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Alignment Error Examination of Elionix E-Beam Writer ELS-7500EX

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Abstract
The alignment error of Elinox ELS-7500EX E-beam Lithography system is examined, as a project of Graduate Student Fellow Program. This report shows the alignment error of 60 and 30 nm in the x- and y-direction, respectively, confirming the tool specification of 60 nm alignment error.

Keywords
alignment error Elionix ELS-7500EX

Disciplines
Engineering

1. Introduction

The alignment error of Elinox ELS-7500EX E-beam Lithography system is examined. This has been carried out as a project of Graduate Student Fellow Program.

2. Experimental Section

A. E-beam lithography

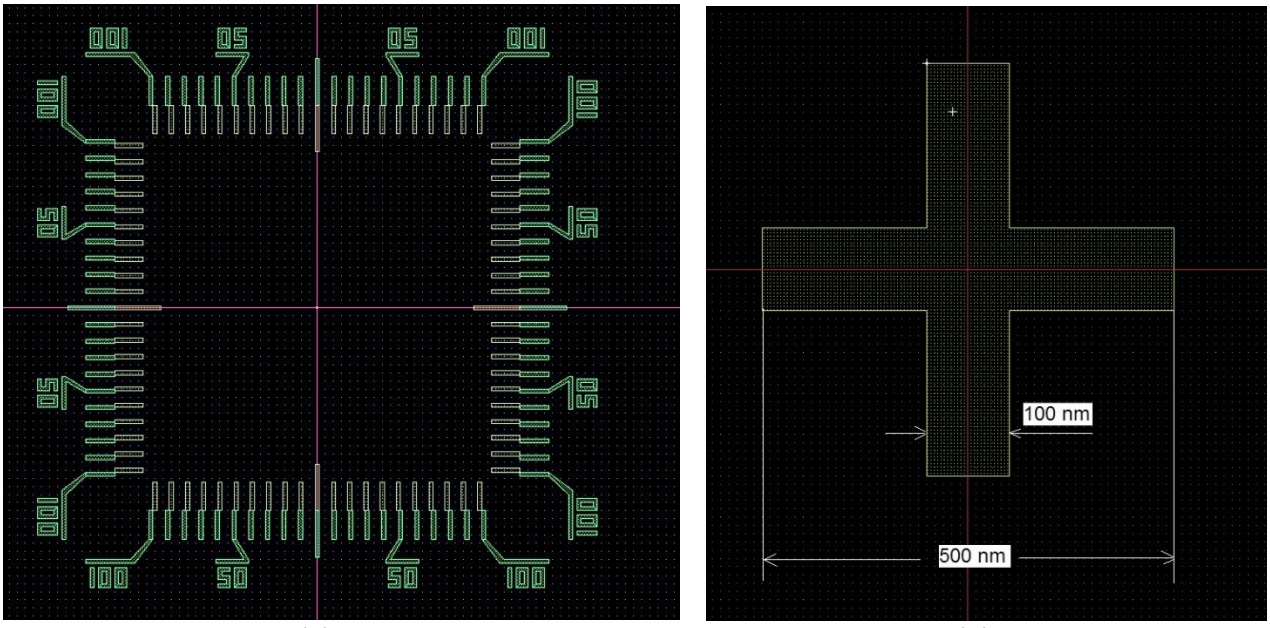
A Si wafer was sonicated in acetone and isopropyl alcohol (IPA) for 5 min each. 100 nm thick PMMA films were spin coated on the Si substrates, followed by baking it at 180 °C for 5 min on a hot plate. E-beam writing was carried out using Elionix ELS-7500EX with the following condition: an acceleration voltage of 50 kV; a beam current of 100 pA; an objective lens aperture of 40 μm; the e-beam dose = 200 μC/cm^2 in the area of 300 x 300 μm^2 with the total dots of 60000 x 60000. The PMMA film exposed was developed for 60 sec in a 3:1 (v/v) mixture of IPA and DI water. The sample developed was rinsed with IPA.

B. Ti and Au deposition and lift-off

5 nm thick Ti film was deposited onto the developed 1st layer sample, followed by 30 nm thick Al film deposition, using Kurt Lesker PVD-75. Then, the sample was lifted off with sonication in acetone. The 2nd layer sample was prepared in the same manner as above.

C. Vanier and Alignment Marks

Figure 1 shows Vanier and Alignment Marks in this study. The outer bars on either side are displaced by 10, 20, …, 100 nm from the inner bars, respectively, as depicted in figure 1(a). As a result, if the outer bar displaced by 40 nm is aligned with the inner bar, then the alignment error is determined to be 40 nm. The length and width of the alignment mark are 500 nm and 100 nm, respectively.



(a) (b)

Figure 1. Vanier and alignment marks in this study. (a) The outer bars on either side are displaced by 10, 20, …, 100 nm from the inner bars, respectively. If the outer bar displaced by 40 nm is aligned with the inner bar, then the alignment error is determined to be 40 nm. (b) The length of the alignment mark is 500 nm, and the width is 100 nm.

