Describe User Manual

Version of 2024-11-18.

1. Introduction

Describe is a powerful slicing and hatching tool used to convert 3D structures from .STL (standard tessellation language) format to the internal language of the Nanoscribe Photonic Professional GT laser writer. It also offers a robust coding environment to mathematically program 3D trajectories from scratch and implement loops for the optimisation of the printing parameters.

2. How to create an .STL file

The CMi staff will not help you to generate and debug the .STL file of the 3D object you want to print.

Many 3D computer-aided design (CAD) programs can export to the .STL format. Among these, you may want to learn and use AutoCAD, Solidworks, Blender, etc.…

A more complete list, including free and open-source software can be found here: https://en.wikipedia.org/wiki/STL_(file_format)

Describe is only compatible with the .STL file format and will not handle other 3D objects formats such as .3MF, .AMF, .PLY, .OBJ, .DWG, etc.…

IMPORTANT: When designing your 3D structure, make sure that the object base lies on the Z=0 plane. Describe will assume that the z=0 plane is the resist/wafer interface and the laser writer will start writing from there.

3. Describe Installation

Describe is available to all CMi users that are getting trained on the Nanoscribe PPGT+.

Please contact the photolithography staff to request the access to the Describe installation binaries and obtain licensing information.

4. What is Describe doing?

Describe will convert your 3D structures into trajectories that the laser will expose to polymerize the photoresist.

With the default meshing mode, the 3D writing sequence works like this: the laser starts from the interface with the substrate (default) and scans the volume in x- and y- directions in the z=0 plane, in straight continuous lines (hatches) or circular continuous lines (contours). Once the plane in finished, the z-axis is moved to the next plane (slice). The distance between each z-coordinate is called the slicing distance. The contour distance, hatching distance and slicing distance will all effect the total writing time of your structure.

What parameters should I choose?

A single shot with the laser at a fixed position will polymerize a small volume of photoresist that we call the voxel. The voxel dimension depends mainly on the objective magnification, the laser power and the type of photoresist.

Typical voxel dimensions:

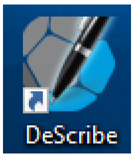
Objective	*x- y- diameter*	*z- height*
63x	*<200nm*	*<700nm*
25x	*<600nm*	*<3um*
10x	*<1200nm*	*<6um*
20x (air)	*<800nm*	*<5um*

In standard applications, hatching (in x- y- directions) and slicing distances should be chosen to make sure some overlap (typ. 50%) exists between adjacent voxels to provide a uniform polymerization to the photoresist. Please note that the laser power and the scan speed will also influence the degree of polymerization and should be adjusted based on hatching/slicing distances.

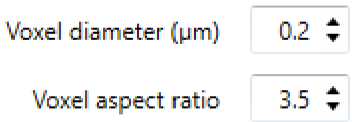
5. The .STL import wizard

This section describes how to import an .STL file and generate the necessary output files to use on the Nanoscribe Photonic Professional GT.

- Start DeScribe!



- File → Open → Select your .stl file
- The Import STL window will pop-up displaying the 3D preview on the left and the “Model” window on the right.
- The 3D preview can be moved and rotated by holding left and right mouse buttons, and zoomed using the mouse wheel.
- First go to options and, in the “3D Preview” tab, enter the Voxel diameter according to the table above and set the aspect ratio to 3.5. This will give you a more representative view of what will be printed.



Model Window:

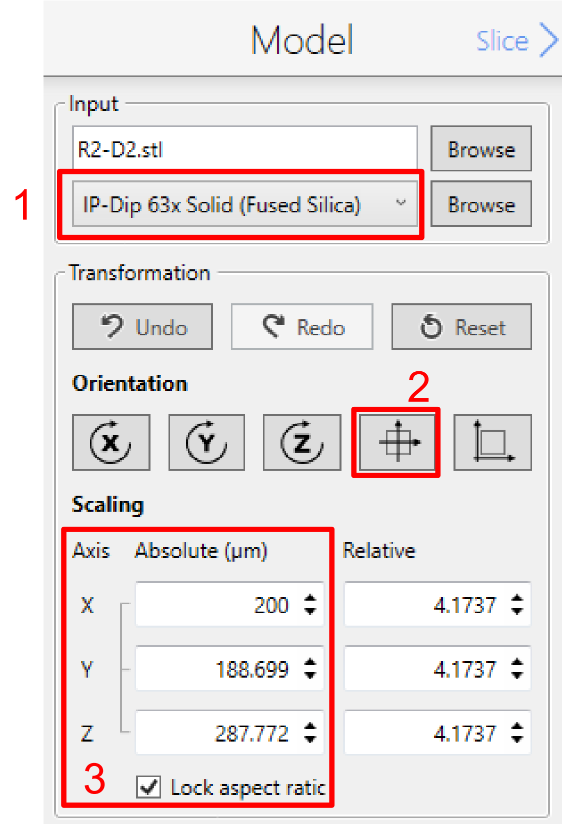
In the “Model” window:

