HNU-EBL (V2.0) Manual

HNU-EBL Manual

Electron Beam Lithography(EBL) EDA tool

Developed by Hunan University(HNU)



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1 Overview

1.1 Application Scenario

Electron beam lithography (EBL) is an important technology for preparing highresolution nanolithography layout by micro-nano machining, which has a wide application prospects. However, the proximity effect in electron beam lithography will reduce the layout quality. Direct exposure without proximity effect correction will have a devastating impact on the resolution. Since the 1970s, the international lithography organization has begun to develop the proximity effect of electron beam lithography. Due to the high technical difficulty, there is no algorithm software that can be directly applied to large-scale engineering plate making in China, so it has independently developed the proximity effect correction software of electron beam lithography (HnuEBL V2.0).

Electron beam lithography (EBL) is a high-resolution mask-less direct-write lithography technology. Because the electron beam spot size is very small (e.g., 1-2 nm), EBL is capable of fabricating advanced patterns with sub-10 nm feature size. However, when exposing a small target region (blue area in the figure 1.1.1 below), the electron beam is scattered and reflected by the photoresist/substrate, leading to undesirable exposure of a large region (orange and green areas). This is called the proximity effect.

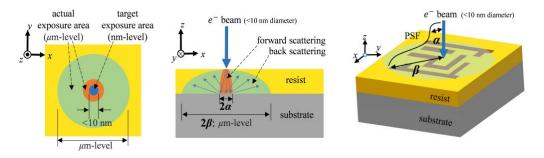


Figure 1.1.1 Proximity Effect

During EBL fabrication, proximity effect / fogging effect / loading effect jeopardizes the pattern fidelity. If they were not corrected, the fabricated pattern (second row in the figure below) will be drastically different from the target pattern (first row in the figure 1.1.2 below). Using the HNU-EBL software toolkit we developed at Hunan University (HNU), the electron beam dose distribution can be automatically corrected, such that the fabricated pattern (third row in the figure below) decently matches the target pattern.

Pattern of one layer of XOR circuit

Surface acoustic wave (SAW) device

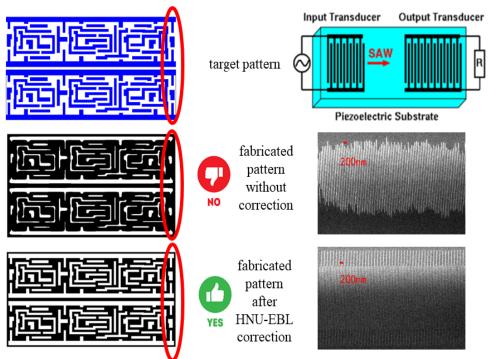


Figure 1.1.2 Layout optimization

The EBL-oriented EDA software tools are indispensable to design and manufacture EUV/DUV masks or sub-10 nm prototype devices. Some international treaties (e.g., 3.D.1-3 of Wassenaar Agreement [1]) and national laws (e.g., 3D003 of U.S. export control laws [2]) impose controls on exporting EBL-oriented EDA software tools to certain countries like China, Russian, etc. Therefore, we are trying to develop these EBL EDA tools from scratch by ourselves. We license HNU-EBL EDA software, free of charge, to anybody from anywhere.

So far, four articles have been published: 电子束光刻"自主可控"EDA 软件 HNU-EBL[3], Efficient Proximity Effect Correction Using Fast Multipole Method with Unequally Spaced Grid for Electron Beam Lithography [4], HNU-EBL: A Software Toolkit for Electron Beam Lithography Simulation and Optimization. [5], Ultrafast and Accurate Proximity Effect Correction of Large-Scale Electron Beam Lithography based on FMM and SaaS. [6]. Six patents: 一种基于神经网络的电子束临近效应矫正方法[7], 大规模电子束曝光版图的高精度邻近效应快速矫正方法[8], 一种基于二 维快速傅里叶变换的电子束曝光的邻近效应矫正方法[9], 一种电子束光刻邻近 效应矫正版图压缩方法[10], 一种基于快速多极子方法的电子束光刻邻近效应矫 正版图能量沉积计算方法[11], 一种基于边缘迭代的电子束光刻剂量形状校正方法[12]. Four software works: 基于 SaaS 模式的电子束曝光仿真与修正软件[13], 电子束光刻邻近效应矫正软件[14], GDSII 文件可视化软件[15], 电子束光刻仿 真计算 EDA 软件[16].

