Durham Magneto Optics Ltd

Application Notes

Performing a dose focus test using the MicroWriter ML® 3 direct write photolithography system

Executive Summary

Here we present processes to perform a dose focus test using the MicroWriter ML® 3 direct write photolithography system.

Introduction

Running a dose focus test is very useful to identify suitable dose and focus parameters for a coated photoresist layer. The dose and focus parameters vary with different types of photoresists layers, or a photoresist layer with varied layer thickness, or a photoresist layer spun on different types of substrates, e.g, Si or glass. When one of these situations happens, we highly recommend running a dose focus test to find the proper dose and focus parameters for this type of sample, and then use the discovered dose and focus for exposures of final designed patterns.

For exposures on the same type of chips but using different resolutions or wavelengths (only applied to a dual wavelength system), it is also highly recommended to run a dose focus test using the resolution or the wavelength.

PROCESS

A. **Load a resist-coated chip**

B. **Have the top surface of the chip in focus**

   a. In the Align wafer panel, enter the rough thickness of the loaded chip in the "Thickness (um)" box.

   b. Bring the top surface of the chip in focus.

   c. Run Autofocus.

C. **Prepare the job list for the dose focus test**

   a. Go to Prepare pattern.

   b. To create a job list for a dose focus test, go to Tools > Job list builder (Figure 1).

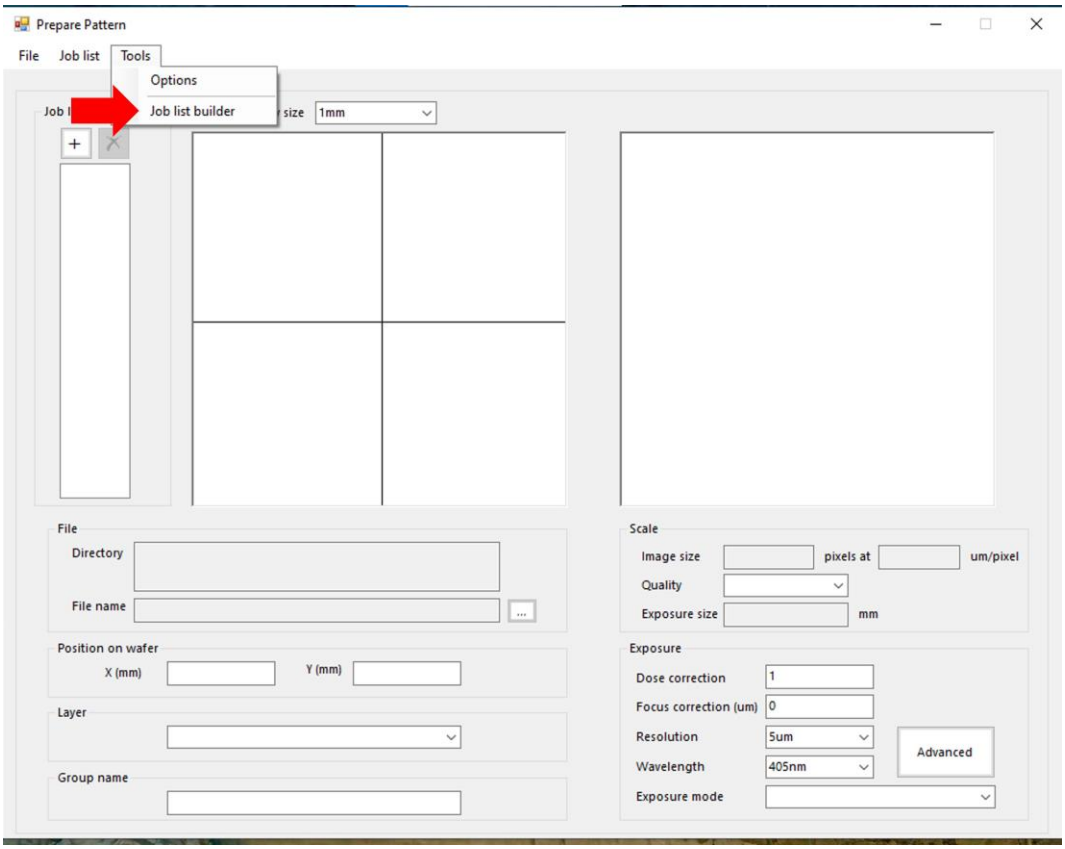

Figure 1 Software tool "Job list builder."

c. Input the write field file: to choose the designed pattern file for the dose focus test, click "…" in the Job List Builder window (Figure 2).

