**EBL Overlay Procedure** *(See the Elionix Registration Instruction Manual)*

The substrate or wafer pattern that you are aligning to must have alignment marks. Ideally, the alignment marks on the substrate/wafer should have high contrast (like gold) so they are easily visible in the SEM.

Note: When aligning to a pattern that was previously exposed on the EBL, the first and second exposures must be done under the same conditions (beam current and accelerating voltage). A difference in beam conditions leads to a slight difference in scan amplitude (exposure size).

Alignment Mark Positions
The following diagram illustrates the ideal positioning of alignment marks in relation to the field ("chip") that is being written on the substrate.
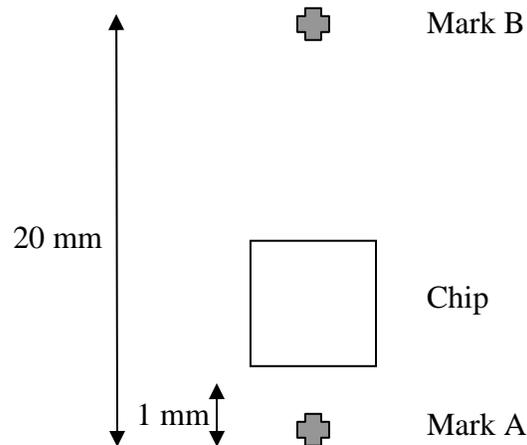
See section 2-2 (p.6) in the Registration Instruction Manual for alignment mark position requirements.

Design CAD Notes
- The alignment marks for the first layer must be drawn and patterned into the substrate/wafer. Suggested alignment mark patterns can be found in the folder ALIGN MARKS on the CAD computers. There is an alignment mark pattern design for each possible combination of field size and dot density settings. To use these alignment mark patterns:
  - Open the ALIGN MARKS folder and then open the sub-folder that matches the dot density of your design (20K, 60K, or 240K).
  - Copy the CON file that matches the field size and dot density of you design, and copy the REG2 CB6 and CC6 files from this folder to your design folder. For example, if your design used a 600um field with a 60,000 dot density, you would copy the following files to your design folder:

1. 600 60K.CO6 (CON file)
2. REG2.CB6
3. REG2.CC6
- The alignment marks will be placed in the proper position relative to your design using the schedule file (see schedule file notes below). Note that the CAD position of all the alignment mark files is 10mm, 10mm.

- When drawing the second layer, use the + icon in the CAD software to define the alignment position of the second layer relative to the first layer. You should use the Reg-2 icon. Note that this icon does NOT actually write an alignment mark on the substrate when doing an exposure.
- Auto registration requires specific alignment marks. See page 4 in the Registration Instruction Manual for a description

Schedule File Notes
- Load your design CON file and select the desired offset x,y coordinates and dose
- Load the alignment mark CON file from the same directory and select the appropriate offset x,y coordinates and dose. Note that the CAD position of all the alignment mark files is 10mm, 10mm.
- Go to Set Options, and enter the desired registration options. (See page 11 in the Registration Instruction Manual)

Registration Window
- **Registration Execution mode**
  - A: to align to a previous layer
  - N: to not perform alignment
- **Control type**
  - Manual: to search for marks manually
  - Auto: to search for marks automatically (requires special alignment marks to be present on the substrate)
- **Registration Error Processing**: Only used for Auto mode in the event that an alignment mark can not be identified by the system
  - C: Continue
  - S: Skip
  - E: Stop

7500 EX Registration Window
- **Registration 2 Mode**
  - ALL REG-2: to perform alignment at each set of alignment marks
  - 1ST REG-2 ONLY: to perform alignment at the first set of marks only
- **FC at Registration**
  - NO: To skip field correction
  - ALL REG-2: To perform field correction at each set of alignment marks