1.2 System Requirements

- Operating system: windows7 and above
- Hardware environment: CPU 1.7GHz, 4 cores, memory 2GB, video memory 2000M, hard disk 500M

1.3 License

You can double click the software to run, the authentication box will pop up, you can import the license address sent by the developer to the user, and click OK to run (as shown in Figure 1.3). (For obtaining the license, please contact the developer. For details, please visit www.ebeam.com.cn.).

Authentication	?	\times
Please import the license authorized by th	e devel	oper
Cancle	OK	
Figure 1.3 Authentication		

1.4 Functional Module

The software mainly includes four functional modules (as shown in Figure 1.4):

- Monte Carlo simulation module
- Proximity effect correction module
- Developing module
- Energy deposition module

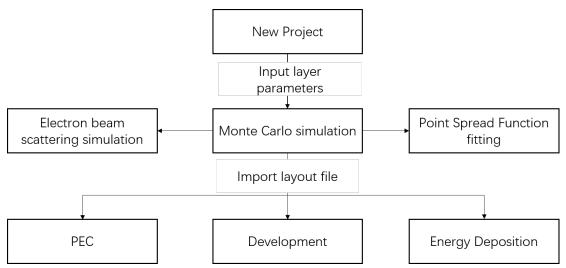


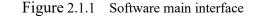
Figure 1.4 software function flow chart

2 Lithography Process Simulation

2.1 New project

(1) You can open the software and click the "File" and "New Project" to create a new project (Figure 2.1.1). You need to fill in the project name and a path to save the project (Figure 2.1.2). You can also click "Open Project" to open an existing project. (Note: The path can only contain English letters and symbols, not Chinese.)

C	HNU-EBL			-	\times
Fi	e Help				
	New Project	Alt+N	ergy Deposition	Development	
	Open Project	Alt+O			
1	Save Project	Alt+S			
	Close Project	Alt+C			
			_		



	?	×
[
Cancal		
	Cancal	

Figure 2.1.2 New project interface

2.2 Simulation Input Parameters

(1) You can click "New Simulation" at the top left of the main interface of the software, and a dialog box will pop up (Figure 2.2.1). The Monte Carlo (MC) simulation can be performed after setting the relevant parameters.

(2) You can enter the material name in "Material" (Figure 2.2.1), such as "PMMA, Si" (selected in the drop-down menu), and enter the layer thickness in "Thickness". The thickness of the "Layer n" layer should be 10nm to 5,000nm, and the thickness of the "Substrate" layer should be 1,000nm to 5mm. If there is no such material in the drop-down menu, you need to click "Edit Material" to add it(Figure 2.2.2). For example, SiC is added .(Figure 2.2.3)

(3) You can click "Insert Row" to add a layer at a specific location or click "Delete Row" to delete the specified layer. The layer sequence is as shown in the table, from top to bottom Layer 1, Layer 2, ..., layer n, Substrate. (Note: The total number of layers is not less than two and the Substrate layer cannot be deleted.)

(4) You can click "insert row" in "PSF depth" to increase PSF values of different depths, and click "delete row" to delete the last added depth. Note that the input PSF depth needs to be less than the maximum thickness of the photoresist, and the minimum spacing between different depths is 5nm.

(5) After adding all layers, you can input the simulated parameters related to electron beam lithography, such as "beam energy, beam diameter, number of electrons", and complete the parameter input setting. If the input parameters are incomplete, the software will prompt the user to improve the parameter input.

New Simulation			?	×
Simulation				
Stack Description				
Туре	Material		Tickness[nm]	
Layer1	PMMA	-		
Substrate	Si	•		
Inserst Row	Delet Ro	w	Edit material	
PSF Depth				
Туре	Depth[nm]		
Depth1				
Inserst Ro	w		Delet Row	
Parameters				
Beam Energy[٧٧]	5		
Beam Diamete	er[nm] 10			
Number of Ele	ctrons[ke-]	100		
Calculate	Stop Calcu	late	Cancel	

Figure 2.2.1 Parameter input interface

ayer S	ubstrate	
laterial		
Name	Mass Density(g/cm^3)	stoichiometry
PMMA	1.187999	H - C - O
HSQ	0.80998	H - O - Si
Ag	10.49	Ag
Au	8.96	Au
AI	2.702	Al
TiO2	4.23	O - Ti
AI2O3	3.7	O - Al
LiNbO3	4.6102	Li - O - Nb

Figure 2.2.2 Edit material parameter	interf	ace
🐵 Edit Material	?	×

Material Name	SiC
Mass Density(g/cm^3)	3. 2

Stoichiometry

_	Element	Count	
1	Si	1	
2	С	1	
			Add
			Delete

Figure 2.2.3 Adding SiC material parameter interface

2.3 Monte Carlo Simulation

(1) You can click "Calculate" to perform MC simulation. After the calculation

 \times

is completed, a dialog box will pop up to display the cost time. You can click "Done" to complete the MC simulation (Figure 2.3.1).