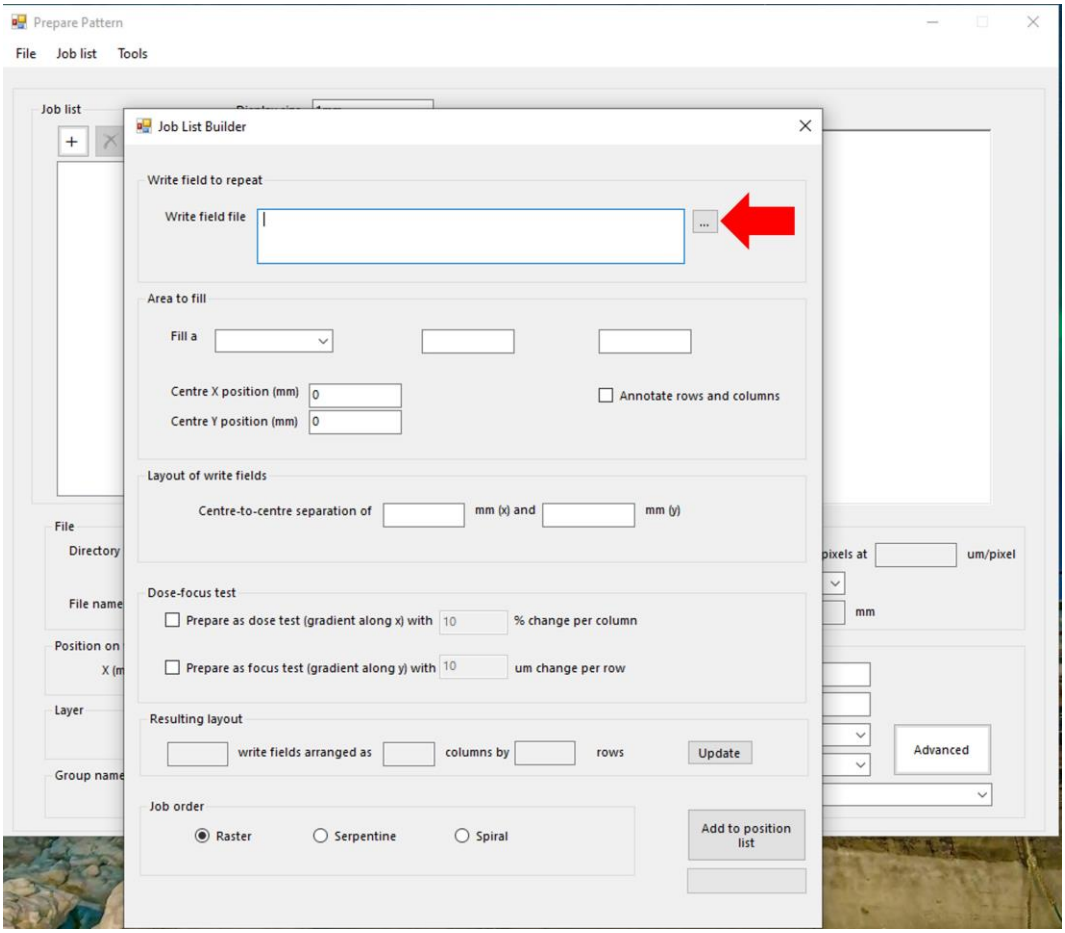

Figure 2 Select the write field file.

d. Find the folder location of the pattern file in the “Open” window, and then click Open (Figure 3). Here we will be using the “large checks 1.bmp” file.