1→ Predefined recommendations for slicing & hatching parameters for different objectives and configurations. All parameters can be edited later.

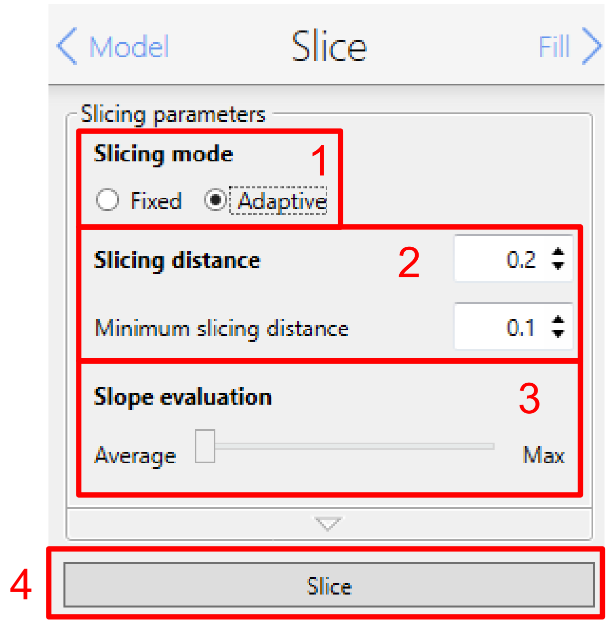
2→ Center the structure around (x,y) = (0,0)

3→ Scaling of the structure

- When the rotation, positioning and scale parameters are ok, click on 



Slice Window:



In the “Slice” window:

1→ Select between fixed slicing distance or adaptive slicing distance The adaptive mode will reduce the slicing distance to smooth staircases for structure with important slopes.

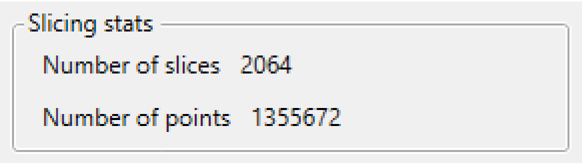
2→ Set fixed/maximum and minimum slicing distance in [um].

3→ Slider to adjust the sensitivity of the adaptive mode. Play with this to see the effect on the 3D model.

4→ Always press "Slice" after any modification to see the effect on the 3D model.

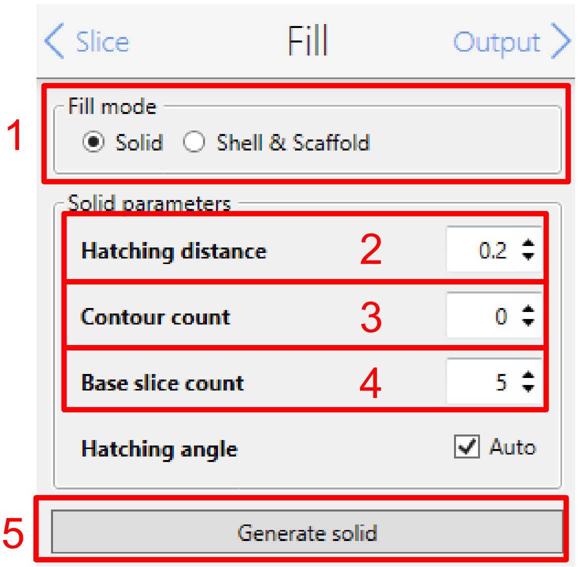
- *Slicing distance recommendations*:
  - ***63x / IP-Dip:*** 0.3 um
  - ***25x / IP-S:*** 1 um
  - ***10x / IP-Q:*** 5 um

- Always have a look at the Slicing stats window to see the number of slices.



