Durham Magneto Optics Ltd

Application Notes

Fabrication of contacts patterns aligned with 2D materials using the MicroWriter ML® 3 Pro direct write photolithography system

Executive Summary

Here we present steps to make contact patterns aligned with a microflake using the MicroWriter ML® 3 photolithography system.

Introduction

For carrying out transport measurements of 2D materials, for example, a microflake, one of the important steps is to make contacts to the material. This requires designed contacts patterns precisely aligned with the material. Such alignment can be easily achieved using the MicroWriter ML® 3 Pro (ML3 Pro). Representative results are shown in Figure 1.

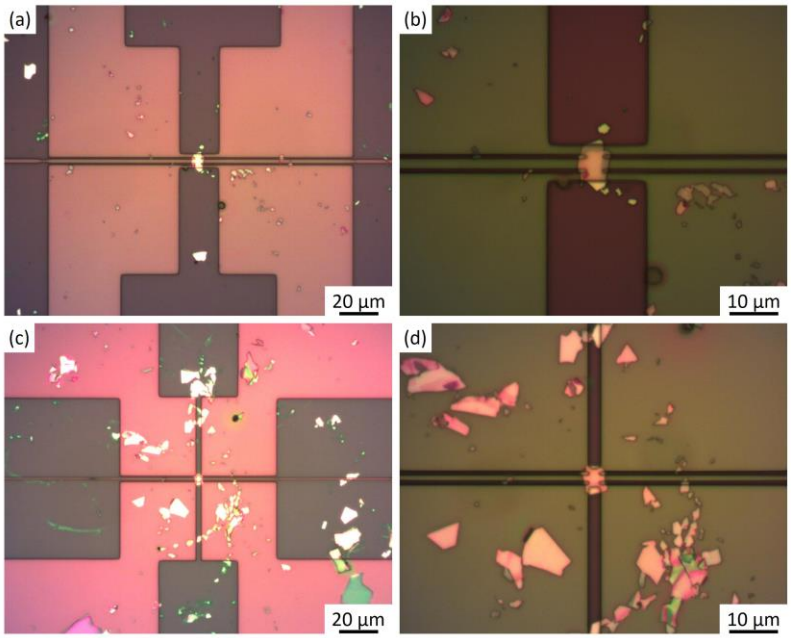

Figure 1 Representative optical microscope images of contacts patterns aligned with microflakes using the MicroWriter ML® 3 direct write photolithography system.

PROCESS

A. Export image of the desired sample

a. Load the sample to the ML3 Pro.

b. Have the real-time microscope in focus on top of the sample surface: Entre the sample thickness (in um) in the Thickness (um) box. Fine tune the thickness to have the microscope image sharp.

   Note 1: Any small Z movement can be achieved using the mouse scroll wheel.

   Note 2: If the sample surface is too clean to make sure that the surface is in focus, we can engage the Focus assist function to have the projected checkboard pattern in focus.

c. Find a desired 2D material under the real-time video microscope of MW3 Pro (Figure 2).

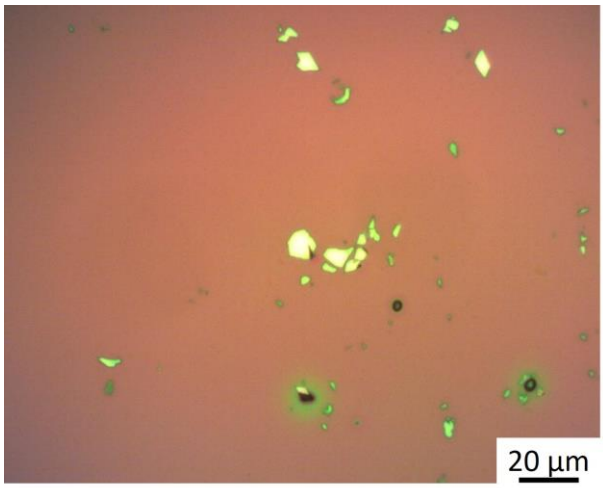

Figure 2 A chosen flake sample under real-time microscope view.

