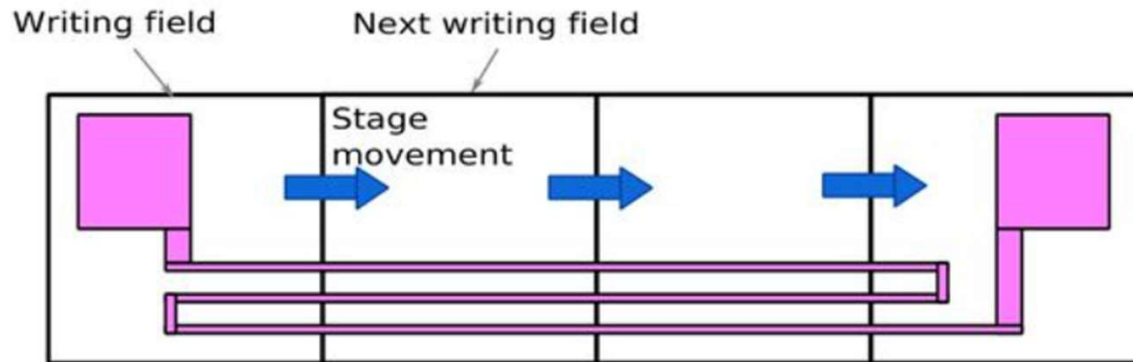


"Pitch 1" = 2, "Pitch 2" = 1 (Scan every other one)

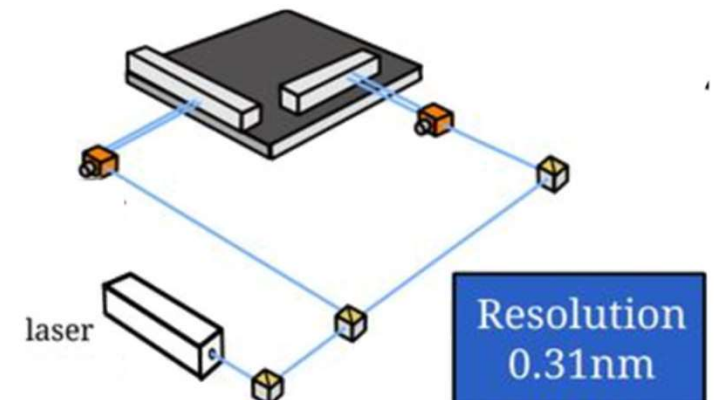


- Dots that beams are irradiated to
- Dots that beams are not irradiated to

Issue: Stitching Errors at Field Boundaries



Stitching Accuracy:
~ 15-20 nm



Field Correction for Dynamic Focus Correction

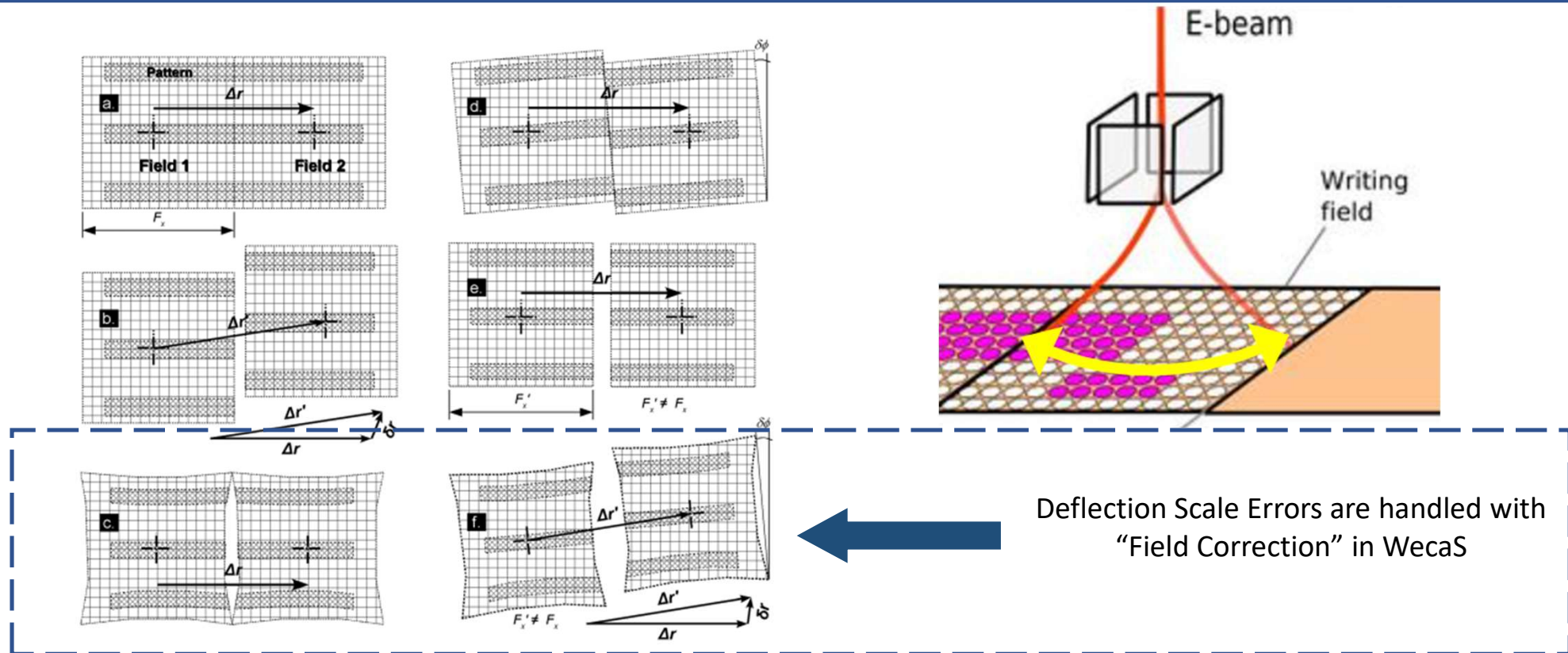
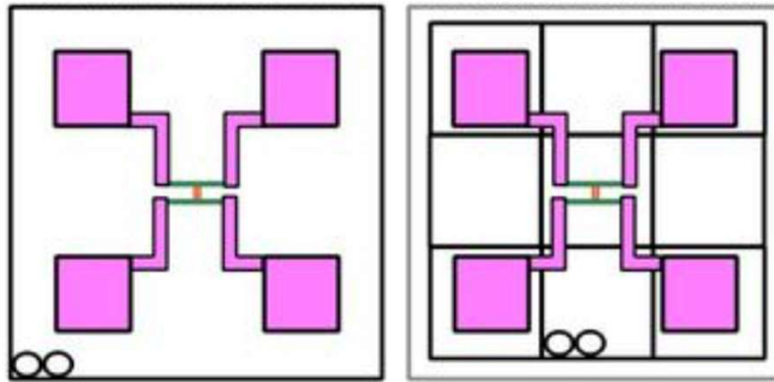


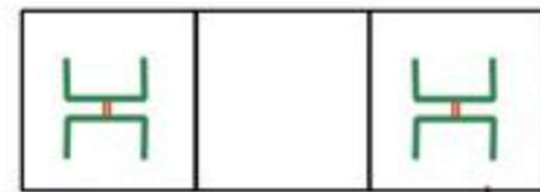
FIG. 1. Types of field stitching errors: (a) ideal case $|\Delta r| = F_x$; (b) shift error, $|\Delta r| \neq F_x$, $\Delta r' = \Delta r + \delta r$; (c) field distortion, $S' = S + [\delta s_y]$; (d) field rotation, $\delta r_{rot} = ((y - y_0)\delta\phi, (x_0 - x)\delta\phi)$; (e) deflector scale 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

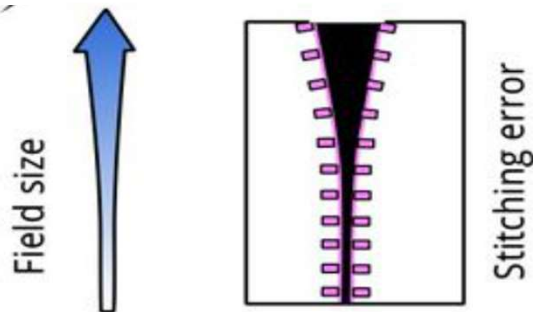
2. Put critical features in the center of the field