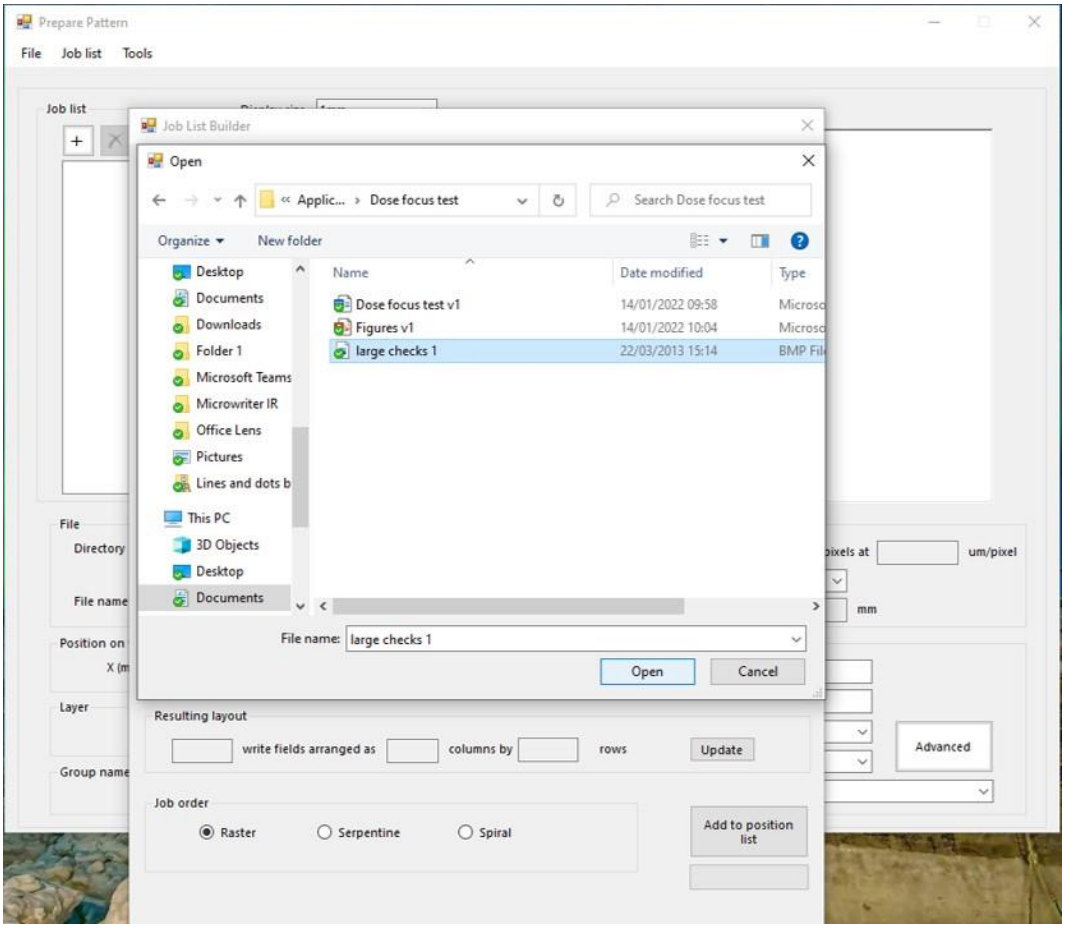

Figure 3 Select the input designed pattern file for the job list builder.

e. Select “Rectangle” in the “Fill a” dropdown menu (Figure 4).