d. Set the centre of the material as the new origin:

   i. Move the camera centre to the material centre by double clicking on the material centre.

   ii. Go to Cetre wafer in the Quick access section.

   iii. In the Global markers window, click the green arrow next to the Marker 1 to place Marker 1 at the current location.

   iv. Click Centre a square/rectangular wafer button.

   v. Click OK to exit the window.

e. Export the current frame of the real-time video microscope to a Bitmap file.

i. Check the pixel size of the export image: In the Align wafer window, go to Microscope > Options.

ii. Set the pixel size (µm): Input the preferred pixel size in the "Pixel size (um)" box (Figure 3). The default pixel size is 1 µm. Note down the pixel size, which will be used later. Click OK when done.

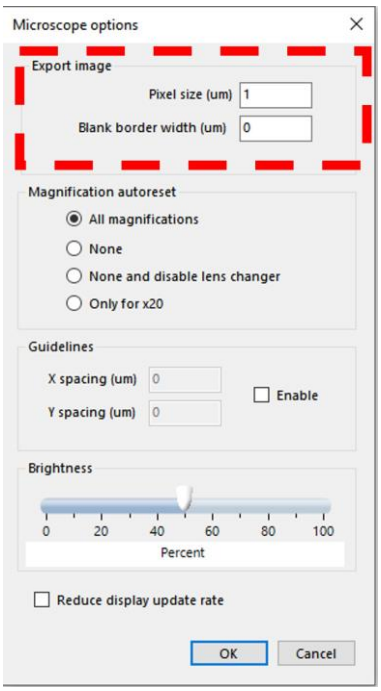

Figure 3 Set the pixel size of the exported image.

Note 1: The blank border width is originally designed for using the Microsoft® Paint software to draw the contact patterns. If we use the design software Clewin or KLayout, we can keep the blank boarder width as 0 µm. Please see the B Prepare design files for more information.

iii. Export the image: Go to Microscope > Export image. Choose the location and enter the image file name.

B. Preparation of design files using the Clewin Layout Editor

There are two ways of drawing the patterns (here the contacts patterns) to be exposed.

The first approach is to open the export Bitmap file using Microsoft® Paint and directly draw the patterns on top of this Bitmap image. The MW3 software only sees the newly drawn patterns when this image file is re-imported to the software for exposures.

The second approach is to use the layout editor software Clewin (supplied with the MW3 Pro) or KLayout. Below we will be focusing on using the Clewin. For Clewin, we suggest using the version after 5.4.30.0, which allows us to input a bitmap file as a background.

a. Create a new file: in Clewin, click the “New” button (Figure 4).