(2) When the program is running, you can click "Stop Calculate" to terminate (Figure 2.3.2). You can re-enter the parameters and click "Calculate" again to start MC simulation.

(3) After the MC simulation is completed, you can click "Save Project" in the "File" at the top of the main interface of the software to save the simulation results (Figure 2.3.3). (Note: Please click the "Save Project" button to save the project in time.)

(4) You can right-click the MC simulation result on the left and left-click "delete" to delete the MC simulation result(Figure 2.3.4).

New Simulation				?	
Simulation					
Stack Description					
Туре	Material		Tickness[nm	1	
Layer1	Layer1 PMMA		20		
Substrate	Si	•	10000		
Inserst Row	Delet R	low	Edit m	aterial	
PSF C Infromat	ion			×	
De Calculation Done! Cost time: 3.026 s					
Inserst F	Row		Delet Row	/	
Parameters					
Beam Energy	[kV]	5	5		
Beam Diamet	er[nm]	1	0		
Number of Electrons[ke-] 100					
Calcul	ate Stop Cal	cula	teCancel]	

Figure 2.3.1 Monte Carlo calculation interface

New Simulation			?	\times		
Simulation						
Stack Description						
Туре	Material	Tic	kness[nm]			
Layer1	PMMA -	- 20				
Substrate	Si	- 1000	00			
Inserst Row	Delet Ro	w	Edit mater	ial		
PSF Depth 💿 W	arning		×			
Typ Depth1 Calculation has stopped.						
Inserst R	low		Yes Delet Row			
Parameters						
Beam Energy	[kV]	5				
Beam Diamet	er[nm]	10				
Number of Electrons[ke-] 100						
Calculate Stop Calculate Cancel						

Figure 2.3.2 Terminate Monte Carlo calculation interface

	HNU-EBL			
File	e Help			
	New Project	Alt+N	ergy Deposition	Development
	Open Project	Alt+O		
	Save Project	Alt+S		
	Close Project	Alt+C		
+	PMMA_20_Si_10000	5_10_10	5	

Figure 2.3.3 Save Monte Carlo calculation results interface

File Help	
New Simulation PEC-FEC Energy Deposition Development	
project: hnu.hnu PMMA 10 Si 10000 5 10 100 PMMA 20 Si 10000 delete PSF_depth_100nm delete PSF_depth_300nm Trajectories PMMA_50_Si 10000_5_10_100 PMMA_20_Si_10000_5_10_100 <li< td=""><td></td></li<>	

Figure 2.3.4 Delete Monte Carlo calculation result interface

2.4 Point Spread Function Fitting

(1) You can click the triangle symbol on the left of the corresponding MC simulation result to display the MC simulation result (Figure 2.4.1).

(2) You can click "PSF" at different depths to display the fitting results of four kinds of point spread functions (double Gauss, double Gauss + index, three Gauss, and three Gauss + index (as shown in Figure 2.4.2)). For the convenience of observation, take a logarithm to display the X and Y coordinates.

(3) You can click "linear" on the right to display the fitting results when the X coordinate is linear; Click "log" on the right to display the fitting results when taking the logarithm of the X coordinate.

(4) You can zoom in and out by scrolling with the mouse wheel or dragging with the left mouse button.

(5) You can click "export" (as shown in Figure 2.4.1) to export the scatter coordinate file.

(6) If you need to check the fitting coefficient of the corresponding Monte Carlo simulation results, left-click the PSF_depth_x corresponding Monte Carlo simulation results can be viewed by right-clicking "detail".(as shown in Figure 2.4.3)

(7) In the fitting coefficient interface of viewing the corresponding Monte Carlo simulation results (as shown in figure 2.4.4), you can select a formula and change the coefficient. Click "redraw" to view the fitting results of the point spread function after changing the coefficient. (Note: the input value of coefficient cannot