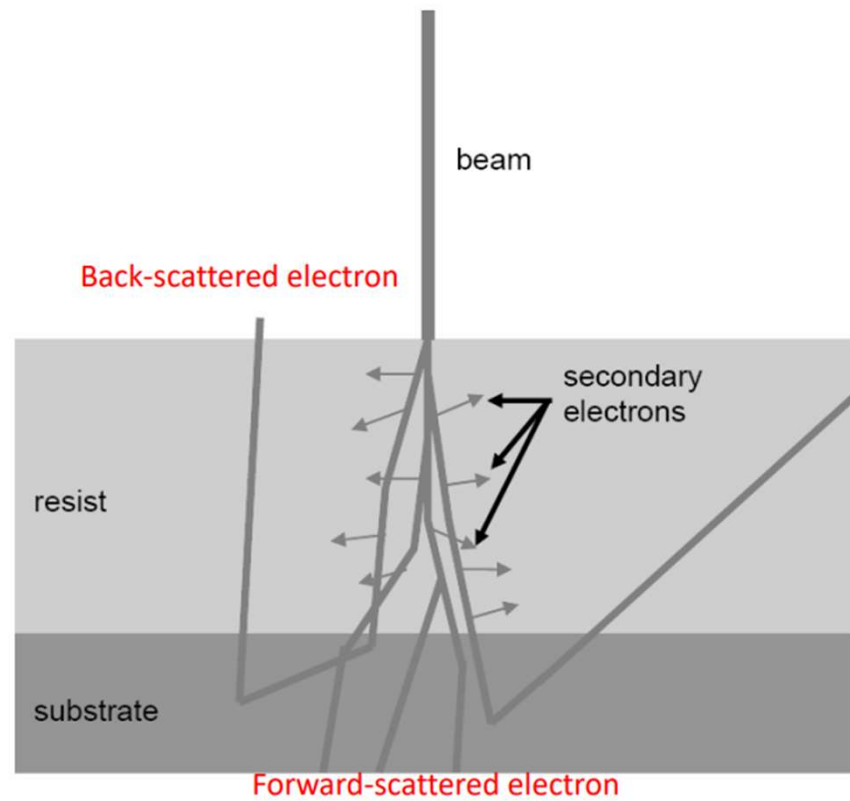
Critical features

writing 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)

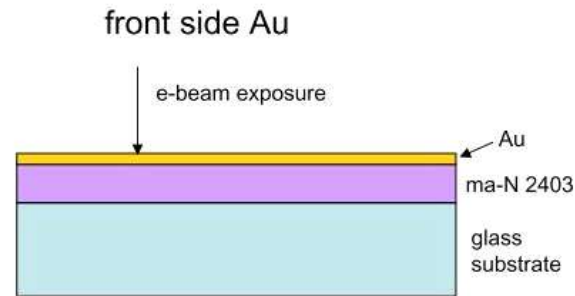
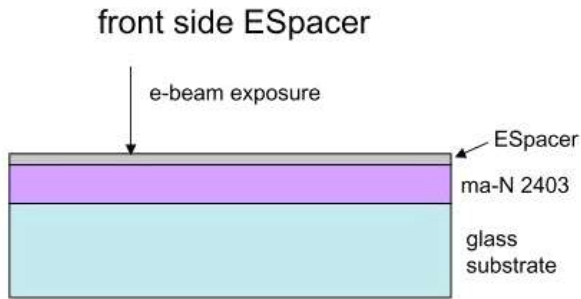
no anti-charging layer



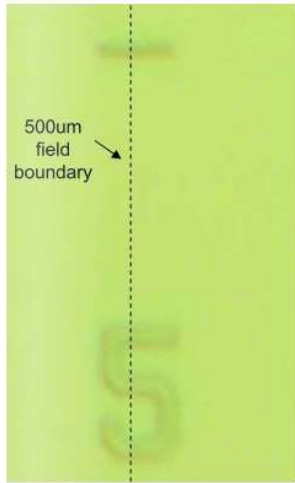
BAD
(severe charging)

By Devin K. Brown, Georgia Tech

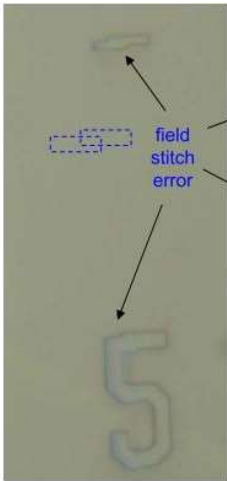
Charging Issues



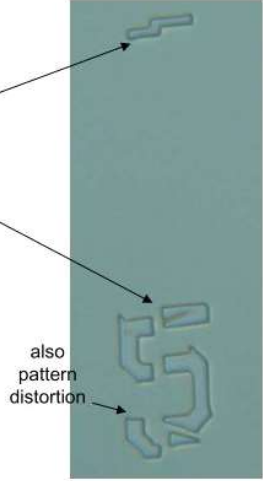
GOOD
(no charging)
Ti/Au/Ti under resist
ESpacer < 1 hour
front side Au



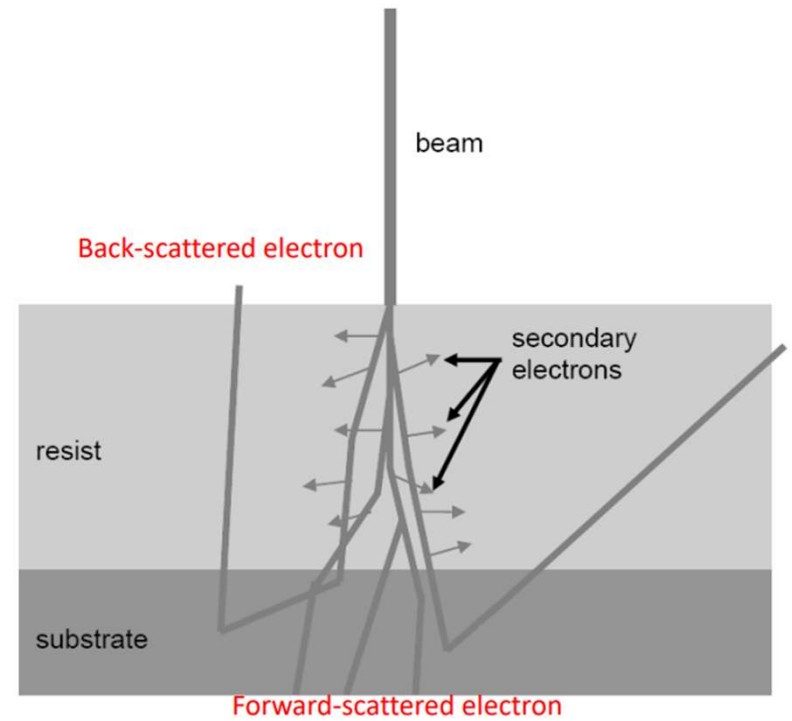
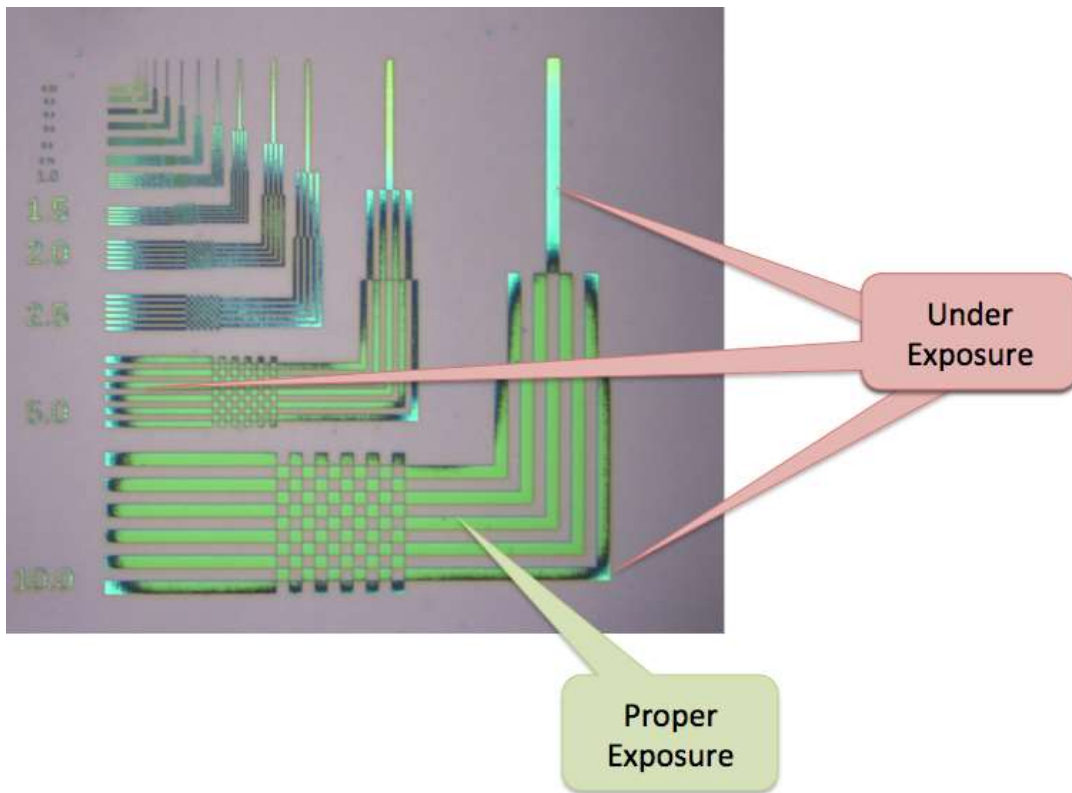
BAD
(moderate charging)
ESpacer > 24 hours