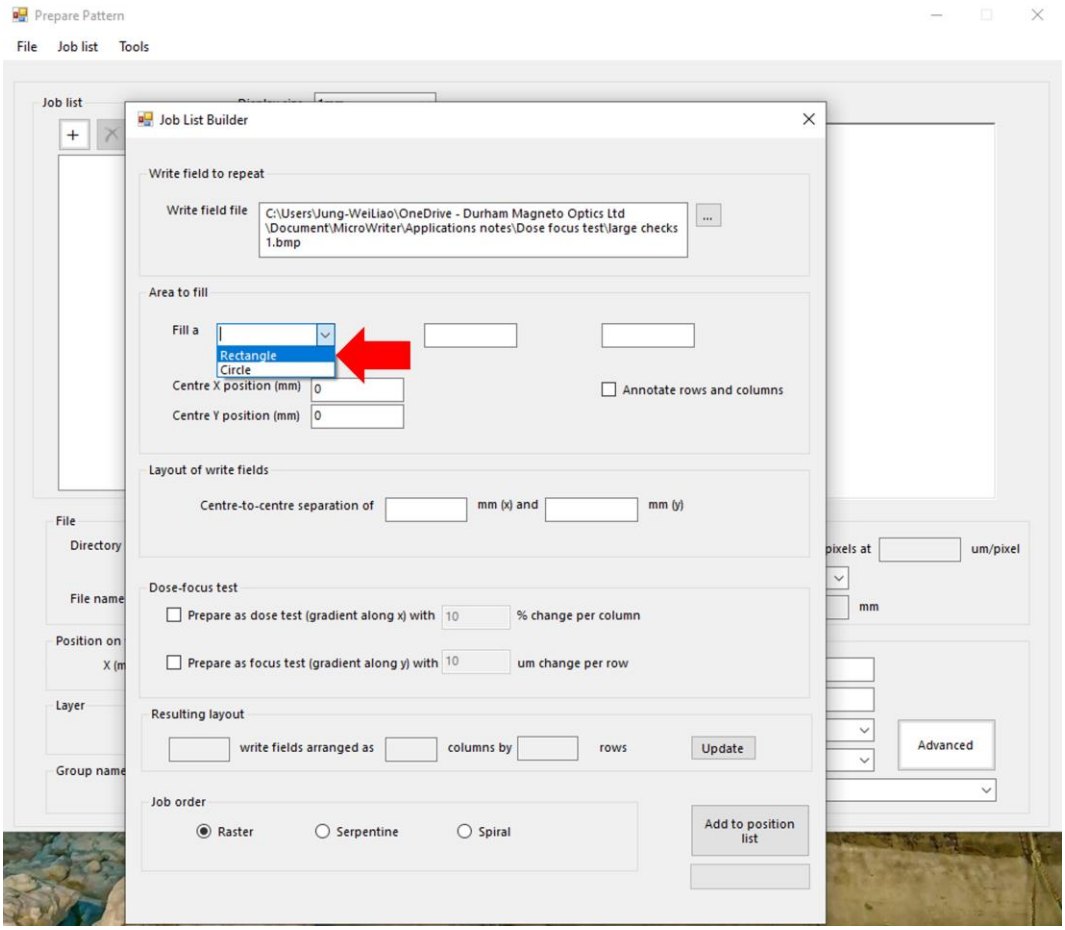

Figure 4 Select the “Rectangle” option in the “Fill a” dropdown menu.

f. Enter the size of the rectangle area (Figure 5). Here we will be filling a 4 mm x 4 mm rectangle area.

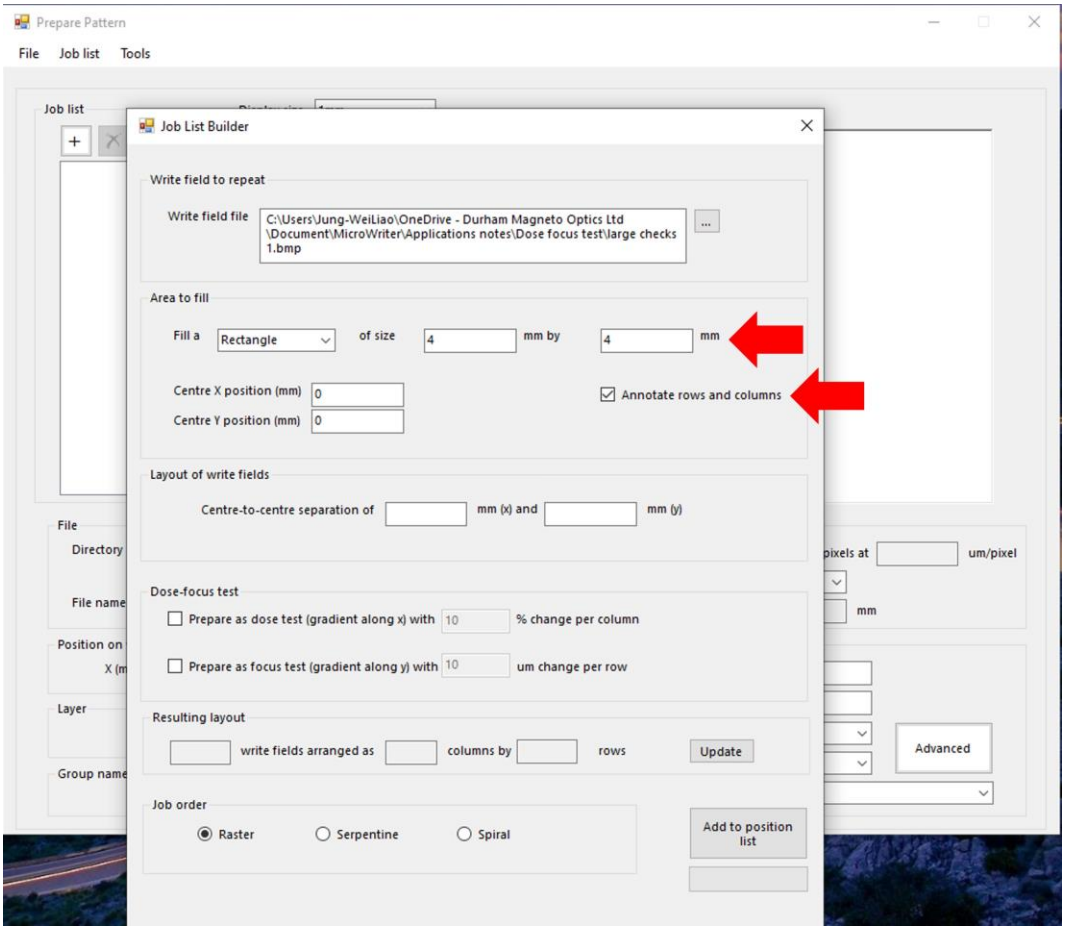

Figure 5 Enter the size of the rectangle area to fill and check the "Annotate rows and columns" option.

g. Check the "Annotate rows and columns" options (Figure 5). This will produce annotations patterns in the exposure results. The annotations help us to identify the location of the desired pattern and therefore the dose and focus parameters used to produce this pattern.

h. Enter the centre-to-centre separation between neighboring patterns (Figure 6). This needs to be larger than each pattern size to avoid overlapping between patterns.