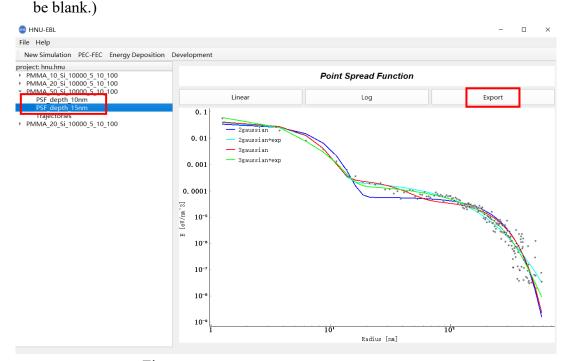


Figure 2.4.1 Point spread function fitting interface

$$f = \frac{1}{\pi(1+\eta)} \left(\frac{1}{\alpha^2} e^{-\frac{x^2}{\alpha^2}} + \frac{\eta}{\beta^2} e^{-\frac{x^2}{\beta^2}} \right)$$
(1)

$$f = \frac{1}{\pi(1+\eta+\nu_2)} \left(\frac{1}{\alpha^2} e^{-\frac{x^2}{\alpha^2}} + \frac{\eta}{\beta^2} e^{-\frac{x^2}{\beta^2}} + \frac{\nu_2}{2\gamma_2^2} e^{-\frac{x}{\gamma_2}} \right)$$
(2)

$$f = \frac{1}{\pi(1+\eta+\nu)} \left(\frac{1}{\alpha^2} e^{-\frac{x^2}{\alpha^2}} + \frac{\eta}{\beta^2} e^{-\frac{x^2}{\beta^2}} + \frac{\nu}{\gamma^2} e^{-\frac{x^2}{\gamma^2}} \right)$$
(3)

$$f = \frac{1}{\pi(1+\eta+\nu+\nu_2)} \left(\frac{1}{\alpha^2} e^{-\frac{x^2}{\alpha^2}} + \frac{\eta}{\beta^2} e^{-\frac{x^2}{\beta^2}} + \frac{\nu}{\gamma^2} e^{-\frac{x^2}{\gamma^2}} + \frac{\nu_2}{2\gamma_2^2} e^{-\frac{x}{\gamma_2}} \right)$$
(4)

Figure 2.4.2 Fitting formula

HNU-EBL
File Help
New Simulation PEC-FEC Energy Deposition
project: hnu.hnu
PMMA_10_Si_10000_5_10_100
PMMA 20 Si 10000 5 10 100
PMMA 50 Si 10000 5 10 100
PSF_depth_10nm
PSF_depth_1 details
Trajectories
PMMA_20_Si_10000_5_10_100

Figure 2.4.3 View the fitting coefficient interface of Monte Carlo simulation results

🕮 Infomatio	n		?	×
Point S	pread Function			
3 Gauss	ion function + exp	function		•
$f = \frac{1}{\pi(1+\eta)}$	$\frac{1}{(1+\nu+\nu_2)}\left(\frac{1}{\alpha^2}e^{-\frac{x^2}{\alpha^2}}+\frac{\eta}{\beta^2}\right)$	$\frac{1}{2}e^{-\frac{x^2}{\beta^2}} + \frac{v}{\gamma^2}e^{-\frac{x^2}{\gamma^2}} + $	$-\frac{\nu_2}{2\gamma_2^2}e^{-\frac{\nu_2}{2\gamma_2^2}}e^{-\frac{\nu_2}{2\gamma_2$	$\frac{x^2}{\gamma_2}$
α (nm) :	5. 17334			
β (nm) :	169.822			
η :	0. 922916			
γ (nm) :	13. 419			
ν:	0. 61119			
$\gamma 2 (nm)$:	59.328			
v2:	1. 3296			
	Redraw	Cancel]	

Figure 2.4.4 Change the fitting coefficient and redraw the interface

2.5 Electron Beam Trajectory Visualization

(1) You can click the triangle symbol on the left of the corresponding MC simulation result to display the MC simulation result.

(2) You can click "Trajectories" to display the electron beam scattering simulation results (Figure 2.5.1). For the convenience of observation, the red marking lines are the layer names and thicknesses of all layers except the substrate in the corresponding MC simulation.

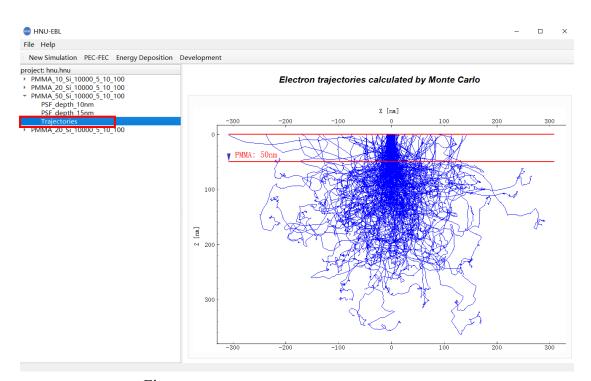


Figure 2.5.1 Electron beam scattering fitting interface

3 Optimization And Measurement Of Lithography Layout

3.1 Proximity effect correction

(1) You can click "PEC-FEC" on the toolbar at the top of the main interface (Figure 2.6.1) to complete the settings of PEC and fogging effect correction (FEC).