- When the slicing parameters look fine, click on

Fill Window:



1→ Select between "Solid" (structure interior is fully written) or "Shell & Scaffold" (structure interior is only partially written) filling modes.

2→ Distance between each line scanned by the laser in [um].

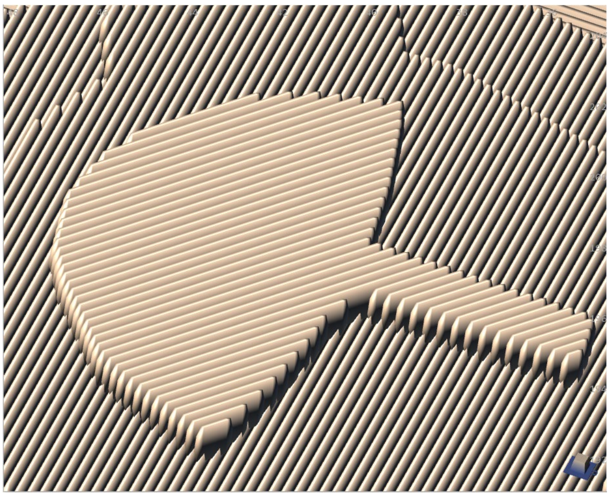
3→ Number of lines that will follow the contour of the structures (instead of straight lines) for smoothing.

4→ Number of bottom (base) slides to be written with the minimum hatching distance for stability.

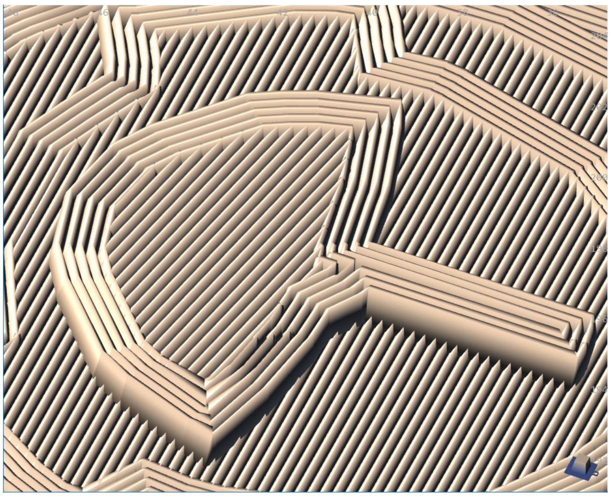
5→ Always press "Generate solid" after any modification to see the effect on the 3D model.

- *Hatching distance recommendations*:
  - ***63x / IP-Dip:*** 0.2 um
  - ***25x / IP-S:*** 0.5 um
  - ***10x / IP-Q:*** 1 um

- *Contour effect:*



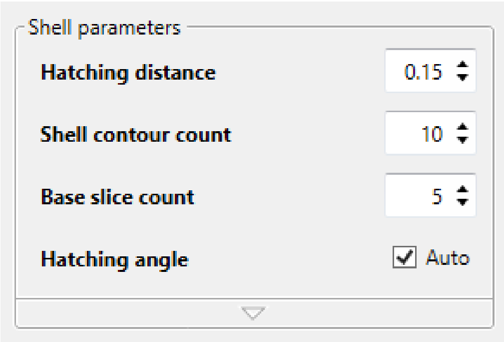
Hatching without contour (Contour count 0)



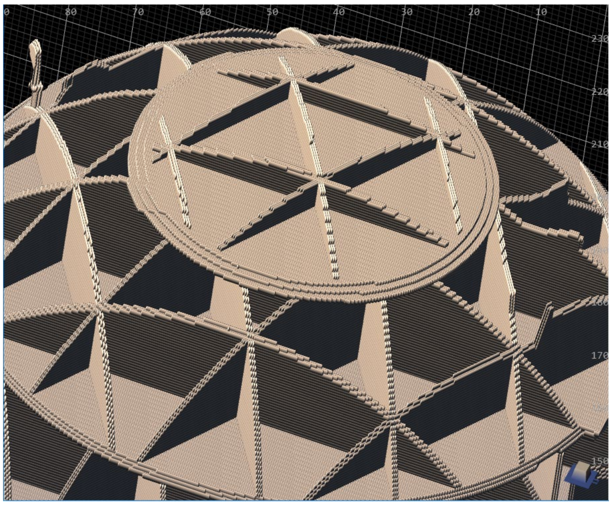
Hatching with contour (Contour count 5)