3. Alignment Procedure and Results

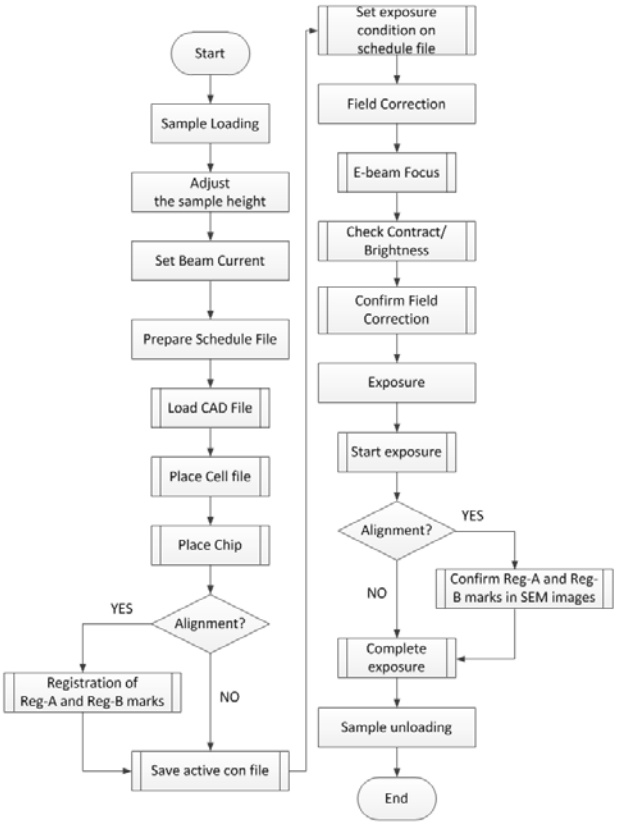
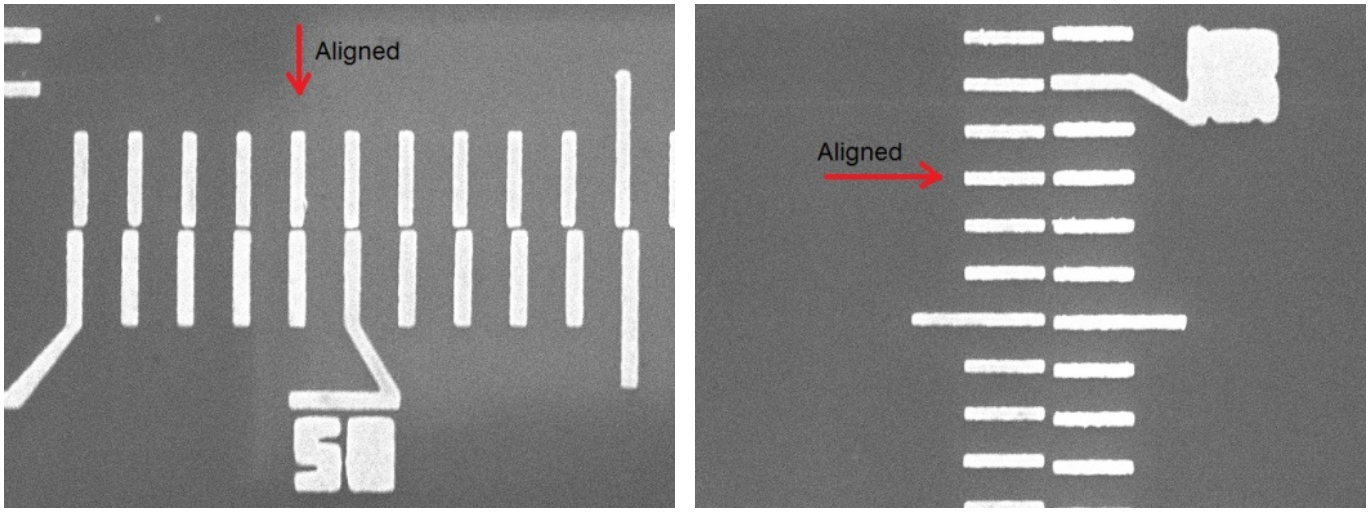


Figure 2. Flow chart of e-beam writing of Elionix ELS-7500EX

The alignment procedure followed the revised standard operating produce (SOP).[1] Figure 2 shows a flow chart of e-beam writing of Elionix ELS-7500EX. Here are the points that care should be taken. The coordinate of **the center of the sample** is input when adjusting the sample height. If the fist layer pattern is placed at the center of the sample, the second layer pattern should also be placed at the center of the sample ideally. Although the second layer is unlikely to be placed at the exact same position, the mismatch will automatically be corrected by the tool after confirming the alignment (registration) marks during the exposure procedure. Thus, it is not necessary to observe the two alignment marks with the coordinates known in the design using SEM, just after setting beam current shown in the SOP, although it is nothing wrong to do it.

For example, it is assumed that the designed coordinates of the origin of the design and the two alignment marks are (0, 0), (0, -2), and (0, 2) in mm, respectively. The sample size is assumed to be 15 mm x 15 mm. If the center of the sample is the same coordinate as the origin of the design, the coordinates of the origin of the design and the two alignment marks **on the sample chuck** are (84.3, 85.5), (84.3, 83.5), and (84.3, 87.5) in mm, respectively. Although this is not true, it is not any problem to input those coordinates into the CAD program because the correction will be done during the exposure procedure, as described above. **It is important that the relative locations are the same as the designed ones.**

Figure 3 shows SEM images of the Vanier marks in (a) the x-direction and (b) the y-direction. The alignment errors in the x- and y-directions are determined to be 60 and 30 nm, respectively, according to the aligned Vanier marks in figure 3 (the specification of the alignment error is shown to be 60 nm in the manual).



(a) (b)

Figure 3. SEM images of Vanier marks in (a) the x-direction and (b) the y-direction. Alignment errors in the x-and y-directions are determined to be 60 and 30 nm, respectively.

4. Summary

The alignment error of Elinox ELS-7500EX E-beam Lithography system has been examined, and determined to be 60 and 30 nm in the x- and y- directions, respectively. This was almost the same as the specification of the tool.

References

[1] https://www.seas.upenn.edu/~nanosop/Elionix_Alignment_SOP.htm