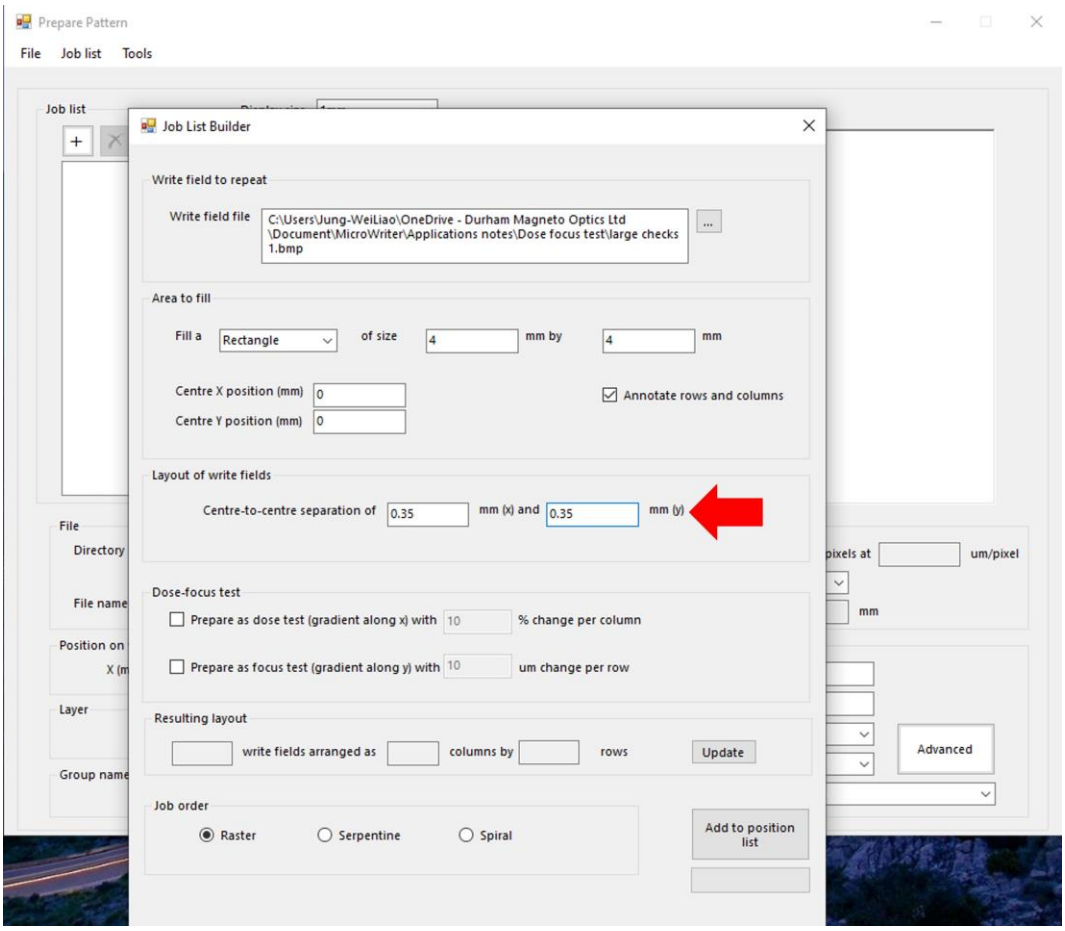

Figure 6 Enter the centre-to-centre separation between neighbouring patterns.

i. Check the “Prepare as dose test …” option (Figure 7). Enter the dose change (in a unit of %) per column. It is suggested to start with 10%.