- - 1ST REG-2 ONLY: To perform field correction at the first set of alignment marks only
  - JUDGEMENT: same as "ALL REG-2" curently
  - **Reg-2 Tolerance angle**: Typical value is 0.02. (Sets the allowed tolerance (in mrad) between alignment angle correction and field correction. After performing a field correction it will perform another alignment check and will verify within this angle.)
  - **Reg-3 Tolerance angle**: Ignore this setting, as it is not used for this system
  - **Reg-2 Mark Shape**: Used for auto alignment only
- Save the schedule file. A good naming convention is to save it with the name "Layer1"for the first layer, "Layer2" for the second layer, and so on.
- To view the schedule file with the chip and alignment mark placements:
  - click Expose
  - click Display Pattern
  - Use Zoom In and Zoom Out to see/verify positions of chips and alignment marks
  - *Note: You can merge schedule files from different layers to view the overlay of the layers

Manual Overlay Procedure for Layer 2
1. Load the wafer/substrate which already has alignment marks from previous processing. It is important to place the wafer/substrate on the stage as close as possible to the same position that was used for the first layer.
    a. Follow EBL procedure for setting/verifying beam current, adjusting focus/astigmatism, and adjusting height sensor
2. Load the schedule file for the second layer (to be aligned to the previous layer that is present on the wafer/substrate)
    a. Determine the coordinates of the alignment marks by viewing the layout

Verify Stage Position of Alignment Marks
3. In SEM mode, move the stage to the position of the first alignment mark (Mark A)
4. Unblank the beam and search for the alignment mark at about 200x. If the alignment mark is present and somewhat centered in the field of view, then skip to step 7. Otherwise, continue with step 5. Center the alignment mark in the viewing window.
5. Center the alignment mark in the viewing window. In the scan menu, use the cross mark to determine the center of the alignment mark
    a. Press the "Init" button to make sure the cross is centered in the window
    b. Use a magnification of 200x and a medium scan setting
    c. Position the alignment mark in the middle of the cross
    d. Write down the coordinates of the center of the alignment mark
6. Go to the schedule file for Layer 2 in the CAD computer and adjust the offset positions so that the position of the alignment marks in the layout match the measured position of the marks on the substrate/wafer. This results in a first order "rough" alignment between the second layer and the pattern on the substrate.

7. In SEM mode, move the state to the position of the second alignment mark (Mark B), and verify that the mark is present within the field of view at 200x. This is done to check that the rotation error of the substrate is within allowable limits. If the B mark is not within the field of view, you will need to unload the substrate and adjust its rotation.
8. If performing Field Correction as part of alignment, and if the beam current is 100pA or less, then move the stage to the field alignment marks (Position 2 in stage memory) and adjust brightness/contrast to optimize for field correction (see EBL Field Correction procedure)
9. Start the Exposure process (see EBL procedure)
   a. Put SEM in EXP mode
   b. Go to the CAD computer and click on exposure (do not select field correction, as the exposure program will select this as part of the alignment). Click on Exposure again, and then click on YES
   c. Go back to the SEM computer and follow the instructions on the exposure screen for fine alignment
      i. Stage will move to the first alignment mark (Mark A)
      ii. Open the beam blanker and go to medium scan
      iii. Move the alignment mark to the center using stage movements, and keep repeating at higher magnifications. (Notes: after a stage movement is performed, blank the beam and wait 30 seconds to allow stage to settle). Above 100Kx, you will need to shift the beam instead of moving the stage using the position shifts in the exposure window.
      iv. Use Slow Scan 1 setting to get fine alignment. (The image shifts between scans in video mode)
      v. When the alignment is good (alignment mark centered), press OK
      vi. The stage will then drive to Mark B, and follow the instructions to repeat the same procedure as for Mark A. Make sure you use the same magnification setting for Mark A and Mark B.
      vii. When the alignment is good for Mark B, press OK.
      viii. If field correction is selected in the schedule file options, the stage will drive to the field correction position and automatically start the field correction routine.
      ix. When the field correction is completed, the stage will drive again to the Mark A position. Follow the instructions in the exposure window (as above) to first perform alignment on Mark A, and then on Mark B. Make sure you use the same magnification setting for Mark A and Mark B. This verifies the alignment after the field correction is performed. Press OK.
      x. The system will calculate the rotation error, and if it is less than the value entered in the schedule file (typically 0.02mrad), it will start the exposure. (If it is outside of this value, the system will repeat the field correction routine).