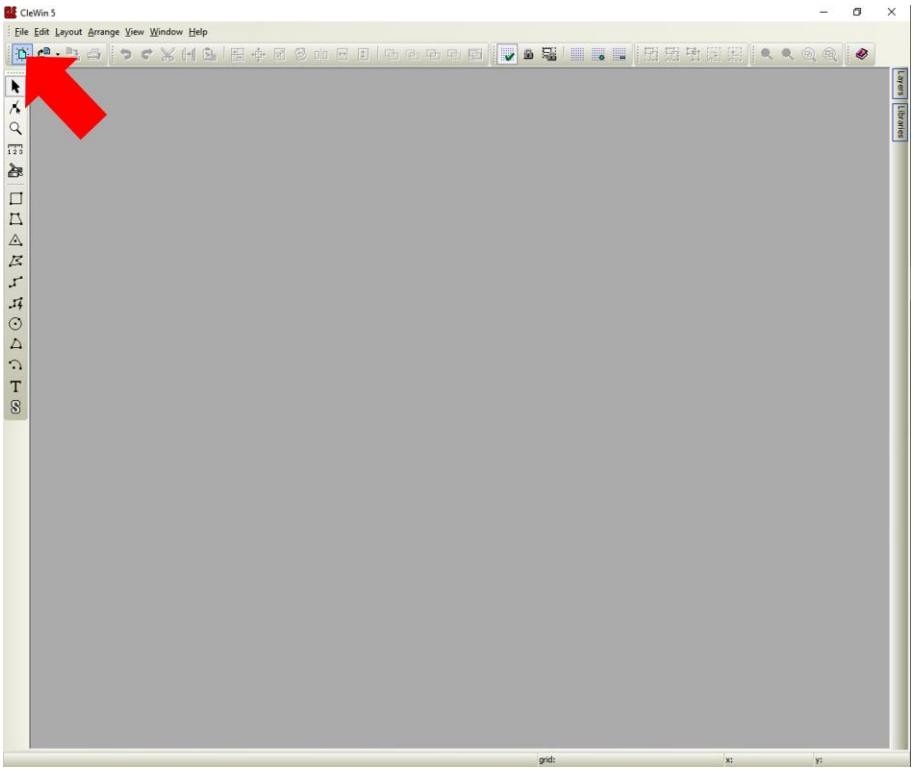

Figure 4 Create a new file in the Clewin software.

b. Go to File > Insert bitmap image… (Figure 5).

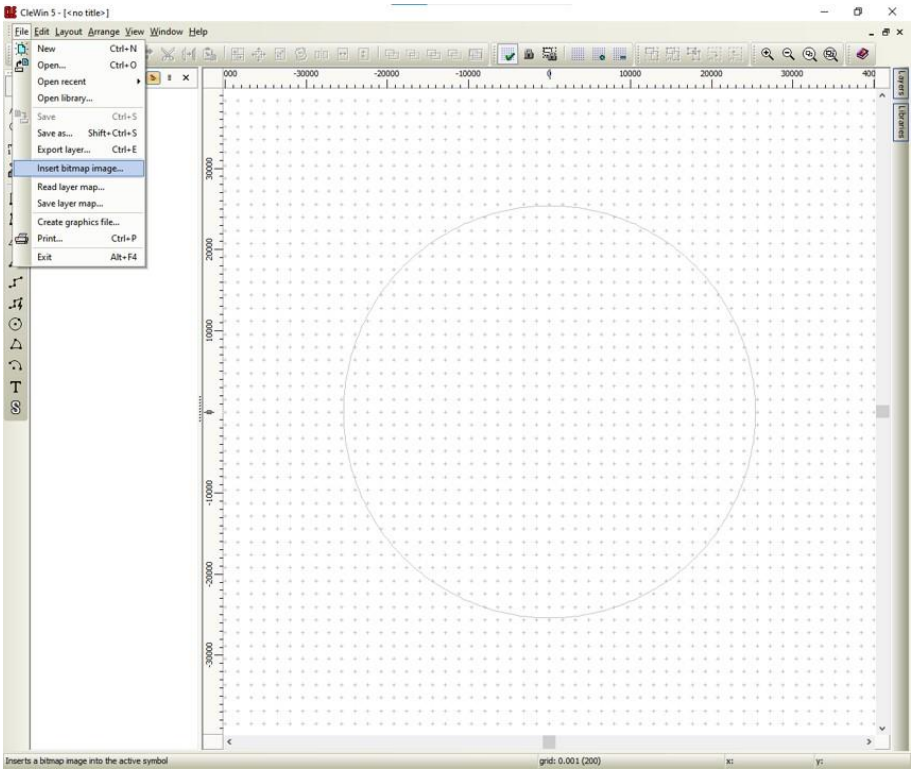

Figure 5 Insert a bitmap file in Clewin.

c. Locate the previously exported image and click the “Open” button (Figure 6).