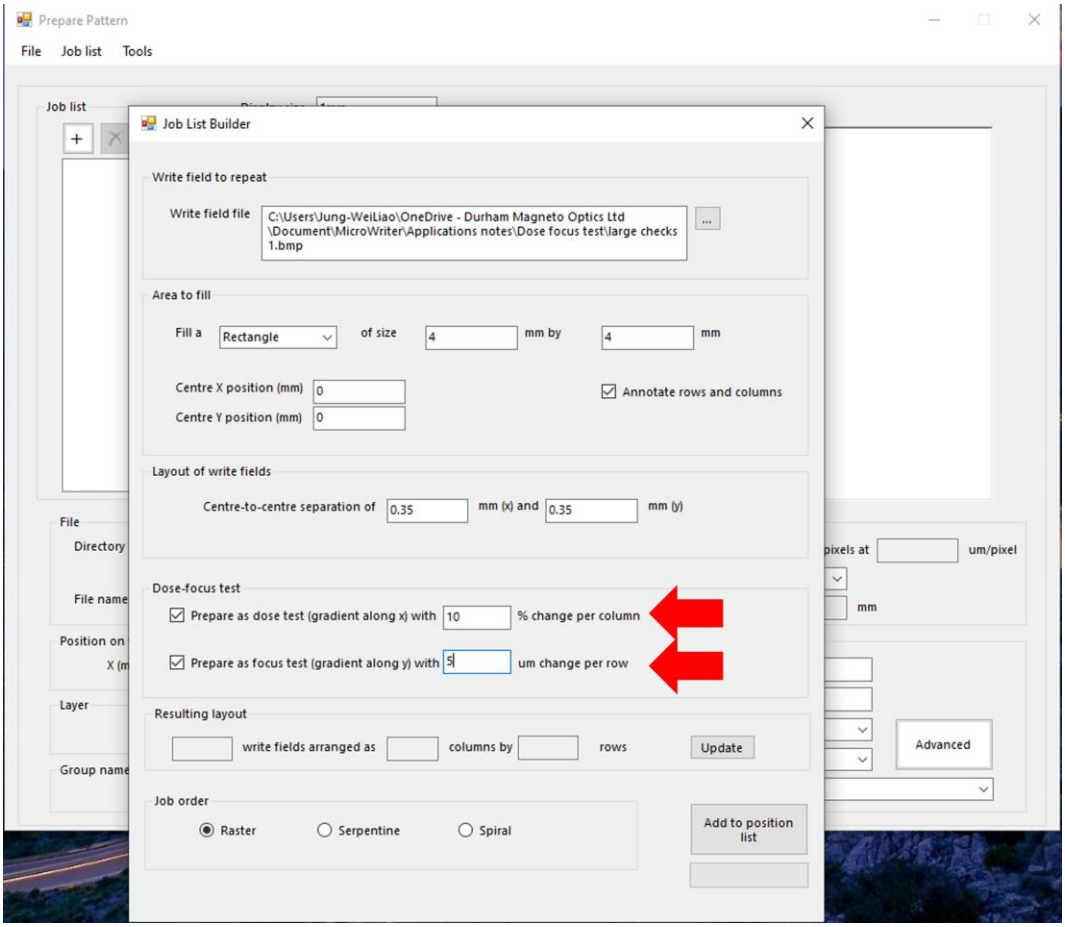

Figure 7 Enter the dose change and focus change for the dose focus test.

j. Check the “Prepare as focus test …” option (Figure 7). Enter the focus change (in a unit of µm) per row.

Note 1: Suggested focus change per row varies with the resolution (Table 1).

Table 1 Suggested focus change per row for each resolution beam.

Resolution beam	Suggested focus change per row
5 µm	25 µm
2 µm	15 µm
1 µm	5 µm
0.6 µm	0.5 µm
0.4 µm	0.3 µm

k. Click “Update” to know in advance how many total numbers of write fields, columns, and rows in the resulting layout (Figure 8).