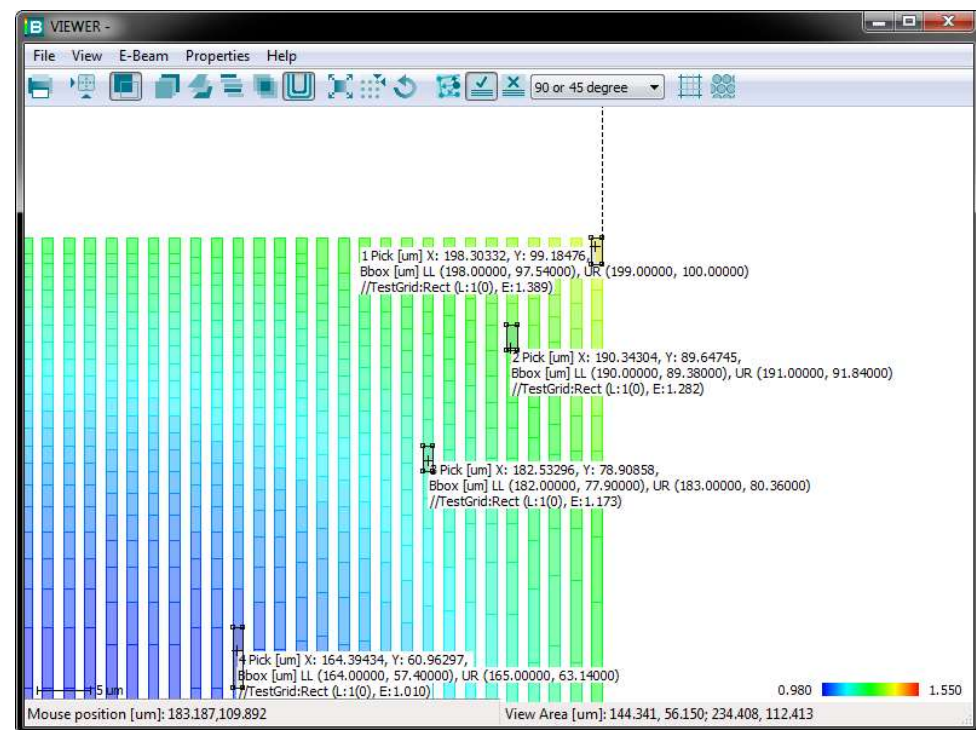
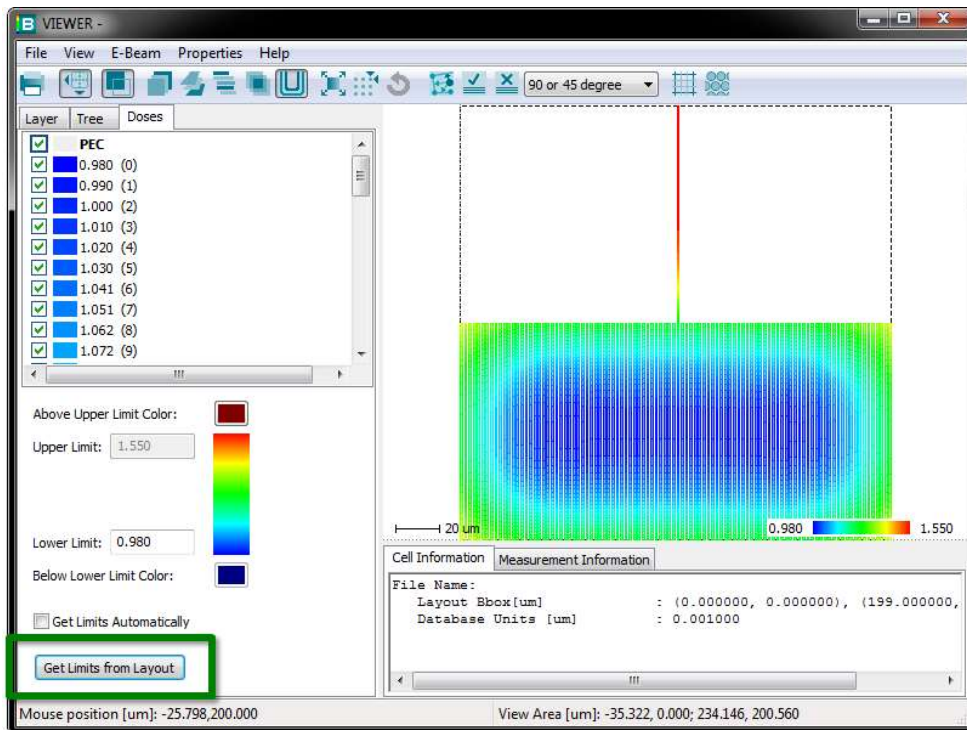
BAD
(severe charging)
no anti-charging layer



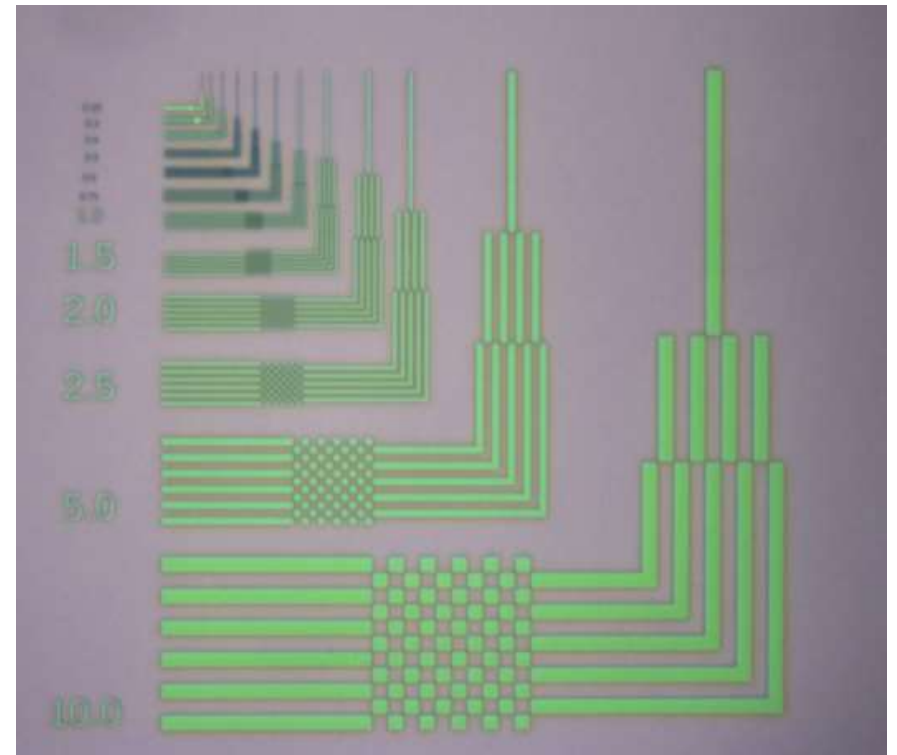
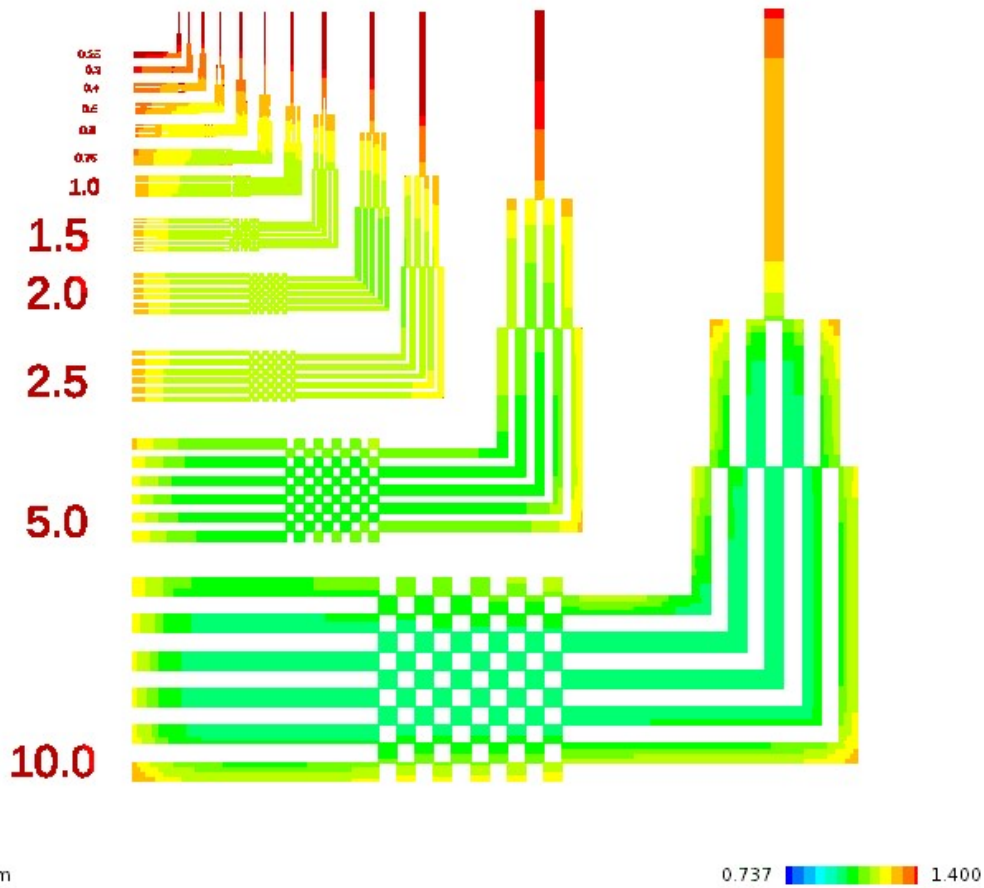
Proximity Effect Issues