(2) Set "PSF results set" and select a group of Monte Carlo calculation results for proximity effect correction.

(3) Based on (2), you can select a PSF depth value of depth.

(4) Based on (3), you can select the formula "PSF parameters" to be fitted, and select the three Gauss formulas in the figure below to correct the proximity effect.

(5) If the atomization effect needs to be considered, check the "fogging effect" and fill in the parameters. If you do not need to consider the atomization effect, ignore it directly. (6) You can select the PEC function "PEC method", and click the drop-down box to display three functions: dose correction, shape correction, and dose_ shape correction, the first method has high precision, but the lithography machine is required to have the ability to change the beam energy and has high requirements for resolution. The second method has low accuracy, but only requires a single intensity of energy for exposure, which is suitable for lithography machines that cannot change the dose. The third method has high accuracy and requires less memory. Move the mouse (note not click) to "?" A prompt message is displayed.

(7) In the "Matrix set" you can set the minimum size (nm) of the exposure unit. And 10nm is selected in the figure below. (Note: If the layout is large, the minimum size of the exposure unit should not be too small. If the size is too small and the computer memory is insufficient, a prompt will be given.)

(8) "GDSII File" is used to open the ".gds" format layout to be corrected. (Note:The path can only contain English letters and symbols, not Chinese.)

(9) "Result Folder" is used to set the output file path after the PEC is completed.

(Note: The path can only contain English letters and symbols, not Chinese.)

PSF Results	PEC Method dose correction ?
PSF Depth	Matrix Set Grid size on EBL pattern(nm): 5
PSF Parameters 3 gaussion \checkmark $\alpha: 5.5937$ $\beta: 186.26$ $\eta: 1.14677$	GDSii File C:/Users/30264/Desktop/xor.gds Result Folder C:/Users/30264/Desktop
γ: 33.6574 ν: 0.211865 Fogging Effect	Structure Set Choose Structures: TEST Choose layers: Layer61 Calculate Stop Calculate Done

Figure 3.1.1 Set PEC interface

(10) A GDSII file can contain multiple structures, and a structure can contain multiple layers. If users only want to perform PEC on part of the layout in the file, they can click on the "structure set" at the bottom of the page to further set the layout to be corrected. But you must select at least one for "Structure" and at least one for "Layer" (Figure 3.1.2 ((top)). If multiple "Structure" has been selected, you cannot select "Layer" again (Figure 3.1.2 (bottom)).

struct	ture set					
	Choose structures:	TEST	•	Choose layers:	.ayer0;Layer1	•
					✓ ALL✓ Layer0✓ Layer1	
struct	ture set					
	Choose structures:	TEST; TEST2	-	Choose layers:		-
		 ✓ ALL ✓ TEST ✓ TEST2 				

Figure 3.1.2 Set the layout to be corrected

(11) You can click "Calculation" (Figure 3.1.3) to perform PEC. If the input parameters are incomplete, the calculation cannot be started. The calculation time is displayed after the calculation is completed (Figure 3.1.4). After the calculation is completed, you need to click "Done" to close the current window, and you can save the output file to the specified folder.

(12) You can click "stop calculation" to abort the current calculation (as shown in figure 3.1.5).

PEC-FEC	? ×
PSF Results	PEC Method dose correction ?
PSF Depth 15	Matrix Set Grid size on EBL pattern(nm): 5
PSF Parameters 3 gaussion α: 5.5937 β: 186.26 η: 1.14677	GDSii File Calculating ? × CalculatingPlease wait a moment
γ: 33.6574 γ: 0.211865	Structure Set
Fogging Effect $\gamma_F(nm)$:	Choose Structures: TEST Choose layers: Layer61
v_F:	Calculate Stop Calculate Done

Figure 3.1.3 Proximity effect correction calculation interface

PEC-FEC	? ×
PSF Results PMMA 50 Si 10000 5 10 100 💌	PEC Method dose correction ?
PSF Depth 15	Matrix Set Grid size on EBL pattern(nm): 5
PSF Parameters 3 gaussion α: 5.5937 β: 186.26 η: 1.14077	GDSii File fromation PEC Calculation Done! Cost Time: 1.285 s OK
γ: 33.6574 ν: 0.211865	Structure Set Choose Structures: TEST Choose layers: Layer61
Fogging Effect γ_F(nm): ν_F:	Calculate Stop Calculate Done