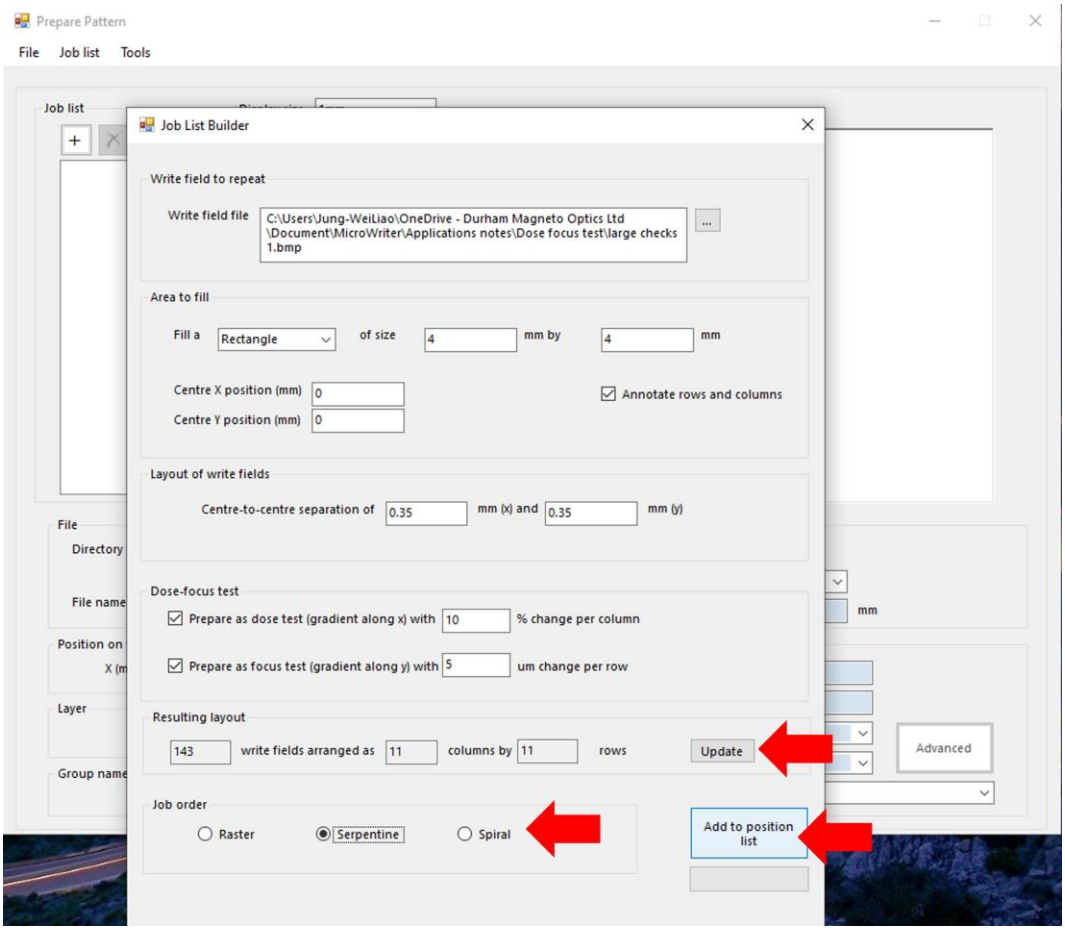

Figure 8 Update, job order, and adding the jobs to the position list.

l. Choose the job order either “Raster” or “Serpentine.” (Figure 8) For running the same job list, running with the serpentine order reduces the exposure time.

m. Click the “Add to position list” button (Figure 8).

n. Overview of the created job list: here we have created an array of “large checkes 1.bmp” pattern and annotations. For each pattern, we apply different dose and focus correction. For the pattern located at the centre of the array (Figure 9(a)), the dose correction is 1 (without any correction), and the focus correction is 0 µm. For patterns above or below this pattern, a focus correction is applied. For example, a focus correction of 10 µm is applied to the pattern shown in Figure 9(b). A dose correction is applied to the patterns at varied positions in X. For instance, the pattern (Figure 9(c)) will be exposed with a dose correction of 1.3. Finally, annotations patterns will be exposed (Figure 9(d)) to assist us finding the locations of each pattern in the exposure result.