- *Shell & Scaffold Mode*

In "Shell & Scaffold", the walls (shell) and the interior (scaffold) of the 3D structure will be written differently. The shell of the structure will be written just like the contour and it should be strong enough to maintain the structure. It is generally recommended to increase the contour count and reduce the hatching distance in this case.



Scaffold Window:



Scaffold exemple

This window will be used to define how the interior is exposed. Different modes are available.

1→ Hatching distance for the scaffold

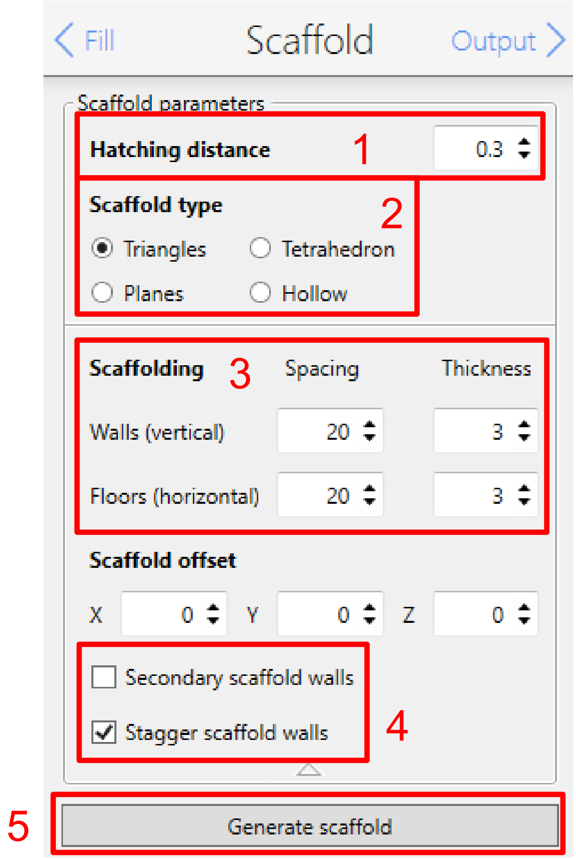
2→ Scaffold type (hollow = empty)

3→ Distance between walls/floors and thickness of walls/floors (number of lines)

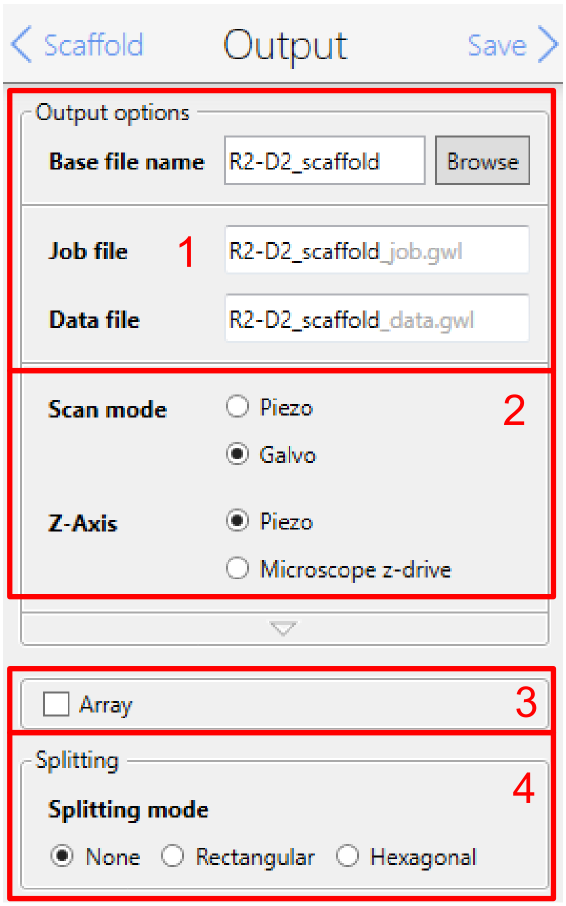
4→ Additional strengthening options

5→ Always press "Generate scaffold" after any modification to see the effect on the 3D model.

