Durham Magneto Optics Ltd

Application Notes

Greyscale lithography using the MicroWriter ML® 3 direct write photolithography system

Executive Summary

Here we present steps to perform a greyscale exposure using the MicroWriter ML® 3 photolithography system, which provides 256 levels of greyscale. Through greyscale lithography, a 2.5-dimensional structure on a photoresist layer can be achieved.

Introduction

Using the greyscale exposure mode of Microwriter ML® 3 direct write lithography system, 2.5-dimensional photoresist structures can be created. Representative examples can be found in Figure 1.

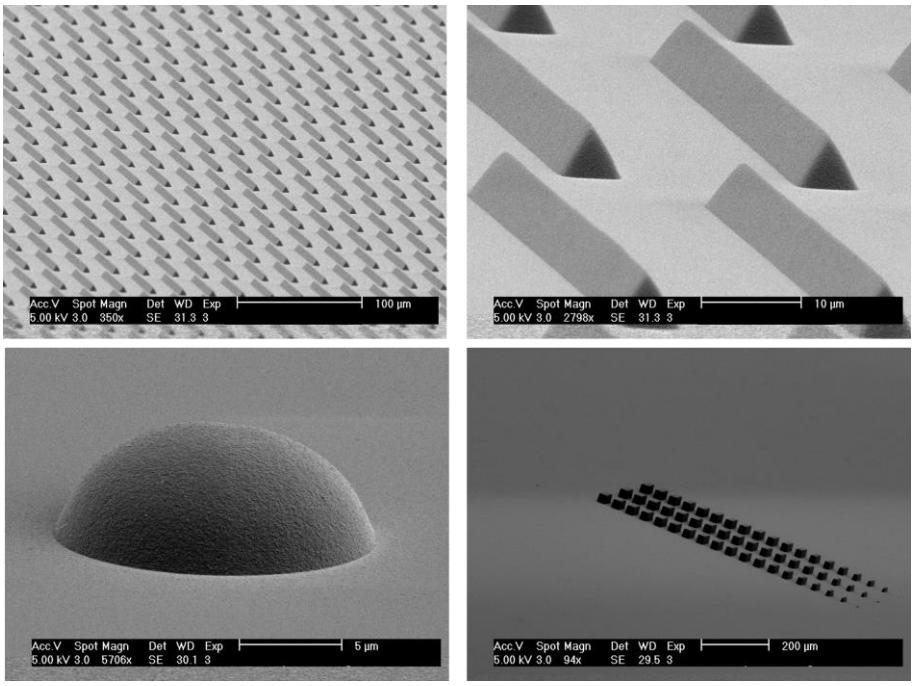

Figure 1 Representative SEM images of photoresist structures made by greyscale exposures using the MicroWriter ML® 3 direct write photolithography system.

PROCESS

A. Preparation of design files

A graphics file (BMP or TIFF etc.) is required to perform a greyscale exposure. In the supplied graphic file, 0-255 colour of the blue channel corresponds to the required dose. 0 is no dose, and 255 is the full dose.

Users might find it inconvenient to create a BMP file for greyscale exposures. For this, we have supplied a software tool (pubSTLtoSTRv1.3.2), which is able to convert a STL file to a BMP file or a STR file for a greyscale exposure. STL is a typical file format for a 3D object. Users can draw their final patterns in 3D and save the patterns as a STL file. Through our software tool, the required BMP file or the stream file can then be produced. Figure 2 shows an example, where Figure 2(a) is a STL file, and Figure 2(b) is the corresponding BMP file. The stream file format is suggested if the total pixel sizes are more than 5000 pxs x 5000 pxs.

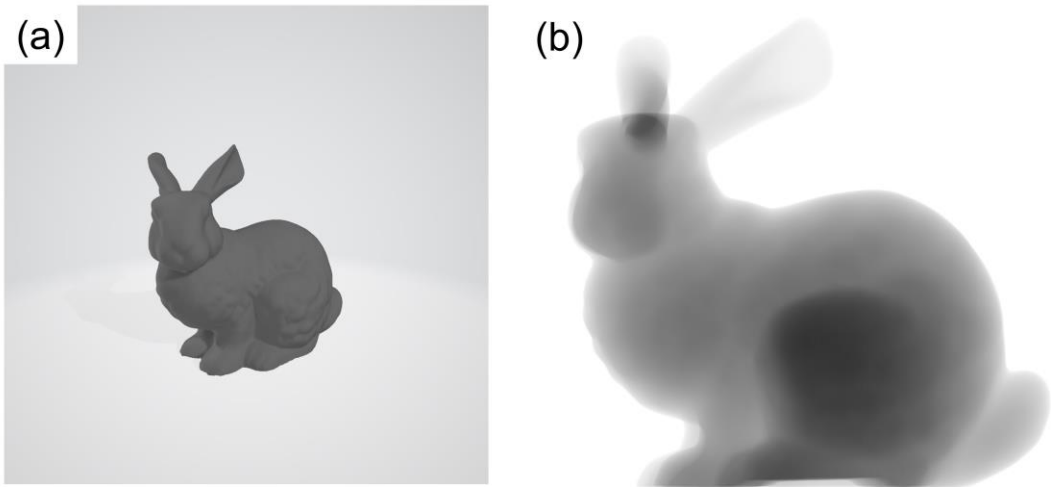

Figure 2 Example of converting an object in a STL file ((a)) into a BMP file ((b)) using the provided STL to BMP converter.