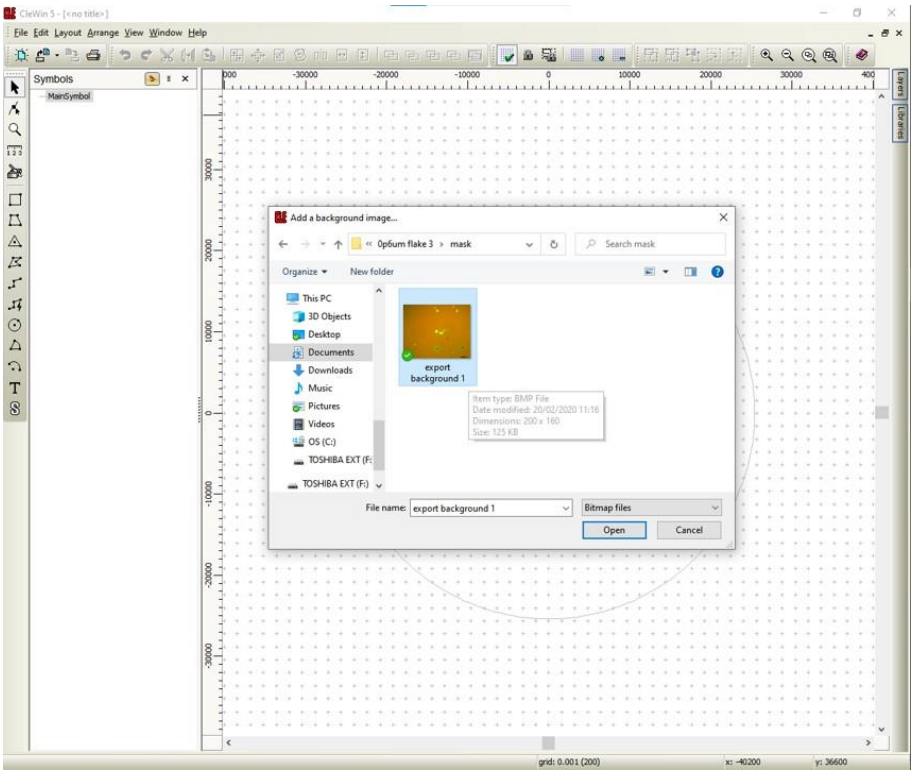

Figure 6 Find and open the previously exported microscope bitmap file.

d. Set the pixel size and the position of the image: Double click on the imported image. In the “Bitmap properties…” window, enter the pixel size and the position of the top-left corner (Figure 7).

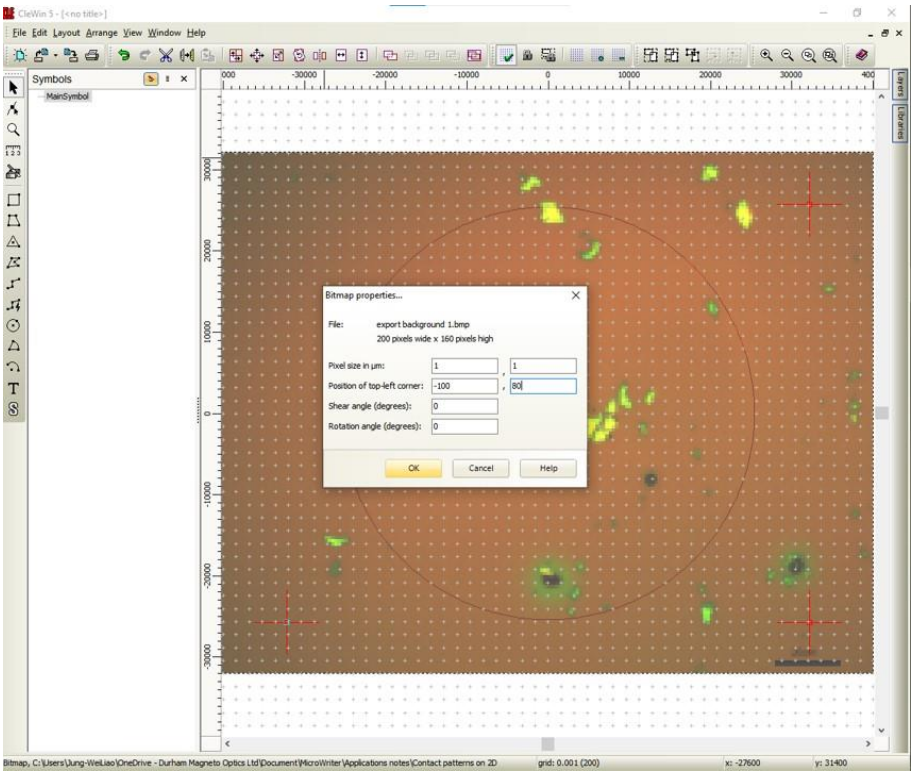

Figure 7 Set the pixel size and the position of the top left corner of the imported bitmap file in Clewin.

e. Draw the design patterns and save the file: Click Zoom all (Highlighted in Figure 8) to zoom the image file with the new pixel size. Draw the contacts patterns aligned with the sample (Figure 8). Save the file when finished.