Figure 3.1.4 Proximity effect correction calculation completion interface

PEC-FEC	? ×
PSF Results PMMA 50 Si 10000 5 10 100	PEC Method dose correction ?
PSF Depth 15	Matrix Set Grid size on EBL pattern(nm): 5
PSF Parameters 3 gaussion \checkmark $\alpha: 5.5937$ $\beta: 186.26$ $\eta: 1.14677$	GDSii File Warnning × … PEC calculation has stopped. OK …
γ: 33.6574 ν: 0.211865	Structure Set Choose Structures: TEST Choose layers: Layer61
Fogging Effect γ_F(nm): ν_F:	Calculate Stop Calculate Done

Figure 3.1.5 Termination proximity effect correction calculation interface

3.2 Development

(1) You can click "development" on the toolbar at the top of the main interface to start the development calculation (as shown in Figure 3.2.1).

(2) You can select a calculated PSF value under a certain parameter in "PSF result".

(3) Based on (2), you can select the PSF value of a certain depth.

(4) Based on (3), you can select a group of models for fitting and development calculation. The three Gaussian models is selected below for a demonstration.

(5) If the atomization effect needs to be considered, check the "fogging effect" and fill in the parameters. If the atomization effect does not need to be considered, it can be ignored directly.

(6) "Matrix set" sets the minimum size (nm) of the exposure unit for correction division, and 5nm is selected in the following figure. (Note: if the layout is large, the minimum size of the exposure unit should not be too small. If the size is too small and the computer memory is insufficient, a prompt will be given.)

(7) "Resist model" selects the development model. There are three models:

threshold, Mack, and notch (as shown in Figure 3.2.2). Threshold model: set a threshold range from 0 to 1. The position where the normalized value of the exposed layout is greater than the threshold displays 1, and vice versa is 0. Mack model [17]: "resist type" indicates whether to select positive resist or negative resist. "Rmax, Rmin" indicates the maximum and minimum development rates. "Mth" standard configuration is the threshold concentration of resist. "N" is the dissolution selectivity parameter. "Dill_c" indicates the exposure rate constant. When the concentration of "notch" is [u] #n, it indicates the strength of the pitting resistance. For the detailed formulas of the latter two development models, see references.

(8) "GDSII file" opens the calculated layout GDS format. (Note: the path can only contain English letters and symbols, not Chinese.)

(9) You can click "calculation" (as shown in Figure 3.2.2) to calculate the edge position error. If the input parameters are incomplete, the calculation cannot be started. There is a prompt box after calculation (as shown in Figure 3.2.3). After calculation, click "done" to close the current window.

(10) You can click "stop calculation" to abort the current calculation (as shown in Figure 3.2.4).

Development	? ×
PSF Results	Matrix Set Grid size on EBL pattern(nm): 2
PSF Depth	Resist Model Threshold
PSF Parameters 3 gaussion \checkmark α (nm) : 5.26534 β (nm) : 146.337	Threshold[0-1]: 0.8
η: 1.07489	GDSII File
$\gamma(nm)$: 31.3554	C:/Users/30264/Desktop/xor.gds
ν: 0.266634	Structure Set
Fogging Effect γ_F(nm): ν_F:	Choose Structures: TEST Choose layers: Layer61 Calculate Stop calculate Done

	Fi	gure	3.2.	1 c	leve	lopmer	it oper	ration	interf	ace
--	----	------	------	-----	------	--------	---------	--------	--------	-----

sist Model	
Threshold 💌	
Threshold[0-1]: 0.9	
sist Model	
Mack 👤	
Resist Thickness[nm]: 20	Rmax[nm/s]: 411.9163
Development Times[s]: 10	Rmin[nm/s]: 0. 45993
Exposure Dose[uc/cm2]: 10	Mth: 0.88619
Resist Type	n: 0. 50248
✓ Positive Negative	Dill_C: 0.000416;
esist Model	
Notch 💌	
Resist Thickness[nm]: 20	Rmax[nm/s]: 487.9162
Development Times[s]: 20	Rmin[nm/s]: 0.34218
	Mth norch: 0. 88049
Exposure Dose[uc/cm2]: 10	With_noren. 0.00045
Exposure Dose[uc/cm2]: 10 Resist Type	n: 0. 9272
	-

Figure 3.2.2 three development models

Development	? ×
PSF Results PMMA 20 Si 10000 5 10 100 💌	Matrix Set Grid size on EBL pattern(nm): 2
PSF Depth	Resist Model Threshold
PSF Parameters 3 gaussion α (nm) : 5.26534 β (nm) : 146.337 η : 1.07489 γ (nm) : 31.3554	Arnning × Development calculation has stopped. OK GDSII File C://Users/30264/Desktop/xor.gds
ν: 0. 260634 Fogging Effect γ_F(nm): ν_F:	Structure Set Choose Structures: TEST Choose layers: Layer61 Calculate Stop calculate Done

Figure 3.2.3 interface for terminating calculation of edge position error

(11) After the calculation of the edge position error is completed, you can click"OK" in the dialog box in Figure 3.2.3 to automatically pop up the dialog boxdisplaying the calculation results of the layout edge position error (as shown in Figure 3.2.4). (Note: the layout containing only text pixels cannot calculate the edge position error.)