Figure 3 shows a screenshot of the software tool. Here we need to:

1. Select the resolution and the quality used for exposures.

2. Enter the image width and the image height of the input STL file.

3. Enter layer thickness of the resist layer and the highest thickness of the objects in the STL file.

   Note 1: We suggest NOT using the whole thickness of the resist layer. The initial part of the resist layer (from the top) tends to respond to the delivered dose less linearly and therefore is relatively difficult to control comparing with the rest of the resist layer.

4. Select the projection plane of the output bitmap image.

5. Select if we would like to invert the output bitmap image.

6. Click "…" button and find the location of the STL file.

7. In the Export actions, select Preview and click the "Go!" button to have a quick view of the output file in the Preview image section. The preview image can be partly magnified by the mouse wheel. Holding the mouse right click can drag the preview image.

8. Choose Export .bmp image or Export stream files (suggested) and click the "Go!" button to produce the final file for exposures.

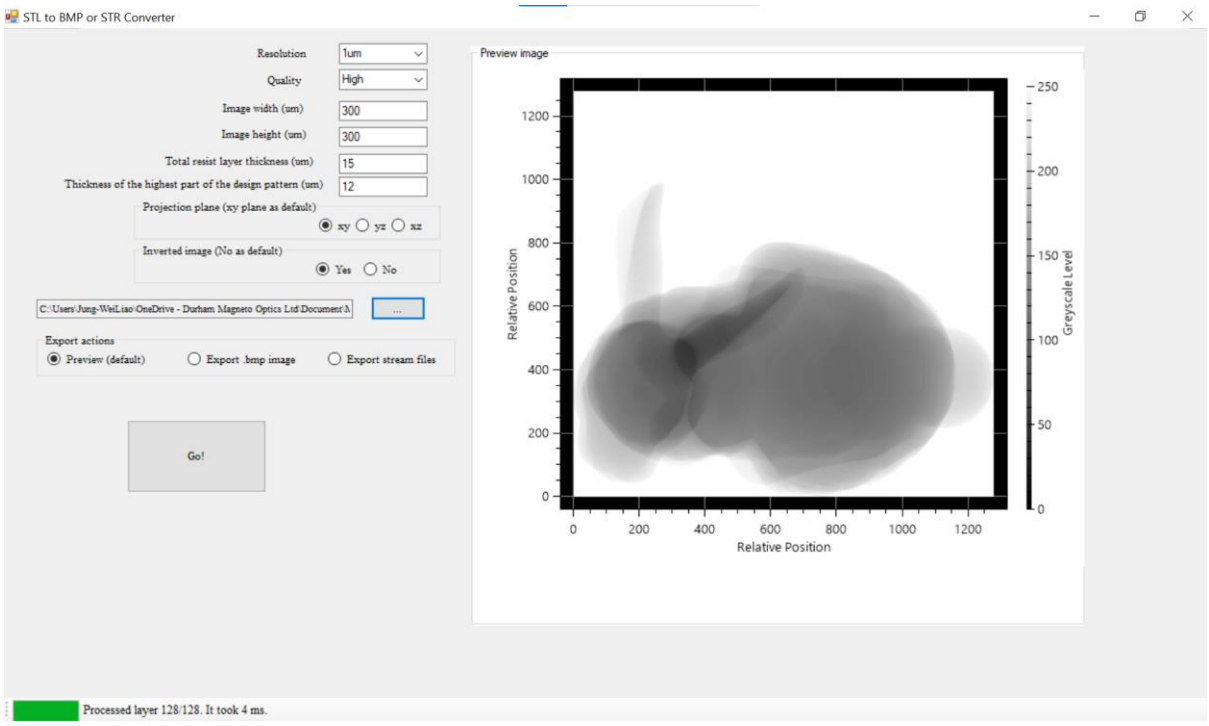

Figure 3 Screenshot of the supplied software tool "STL to BMP Converter".

Note 1: Remember to use the same resolution and quality used in the converter for exposures in the MW3 software. Otherwise, it would result in changing the overall size of the final exposed pattern. This is because different resolutions and qualities usually correspond to different pixel sizes (Table 1).

Table 1 Pixel sizes of different resolutions in different exposure qualities.

Resolution	Fastest exposure quality	Normal exposure quality	High exposure quality	Super exposure quality
5 µm	2 µm/pixel	2 µm/pixel	1 µm/pixel	0.5 µm/pixel
2 µm	1 µm/pixel	1 µm/pixel	0.5 µm/pixel	0.2 µm/pixel
1 µm	0.5 µm/pixel	0.5 µm/pixel	0.2 µm/pixel	0.1 µm/pixel
0.6 µm	0.5 µm/pixel	0.5 µm/pixel	0.2 µm/pixel	0.1 µm/pixel
0.4 µm	0.25 µm/pixel	0.25 µm/pixel	0.1 µm/pixel	0.1 µm/pixel

B. Correct greyscale

For more information about this process, please refer to the Correction greyscale section on Page 65 in the MW3 user manual v3.20.

C. Dose focus test

The final patterns can vary with the dose and focus parameters for exposures. We suggest using the previously obtained file to run a dose focus test, with the exposure mode of Greyscale. Examine the developed results and choose the preferred dose and focus parameters.

Note 1: For more information about running a dose focus test, please refer to the application note “Dose focus test”.

D. Exposures

In the prepare pattern panel of MW3 software, input the previously produced file. Then select the corresponding resolution and the quality. Change the exposure mode to Greyscale to have full 256 greyscale levels.