- When the scaffold parameters look fine, click on Output >



Output Window:



1→ Naming output files.

2→ Writing modes: 1) **Scan mode: Galvo is preferred** as it is much faster (100x). Piezo mode is more accurate can be used with small structures only when higher precision/smoothness is needed. 2) **Z-Axis: Piezo is preferred** but splitting/stitching will appear for structures higher than 300um (piezo z- travel range), Microscope z-drive can be considered if stitching is extremely problematic.

3→ Creating arrays of structures.

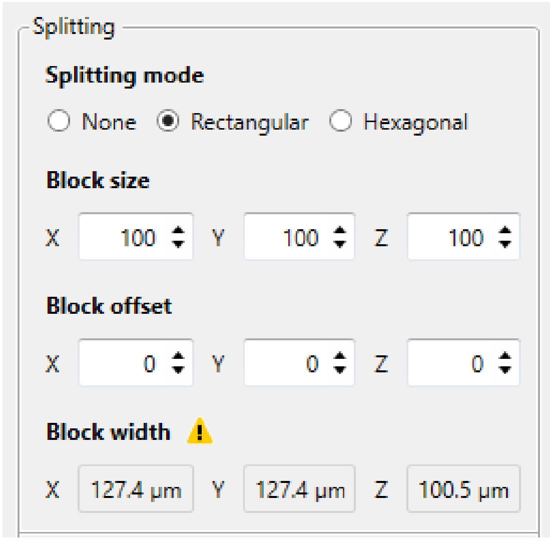
4→ Splitting of the structure. Splitting will be necessary when the structure extend the Galvo/Piezo scanning ranges.

The table below list the limits where splitting needs to be activated

Objective	*x- y- dimension*	*z- height*
63x	***ϕ > 200um (Galvo)*** *D > 300um (Piezo)*	*> 300 um (piezo)* *No limit (z-drive)*
25x	***ϕ > 400um (Galvo)*** *D > 300um (Piezo)*	*> 300 um (piezo)* *No limit (z-drive)*
10x	***ϕ > 800um (Galvo)*** *D > 300um (Piezo)*	*> 300 um (piezo)* *No limit (z-drive)*
20x (air)	*ϕ > 600um (Galvo)* *D > 300um (Piezo)*	*> 300 um (piezo)* *No limit (z-drive)*

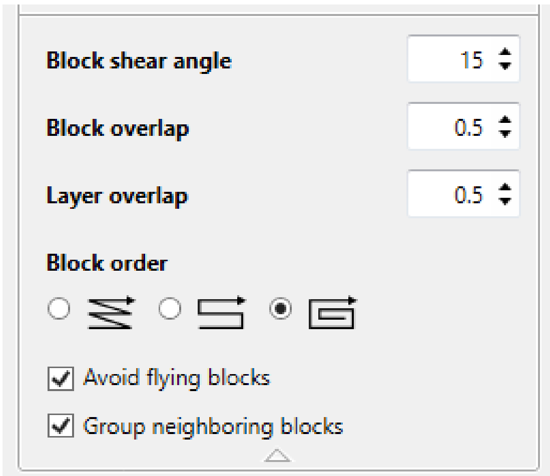
The Piezo mode is limited to the movement range of the piezo stage which is 300 um in all directions. The Galvo mode does not have a hard limit but laser intensity and aberration will start to be an issue at a certain distance from the objective axis (0,0).

- *Splitting*



Use this window to define the shape, dimension and positions of all writing blocks. Moving between blocks will require movement with the coarse stage (x-axis, y-axis) and microscope z-drive (z-axis).

- *Stitching options:*



Use this window to define the stitching options (shear angle, overlaps, block writing orders, etc.…). Block shear angle is recommended between 15 and 30 degrees.

- When all of this is done, click Save
- The "code" window will be populated. This is your actual exposure job.