Proximity Effect solution: Dose Modulation -- Beamer



Proximity Effect (Solved)



Resists and Exposure Doses ($\mu\text{C}/\text{cm}^2$)

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)

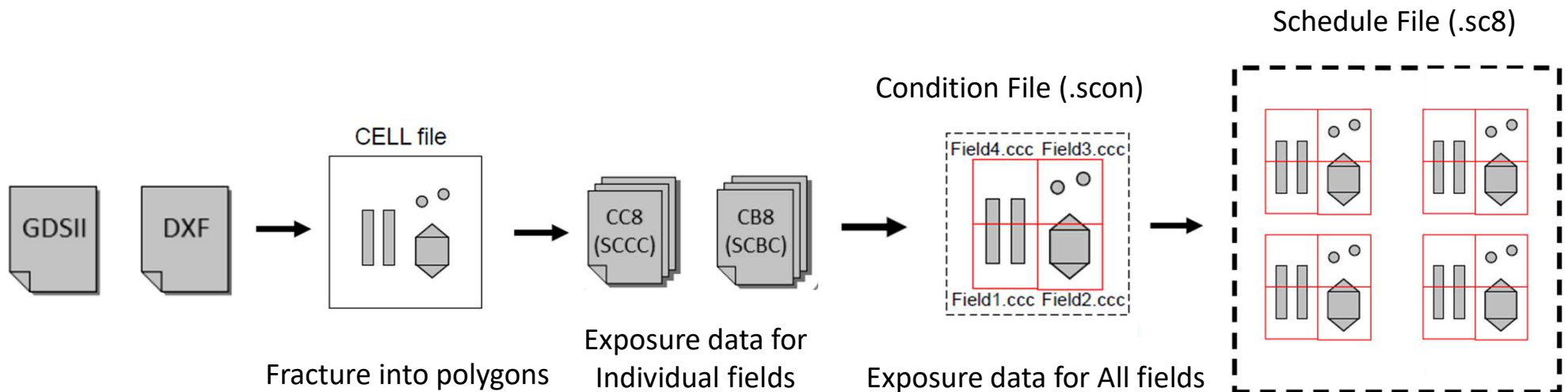
Anti-Charging Agents for Insulating Substrates