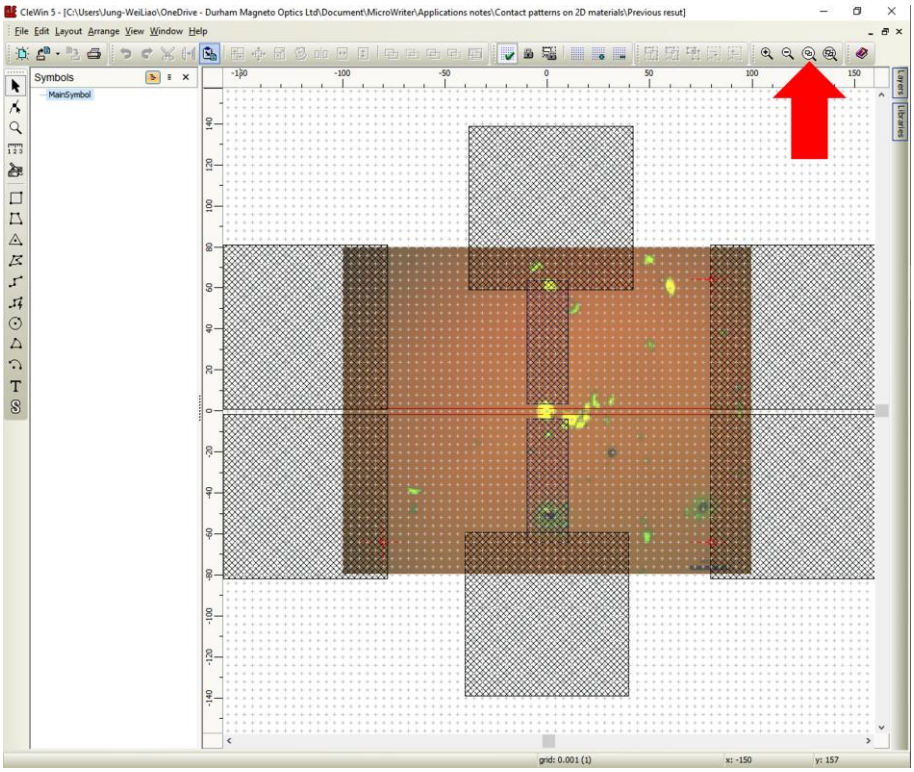

Figure 8 Contact patterns drawn with the bmp file image as the background.

C. Using the software tool "Virtual Mask Aligner" (VMA) to double check the alignment

a. Load the designed .cif file in the MW3 software (Figure 9):

Go to the Prepare pattern. Add a job (or several jobs, depending on number of layers in the designed file). Choose this job. Input the .cif file by clicking the "…" button in the File section. Choose the preferred quality and the resolution.