R2-D2_test_job.gwl

```
% File generated by DeScribe 2.5.2

% System initialization
InvertZAxis 1

% Writing configuration
GalvoScanMode
ContinuousMode
PiezoSettlingTime 10
GalvoAcceleration 2
StageVelocity 200

% Scan field offsets
XOffset 0
YOffset 0
ZOffset 0

% Writing parameters
PowerScaling 1.0

% Solid hatch lines writing parameters
var $solidLaserPower = 40
var $solidScanSpeed = 10000

% Base writing parameters
var $baseLaserPower = $solidLaserPower
var $baseScanSpeed = $solidScanSpeed

var $interfacePos = 0.5

% Include slicer output
include R2-D2_test_data.gwl
```

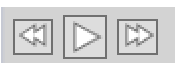
The important parameters to modify are listed below.

- *"InvertZaxis"* : Should be set to "1" when writing in DILL mode, should be set to "0" when writing in immersion mode.

```
% System initialization
InvertZAxis 1
```

- *"LaserPower"* and *"ScanSpeed":* These two parameters define the laser scanning conditions. Typical starting values:
  - ***63x / IP-Dip:*** LaserPower = 40, ScanSpeed = 10000
  - ***25x / IP-S:*** LaserPower = 70, ScanSpeed = 50000
  - ***10x / IP-Q:*** LaserPower = 90, ScanSpeed = 100000

```
% Solid hatch lines writing parameters
var $solidLaserPower = 40
var $solidScanSpeed = 10000
```

- *"FindInterfaceAt"* (var $interfacePos): The position of the interface in the z-axis system im [um]. It is recommended to have a value >0 (typical 0.5) to start writing inside the wafer and make sure to have a good adhesion.
- For other commands and variables, check the "Command Reference" window or ask the staff.
- Press "F5" to generate the 3D Preview.
- You can visualize the writing process by pressing 

- Check the estimation for the total printing time (bottom right of the 3D preview window).

00:24:07 / 00:44:20

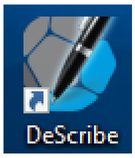
- If the time seems reasonable, you files are ready for writing! You should transfer the following 2 files and 1 folder to the Nanoscribe computer:

***_data.gwl**	file
***_job.gwl**	file
***_files**	folder

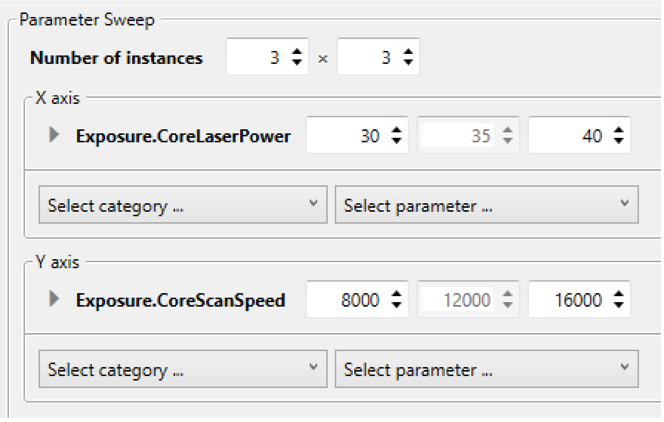
6. Advanced import options for parameter sweeps.

This section describes how to perform a laser power and scan speed optimization matrix from your .STL and job file. Before doing this, it is necessary to create job files using the standard conversion described in point 4. This will create a recipe for slicing and hatching parameters that you can now use.

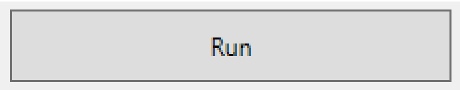
- Start DeScribe!



- File → Advanced STL Processing
- In "Source file", browse for your .STL file.
- In "Processing parameters", browse for your .recipe file.
- In the "Parameter Sweep" window, you can define your matrix by selecting the number of instances, starting and ending values for different parameters.
- For the laser power, look for the **Exposure.CoreLaserPower** parameter,
- For the scan speed, look for the **Exposure.CoreScanSpeed** parameter
- You should get something like this:



- Select the output directory and click on



- The code will be created with added text to identify each element.
- Continue with “F5” as usual.