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

WecaS



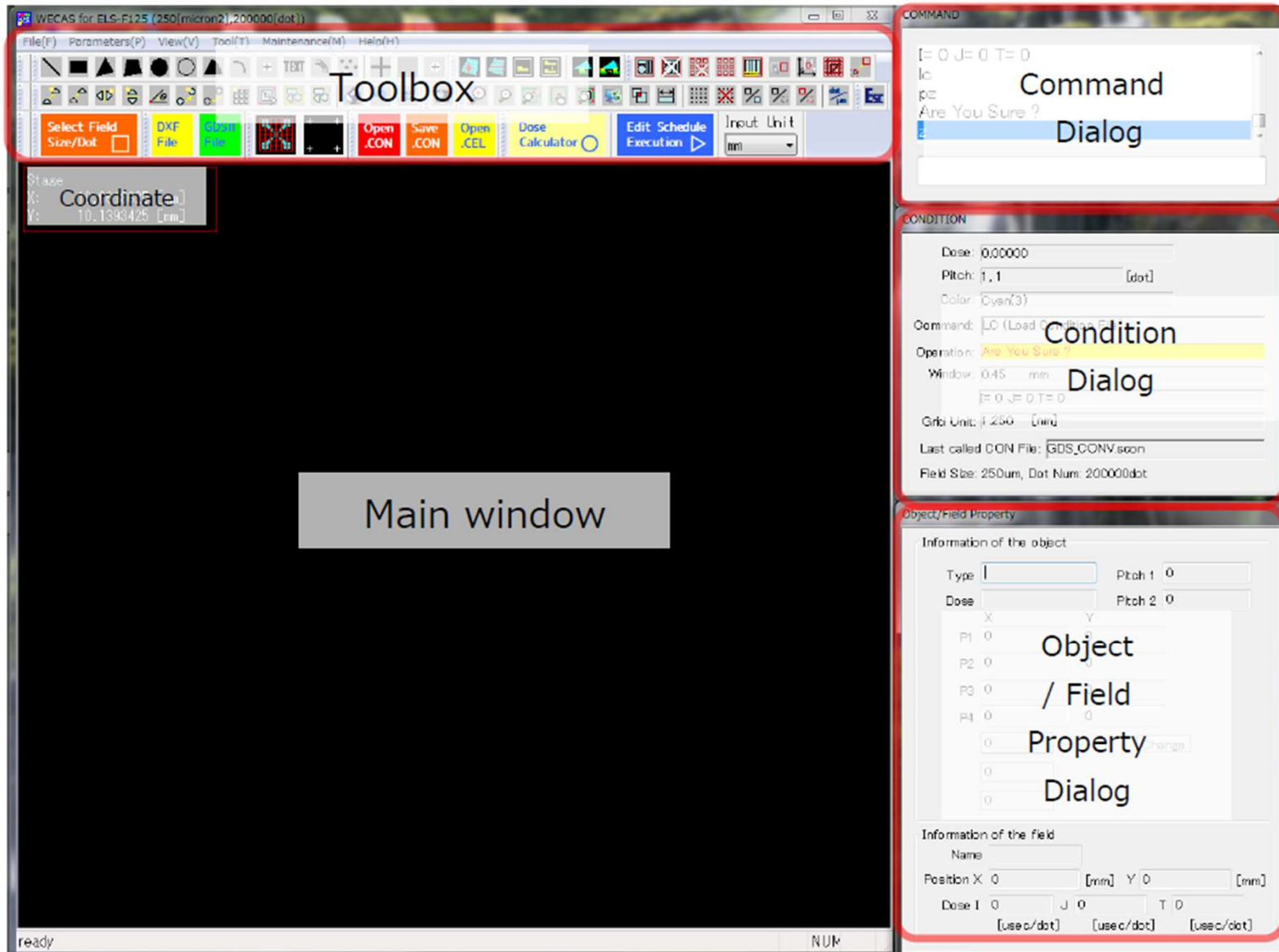
Data structure / Files created



WecaS

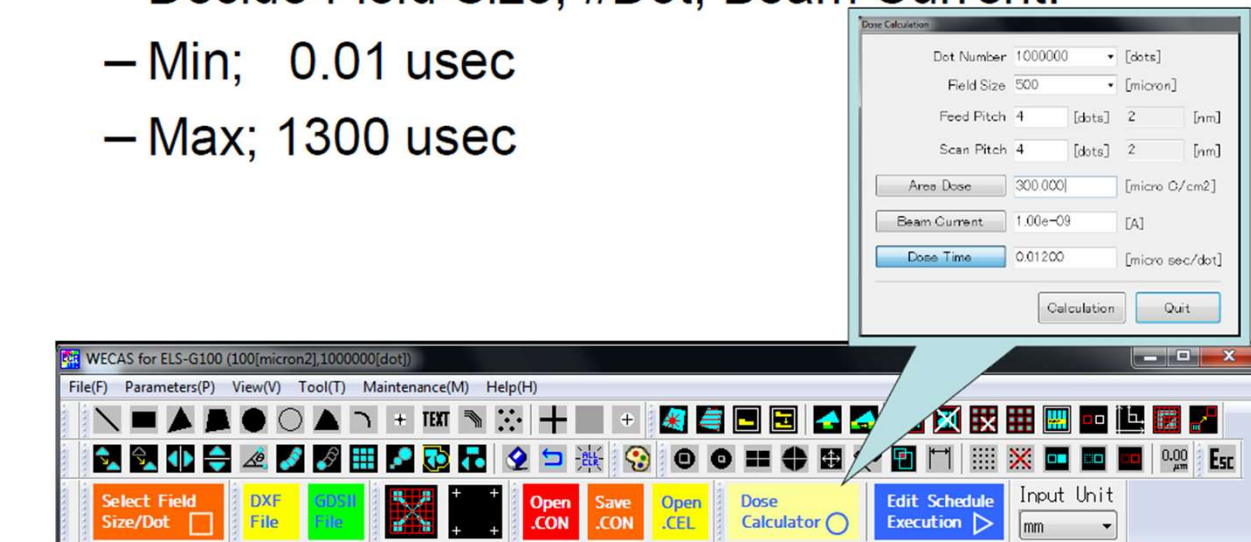


- 1) Calculate the dose time ($\mu\text{s}/\text{dot}$)
- 2) Define CAD Grid (Field, Dots)
- 3) GDS/DXF Conversion \rightarrow into CELL file
- 4) Set Pitch/Dose
- 5) Place / Compute Fields
- 6) Save CON File
- 7) Edit Schedule Execution
 - a. Dose Assignment
 - b. Set Options



(1) Estimate Dose

- ◆ Estimate Area Dose [$\mu\text{C}/\text{cm}^2$]
 - Depends on Resist, Developer, V_{acc} , etc.
- ◆ Calculate Dose Time [μsec]
 - Decide Field Size, #Dot, Beam Current.
 - Min; 0.01 μsec
 - Max; 1300 μsec



(2) Define the Field Size and the Grid



PERSONAL SETTING

OWNER SELECT:

PERSONAL SETTING

OWNER NAME:

FIELD SIZE [DOT]: 50,000 200,000 500,000 1,000,000

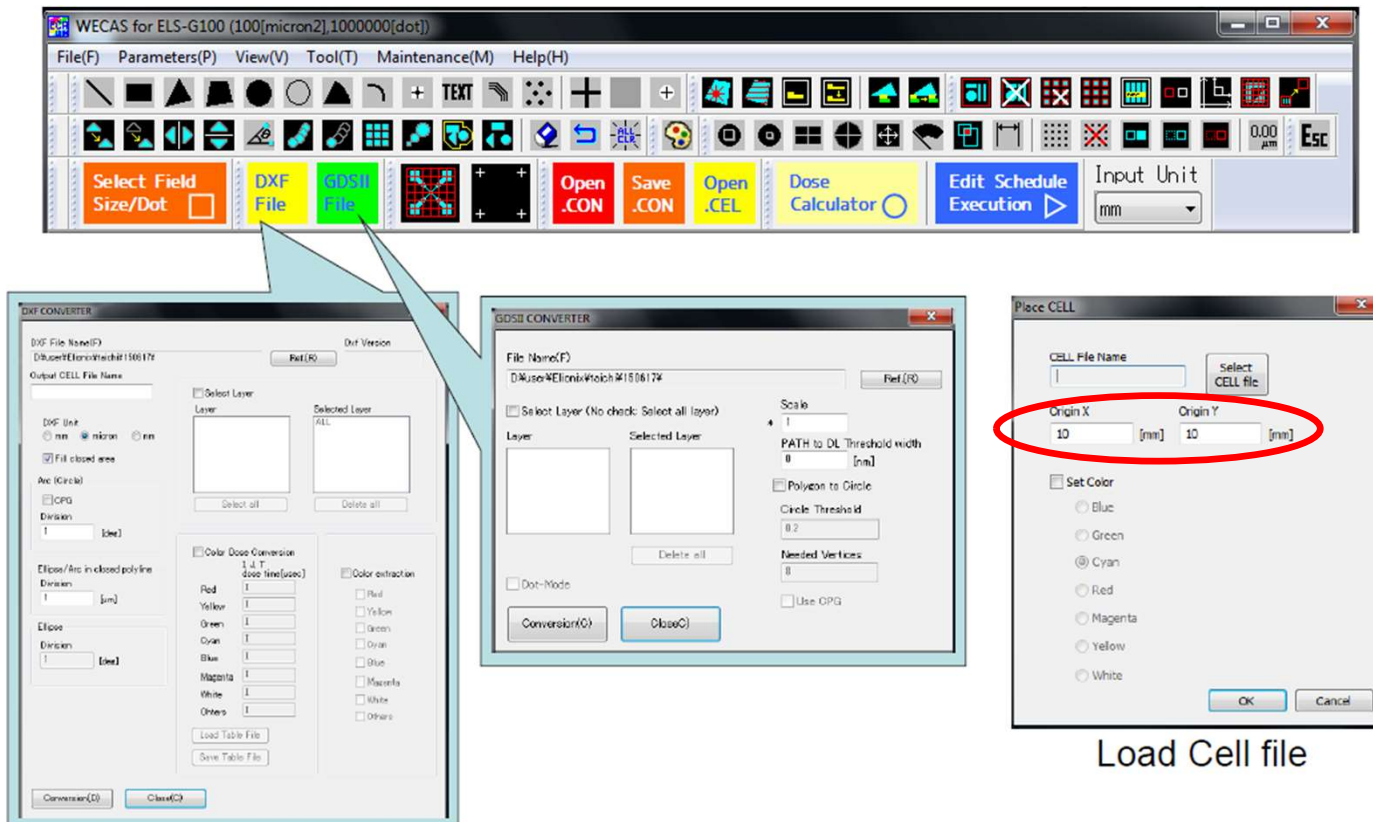
FIELD SIZE [μ m]:

DATA DIRECTORY:

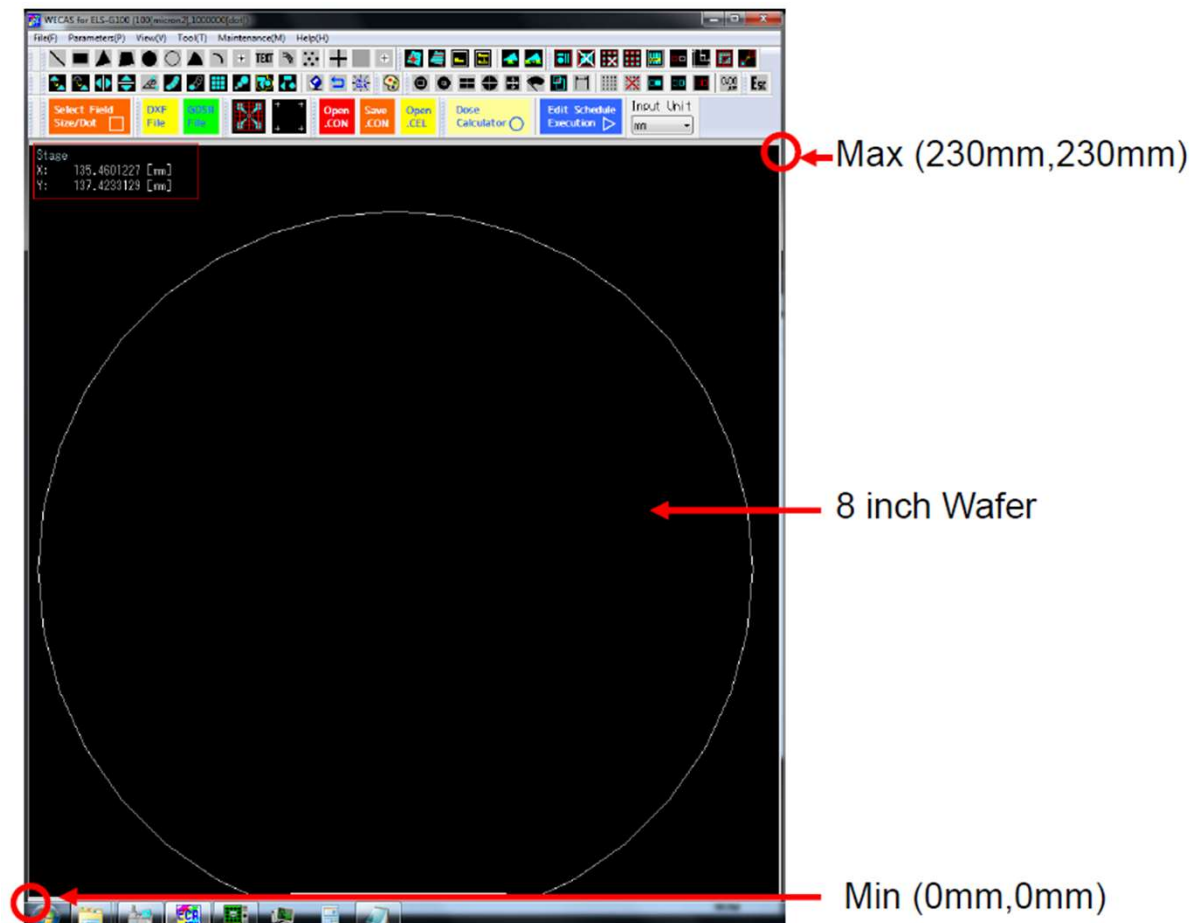
HARD SETTING

HARD SETTING:

(3) Convert GDSII/DXF into Cell File



Note: Writing / CAD Area – 1st Quadrant Only



(4) Set Pitch and Dose

The screenshot displays the WECAS software interface for ELS-G100. The main window title is "WECAS for ELS-G100 (100[micron2],1000000[dot])". The menu bar includes File(F), Parameters(P), View(V), Tool(T), Maintenance(M), and Help(H). The toolbar contains various icons for file operations, editing, and simulation. A secondary toolbar below the main one includes buttons for "Select Field Size/Dot", "DXF File", "GDSD File", "Open .CON", "Save .CON", "Open .CEL", "Dose Calculator", and "Edit Schedule Execution". The "Input Unit" is set to "mm".

In the main workspace, the "Stage" coordinates are displayed as:
X: 18.1391700 [mm]
Y: 16.9690700 [mm]

A 3x3 grid of cyan squares is visible, with a cyan crosshair centered on the middle square. A light blue callout box points to the "Dose Calculator" button in the toolbar.

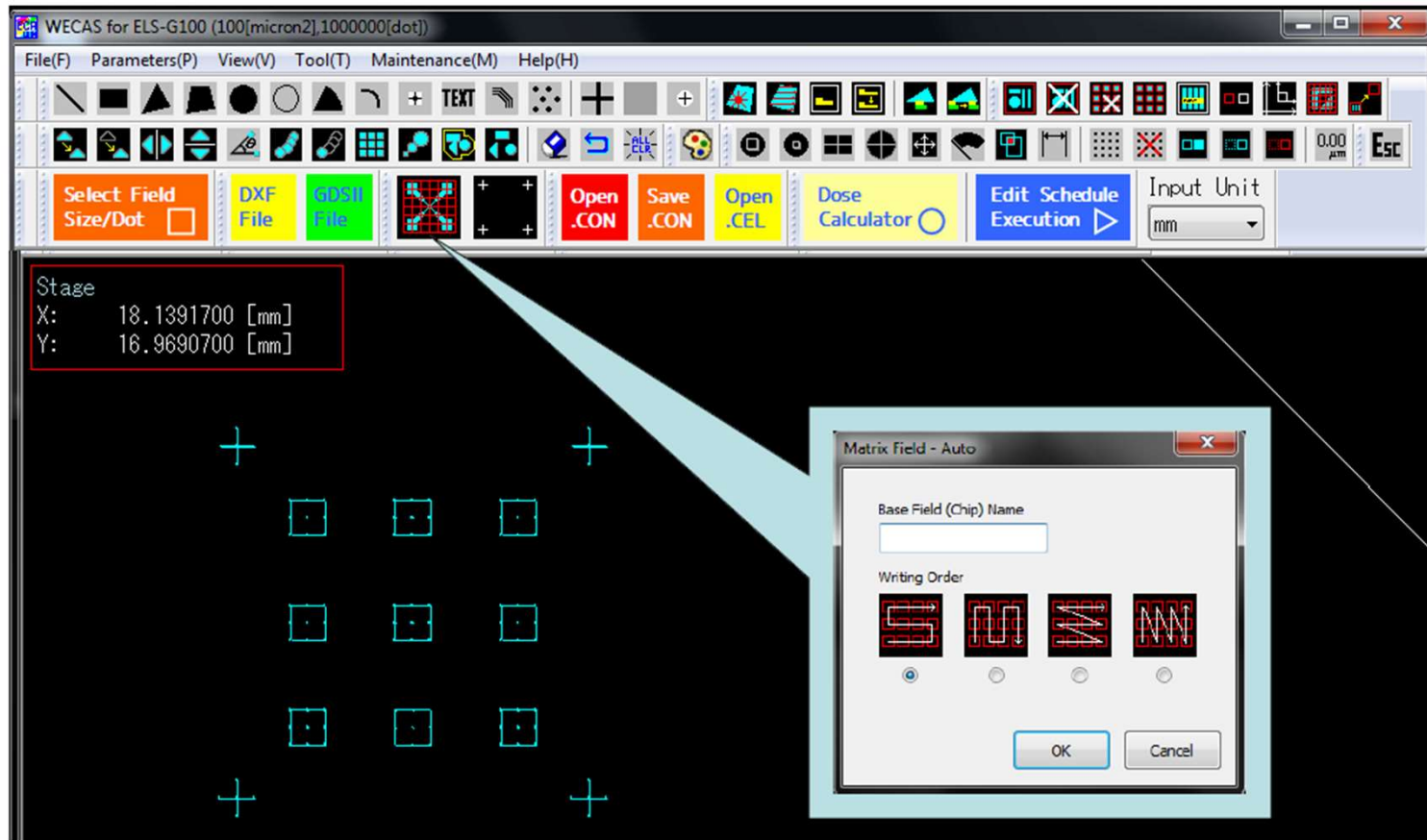
The "Set Color/Pitch/Dose" dialog box is open, showing a table of parameters for different colors. The "Unit" is set to "Dot".

Color	Feed Pitch [dot]	Scan Pitch [dot]	Dose Time [usec/dot]	Apply
Blue	1	1	0.000000	Apply
Green	1	1	0.000000	Apply
Cyan	1	1	0.000000	Apply
Red	1	1	0.000000	Apply
Magenta	1	1	0.000000	Apply
Yellow	1	1	0.000000	Apply
White	1	1	0.000000	Apply