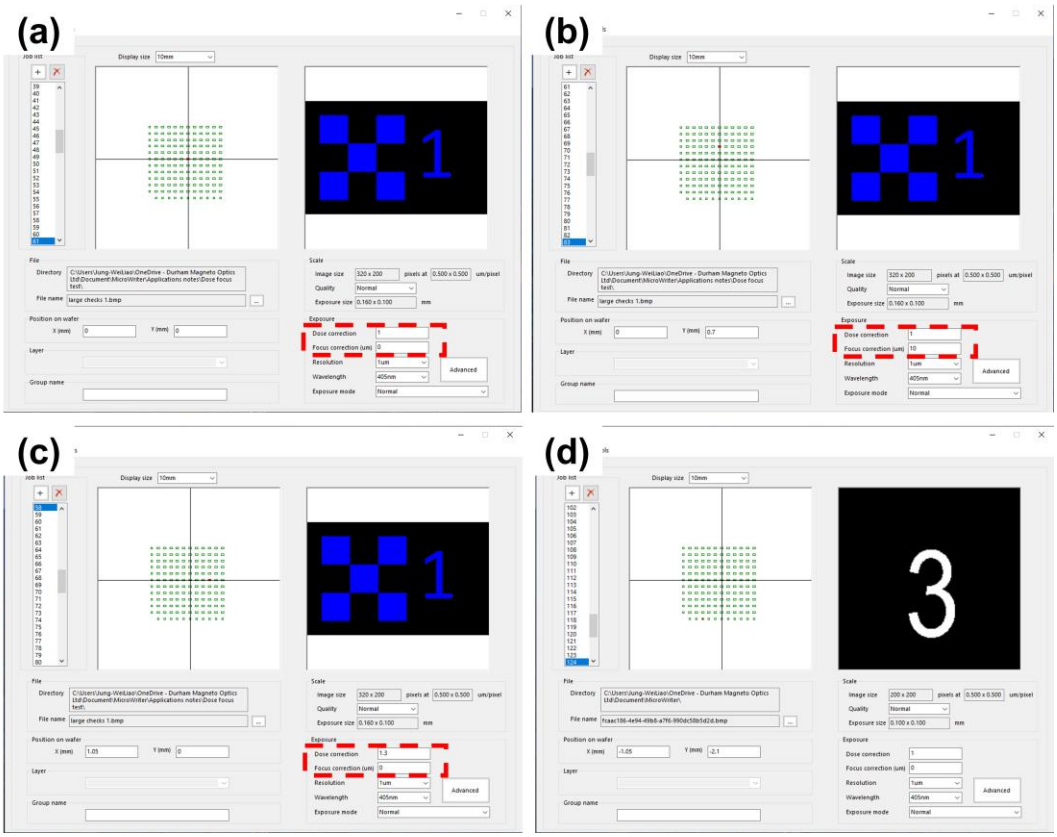

Figure 9 Overview of the created job list for running a dose focus test: (a) the centre job, where no dose correction and no focus correction are applied. (b) A job located above the centre job. This job is applied with a focus correction of 10 µm. (c) A job located to the right of the centre job. This job is applied with a dose correction factor of 1.3. (d) Annotations in the array.

o. (Optional) Change the resolution, exposure quality, exposure wavelength, or exposure mode:

For each job, the default exposure parameters are Normal exposure quality, 1 µm resolution beam, and Normal exposure mode. Assuming we would like to run a dose focus test for the 0.6 µm resolution beam instead of the 1 µm resolution beam, we can:

1. Go to Job list > Select all (Figure 10).

2. Select “0.6 µm” in the “Resolution” dropdown menu.

3. Click on Advanced button and uncheck “Enable (best stitching)” then click ok.

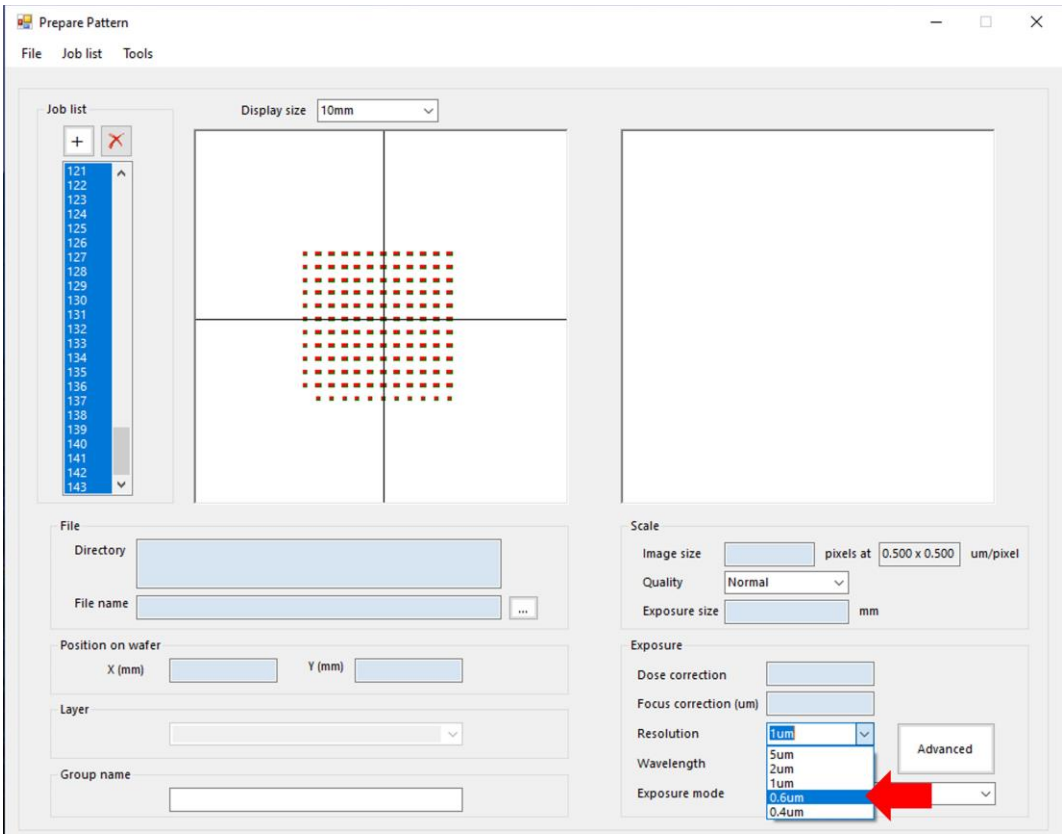

Figure 10 Changing resolutions used for the dose focus test.

D. **Start exposure**

Go to the Expose panel. Entre the centre dose for the dose focus test. Click green traffic light to start the exposure.

E. **Develop the exposed chip and identify the dose and focus parameters from the developed array.**

a. Find the pattern with shapes most suitable for our applications.

b. Identify the location of the patterns through the annotations.

c. Find the corresponding dose correction and the focus correction from the previously created job list.

d. The optimal dose = (the centre dose) x (the dose correction). The optimal focus = the focus correction.