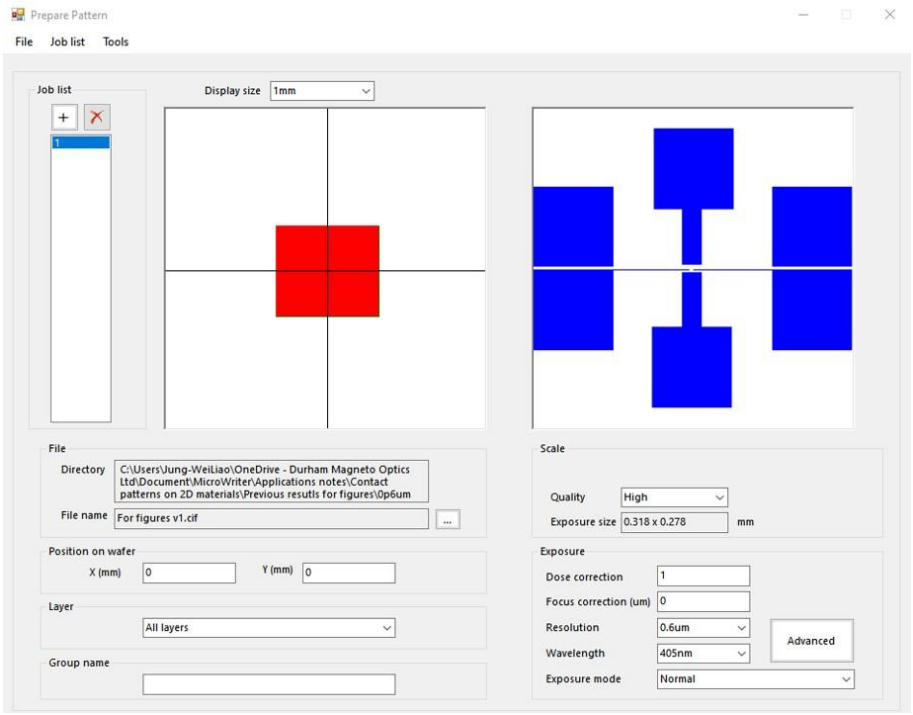

Figure 9 Load the .cif file and set up the exposure parameters in the Prepare pattern window.

b. (Optional) Enable VMA to superimpose the contacts patterns onto the real-time video microscope display [Figure 10(a)]:

   In the Align wafer window, go to Alignment > Virtual mask aligner > Show pattern to be exposed.

c. (Optional) Fine-tune the positions and angles of the design pattern in real-time to improve the alignment between the pattern and the microflake if needed:

   Go to Alignment > Release mask from wafer. This allows us to change the centre position of the projected pattern in real time. Disable this function when done.

d. Exposure and develop the sample, leading to result shown in Figure 10(b).

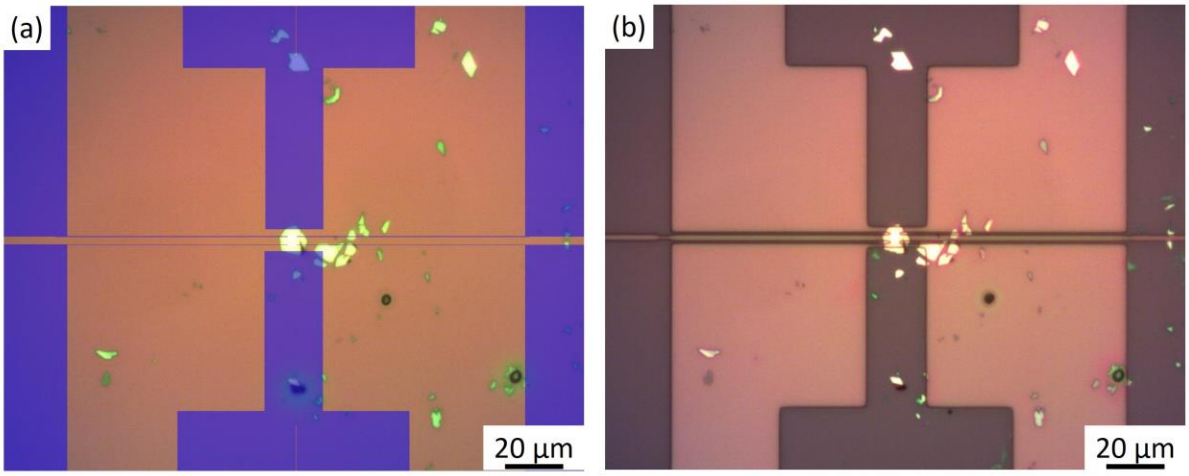

Figure 10 (a) Superimposition of the designed contacts (in blue) onto the real-time microscope image using VMA. (b) A microscope image of the exposure result.