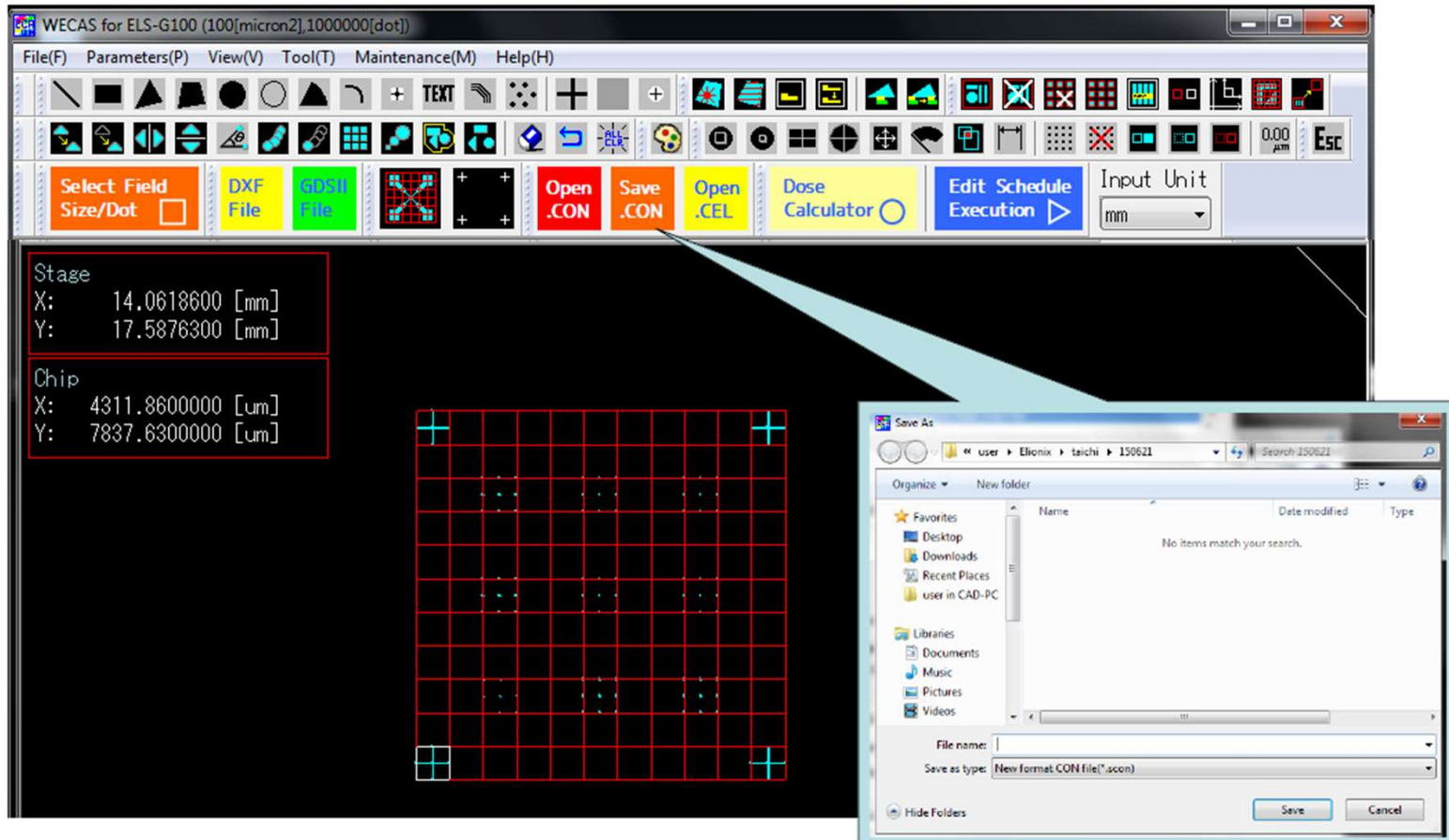
Unit: nm Dot

Buttons: Reset, All, OK, Cancel

(5) Auto Placement of Fields



(6) Save .SCON File



(7a) Create Schedule File – Dose Assignment



Dose Time
[usec/dot] 0.00000
Dose Coef. 1.0000

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

No.	Condition File	Select CON file	Position (Xt, Yt)	Dose Time (usec/dot)	Dose Coef.	Birth Modulation (N)
1			0.000000 0.000000	0.00000	1.0000	0.0000
2			1.000000 0.000000	0.10000	1.0000	0.0000
3			1.000000 0.000000	0.10000	1.0000	0.0000
4			1.000000 0.000000	0.10000	1.0000	0.0000
5			1.000000 0.000000	0.10000	1.0000	0.0000
6			1.000000 0.000000	0.10000	1.0000	0.0000
7			1.000000 0.000000	0.10000	1.0000	0.0000
8			1.000000 0.000000	0.10000	1.0000	0.0000
9			1.000000 0.000000	0.10000	1.0000	0.0000
10			1.000000 0.000000	0.10000	1.0000	0.0000
11			1.000000 0.000000	0.10000	1.0000	0.0000
12			1.000000 0.000000	0.10000	1.0000	0.0000
13			1.000000 0.000000	0.10000	1.0000	0.0000
14			1.000000 0.000000	0.10000	1.0000	0.0000
15			1.000000 0.000000	0.10000	1.0000	0.0000
16			1.000000 0.000000	0.10000	1.0000	0.0000
17			1.000000 0.000000	0.10000	1.0000	0.0000
18			1.000000 0.000000	0.10000	1.0000	0.0000
19			1.000000 0.000000	0.10000	1.0000	0.0000
20			1.000000 0.000000	0.10000	1.0000	0.0000
21			1.000000 0.000000	0.10000	1.0000	0.0000
22			1.000000 0.000000	0.10000	1.0000	0.0000
23			1.000000 0.000000	0.10000	1.0000	0.0000
24			1.000000 0.000000	0.10000	1.0000	0.0000
25			1.000000 0.000000	0.10000	1.0000	0.0000
26			1.000000 0.000000	0.10000	1.0000	0.0000
27			1.000000 0.000000	0.10000	1.0000	0.0000
28			1.000000 0.000000	0.10000	1.0000	0.0000
29			1.000000 0.000000	0.10000	1.0000	0.0000
30			1.000000 0.000000	0.10000	1.0000	0.0000

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

The screenshot shows the 'Set Option' dialog box with the following settings highlighted by red boxes and arrows:

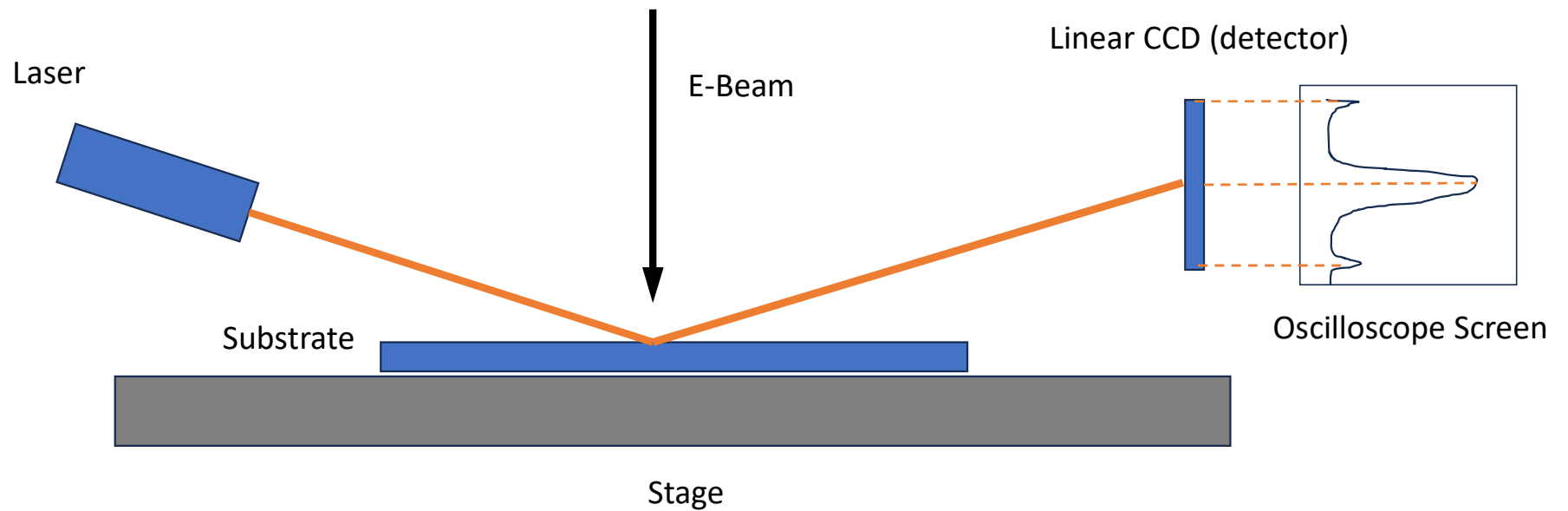
- XY-Laser:** REAL TIME (dropdown)
- Z-Movement:** PRESET(HS ON) (dropdown), Z Preset [mm]: 3.2, Z Tolerance [um]: 0.5
- Global Mark (Reg-2):** OFF (radio button)
- Local Mark (Reg-4):** OFF (radio button)
- Periodic Correction:** OFF (radio button)
- Width Modulation:** OFF (radio button)
- Dose Correction:** OFF (radio button)
- Dynamic Correction:** ON (radio button)
- Scan Type:** Digital (radio button)
- Field Mark (Reg-3):** OFF (radio button)
- Field Correction:** ALL REG-2 (dropdown)
- Search Position Repeatability:** 100 [nm]
- Field Mark (Reg-3):** Keep Last Rotation (checkbox checked)
- Field Mark (Reg-3):** Error Processing: END (dropdown)
- Field Mark (Reg-3):** Search Position Repeatability: 100 [nm]
- Wide Area Correction:** OFF (radio button)
- Wide Area Corr. File Name:** ThetaCmps.cmp
- Wide Area Correction:** OFF (radio button)
- Wide Area Corr. File Name:** ThetaCmps.cmp
- Wide Area Correction:** OFF (radio button)
- Wide Area Corr. File Name:** ThetaCmps.cmp

Arrows point from the following text boxes to the highlighted settings:

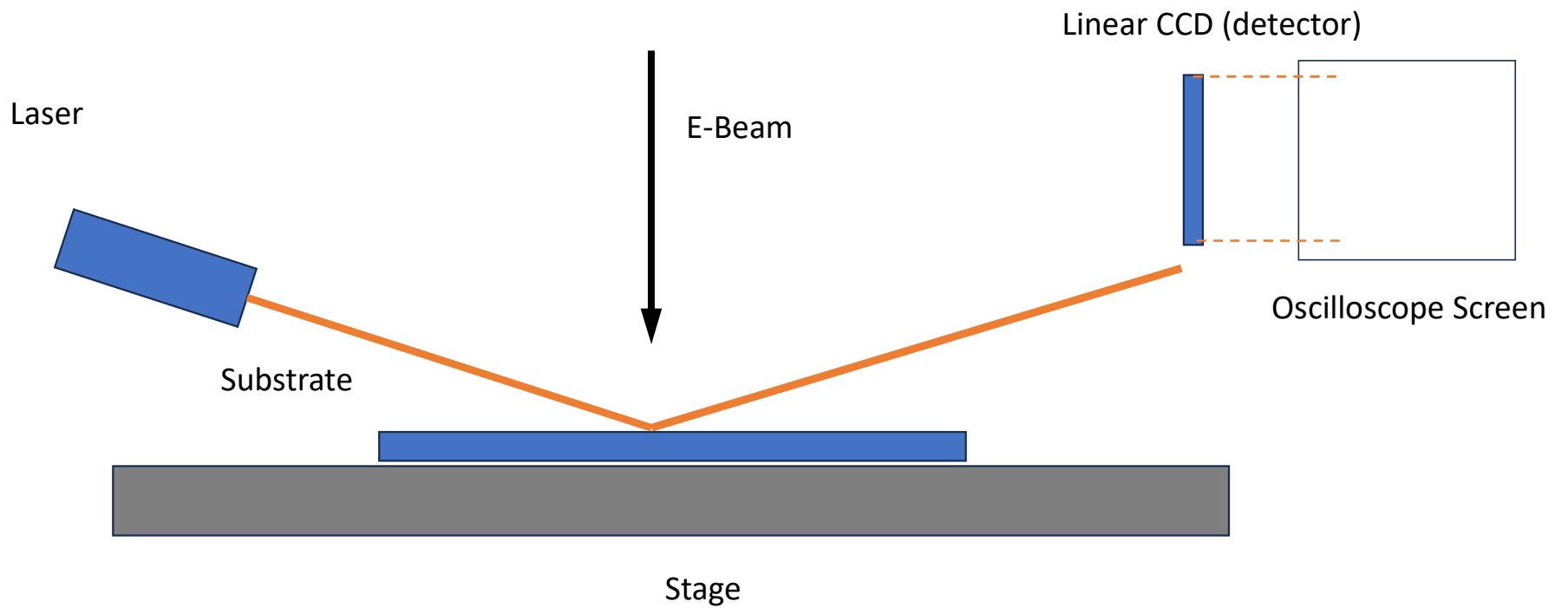
- Check Settings:** Points to the XY-Laser and Z-Movement settings.
- Each setting, please click the "OK" button when you are finished:** Points to the OK button.

The dialog box also includes buttons for 'Change(C)', 'Clear(L)', 'OK', and 'Cancel'.

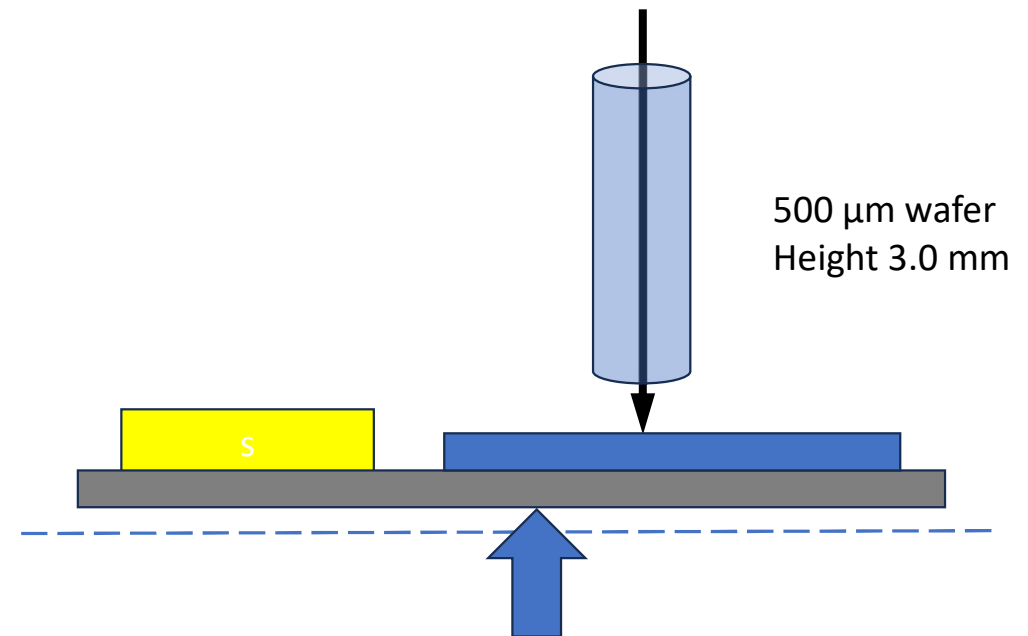
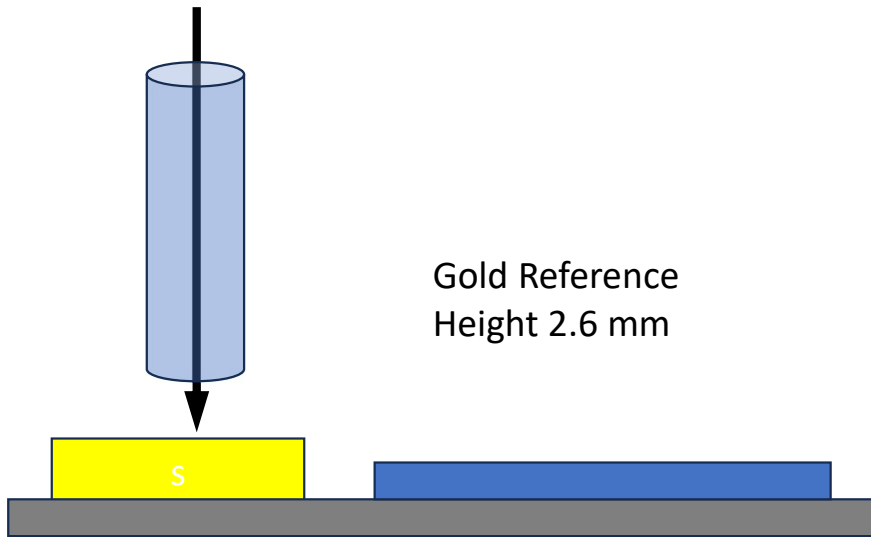
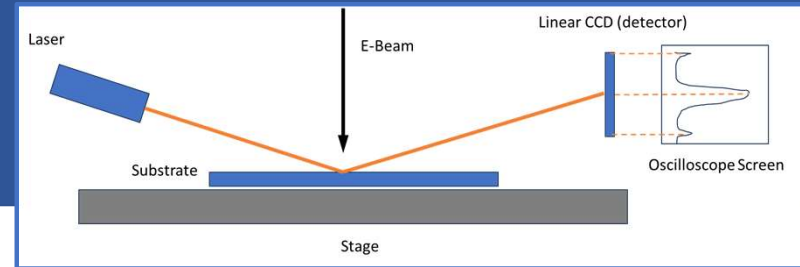
Preset Height and Height Sensor



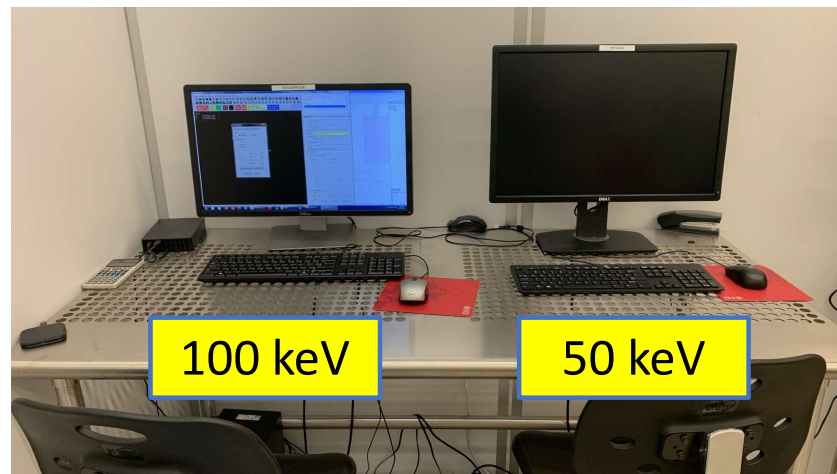
Preset Height and Height Sensor



Preset Height (offset)



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 lose reservation access or both

ELIONIX

Electron Beam Lithography