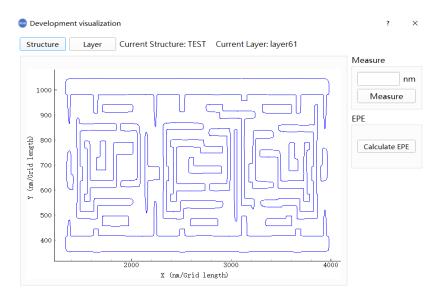


Figure 3.2.4 edge position error interface

(12) You can click "structure" above to select the edge position error of any structure (as shown in figure 3.2.5), and the first structure is displayed by default. Multiple structures cannot be selected for display.

🕮 structure in	formation	?	×
	Structure		
	TEST		
	TEST2		
	ОК	Cancel	

Figure 3.2.5 structure selection interface

(13) You can click "layer" above to select the edge position error of any layer (as shown in figure 3.2.6). The first layer is displayed by default. Note that only one layer can be selected.

on	?	×
Layer		
layer0		
layer1		
ОК	Cancel	
	Layer layer0 layer1	Layer layer0 layer1

Figure 3.2.6 layer selection interface

(14) You can click "measure" and two points will appear in the center of the left side of the interface. After moving the two points, click "measure" and the distance between the two points will be displayed. After each move, click "measure" to display the gap between the two points (as shown in figure 3.2.7).

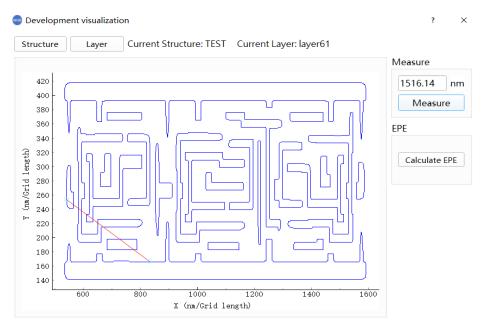
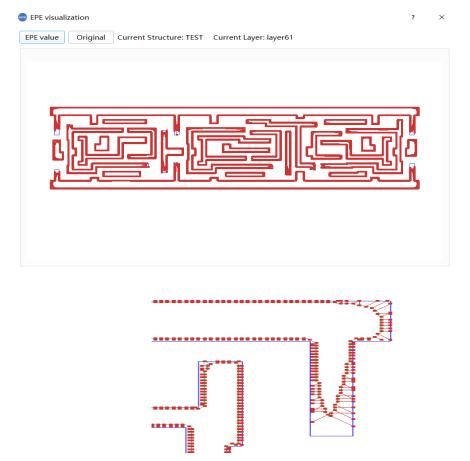


Figure 3.2.7 measuring the distance between two points

(15) You can click "calculate EPE" to calculate the EPE result of the current layout and support dragging and zooming in (as shown in figure 3.2.8). Click "EPE value" to display the information of the current EPE (as shown in figure 3.2.9). Click "original" to return to the original location.



information		?	×
Total EPE value			
Current Structure:	Т		
EPE value (nm):			
		(ок

Figure 3.2.8 EPE effect diagram

Figure 3.2.9 basic information on EPE

3.3 Energy Deposition

(1) You can click "energy deposition" on the toolbar at the top of the main interface to start the settings related to calculating energy deposition (as shown in Figure 3.3.1).

(2) Select the results of different parameters after calculation in "PSF result".

(3) After (2) selection, you can select the PSF depth value to be viewed in "PSF depth".

(4) After (3) selection, you can select the formulas to be fitted, and select the three Gauss formula for energy deposition calculation in the figure below.

(5) If you need to consider the atomization effect, you can enter parameters after checking the "fogging effect". If you don't need to consider the atomization effect, you don't need to check it and ignore it directly.

(6) "Matrix set" is set to calculate the minimum size of the divided exposure unit (nm), and 5nm is selected in the following figure. (Note: if the layout is large, the minimum size of the exposure unit should not be too small. If the size is too small and the computer memory is insufficient, a prompt will be given)

(7) "GDSII file" opens the calculated GDS format layout. (Note: the path can only contain English letters and symbols, not Chinese.)

(8) You can click "calculation" (as shown in Figure 3.3.1) to calculate the energy deposition. If the input parameters are incomplete, the calculation cannot be started. There is a prompt box after calculation (as shown in Figure 3.3.2). After calculation,

click "done" to close the current window.

(9) You can click "stop calculation" to abort the current calculation (as shown in Figure 3.3.3).

ENERGY	? ×
PSF Results PMMA 50 Si 10000 5 10 100 ▼	Matrix Set
PSF Depth 15	Grid size on EBL pattern(nm): 5
PSF Parameters	GDSii File
$\boxed{\begin{array}{c} 3 \text{ gaussion} \\ \hline \\ \alpha(nm): 5.5937 \\ \beta(nm): 186.26 \end{array}}$	C:/Users/30264/Desktop/xor.gds
η: 1.14677	Structure Set
γ(nm): 33.6574 ν: 0.211865	Choose Structures: TEST 💌 Choose layers: Layerôl 💌
Fogging Effect $\gamma_F(nm)$: ν_F :	Calculate Stop Calculate Done

Figure 3.3.1 calculation of energy deposition interface

ENERGY	? ×
PSF Results	Matrix Set
PMMA 50 Si 10000 5 10 100 💌	
PSF Depth	Grid size on EBL pattern(nm): 5
15 💌	
PSF Parameters	GDSii File
3 gaussion	tion ×
α (nm): 5.5937	Energy Deposition Calculation Done!
β (nm) : 186.26	ОК
η: 1.14677	
$\gamma(nm)$: 33.6574	
ν: 0.211865	Choose Structures: TEST 🔹 Choose layers: Layerô1 💌
Fogging Effect	
γ_ <i>F</i> (nm):	Coloulate Stee Coloulate Dans
v_F:	Calculate Stop Calculate Done

Figure 3.3.2 calculation of energy deposition completion interface

energy	? ×
PSF Results	Matrix Set
PMMA 50 Si 10000 5 10 100 💌	
PSF Depth	Grid size on EBL pattern(nm): 5
15 💌	
PSF Parameters	GDSii File
3 gaussion 💿 Warnning	×
α(nm): 5.5937	ergy Deposition calculation has stopped.
β (nm): 186.26	ОК
η: 1.14677	
$\gamma(nm)$: 33.6574	
ν: 0.211865	Choose Structures: TEST Choose layers: Layer61
Fogging Effect	
γ <i>F</i> (nm):	
v_F:	Calculate Stop Calculate Done

Figure 3.3.3 energy deposition interface of termination calculation

(10) Figure 3.3.3 terminate the calculation of the energy deposition interface. After the energy deposition calculation is completed, click "OK" in the dialog box in Figure 3.3.3 to automatically pop up the dialog box displaying the layout energy deposition calculation results (as shown in figure 3.3.4).(Note: the layout containing only text pixels cannot calculate the energy deposition; when the dose corresponding to the graphics is all 0, the calculation results cannot be displayed.)

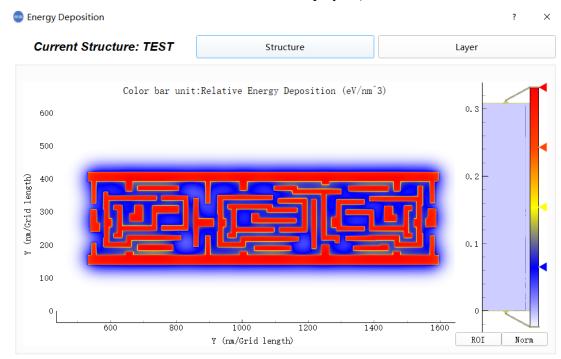


Figure 3.3.4 interface of energy deposition calculation results

(11) You can click "structure" on the upper right to select and display the energy deposition of a structure (as shown in Figure 3.3.5), and the first structure is displayed by default. Multiple structures cannot be selected.

structure inf	ormation	?	×
	Structure		
	TEST		
	TEST2		
	ОК	Cancel	

Figure 3.3.5 structure selection interface

(12) You can click "layer" on the upper right to select the energy deposition of any layer (as shown in figure 3.3.6). All layers are displayed by default. Multiple layers can be selected for display.

iayei	r information	?	×
All Lay	vers		
	Layer		_
	Layer0		
	Layer1		
V	Layer2		
	Layer3		

OK Ca

Figure 3.3.6 layer selection interface

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