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Elionix ELS-7500EX: Field Size Analysis

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Abstract

This report documents the field distortion of the Elionix ELS-7500EX electron beam lithography system at the University of Pennsylvania Singh Center for Nanotechnology at the Quattrone Nanofabrication Facility. The system is equipped with a 20MHz fixed clock and fixed focus. The aim of the work is to understand optimal field sizes to use for critical dimensions 80nm and above. Field uniformity was analyzed as a function of critical dimension and objective lens aperture (OLA) a.k.a. final paerture. As features scale down below 300nm, they are more susceptible to the systematic effects of field distortion. Suggested field sizes depend on the feature size that is desired.

Keywords

Field Size, Field distortion, analysis, elionix, electron beam lithography

Disciplines

Nanoscience and Nanotechnology

Abstract:

This report documents the field distortion of the Elionix ELS-7500EX electron beam lithography system at the University of Pennsylvania Singh Center for Nanotechnology at the Quattrone Nanofabrication Facility. The system is equipped with a 20MHz fixed clock and fixed focus. The aim of the work is to understand optimal field sizes to use for critical dimensions 80nm and above. Field uniformity was analyzed as a function of critical dimension and final aperture or objective lens aperture (OLA). Our findings show as features scaled down below 300nm, they are more susceptible to systematic effects of field distortion. Suggested field sizes depend on the feature size that is desired.

Materials:
- Diluted ZEON Chemicals ZEP520A
- Si wafers

Equipment:
- ReynoldsTech Spinner
- Torrey Pines Scientific Hotplate
- Carl Zeiss Optical Microscope
- FEI Strata DB235 FIB

Protocol:

Spin Coat and Soft Bake
1. Mount wafer and ensure that it is centered.
2. Spin wafer at 1000 RPM for 60 seconds to achieve 200nm thickness.
3. Bake wafer at 180 °C for 90 seconds and allow wafer to cool after removal.

Exposure
1. Generate an array of 100nm, 200nm and 300nm vertical line-space pattern on a 50% duty cycle and 1200 micron long such that they fill an entire 1200 micron field
2. Using the Elionix ELS-7500EX EBL tool, expose the pattern using 200pA with a 30 40, or 60 micron objective lens aperture (OLA, a.k.a. final aperture).

Development at ~20°C
1. Pour o-xylene into the first clean beaker.
2. Pour IPA into the second clean beaker.
3. Set timer to 70 seconds.
4. Drop exposed wafer into bath of o-xylene making sure the wafer is completely submerged, and start the timer. Do not agitate.
5. After 70 seconds submerge the wafer into the IPA bath to stop development.
6. After roughly 30 seconds remove the wafer and place on a TexWipe.
7. Blow dry the wafer with N_2.

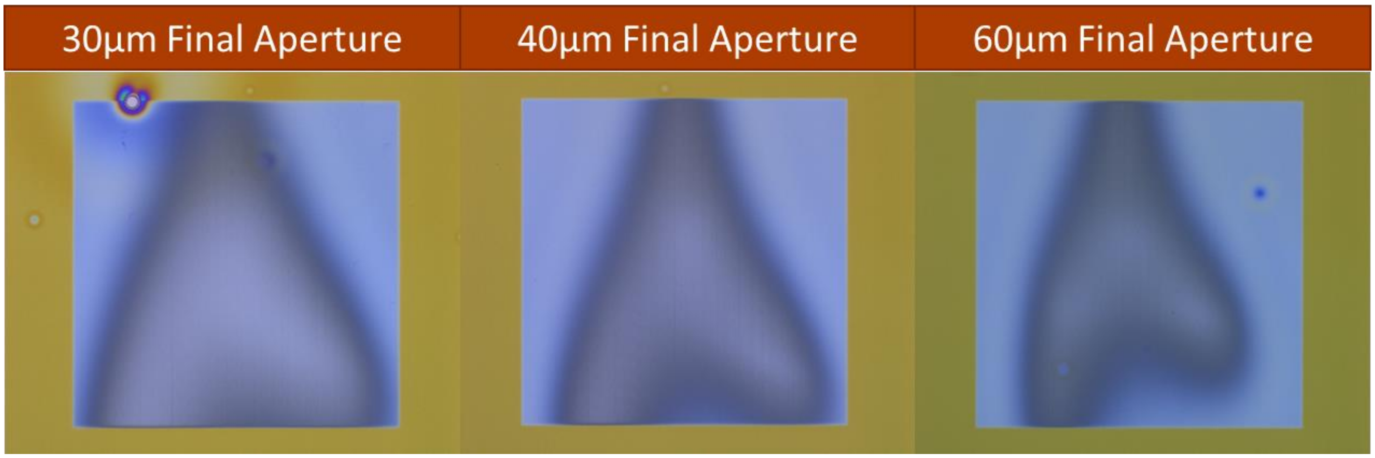
Results and Discussion:

The Elionix ELS-7500EX is capable of the following field sizes and resolution:

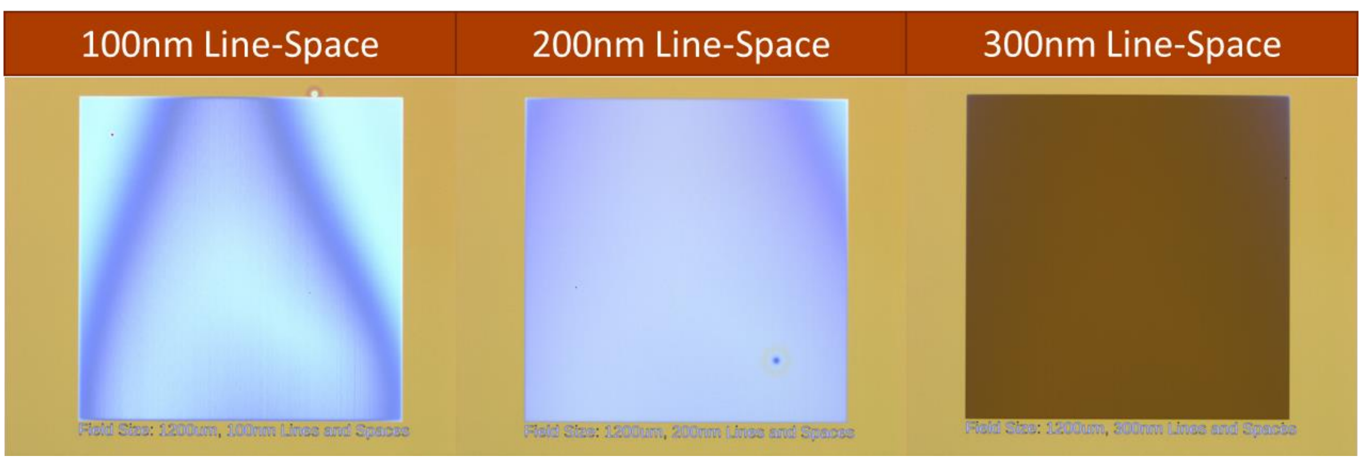
Available Field Sizes and Resolution at 60k Dots per Field					
Field Size [µm]	75	150	300	600	1200
Resolution [nm]	1.25	2.5	5	10	20

Understanding what field size to use is a common question in e-beam. Specifically, the Elionix ELS-7500EX is not equipped with dynamic focus. This means that distortion in the beam will impact the quality of the image in resist. Common practice is to always center the pattern or critical features in the middle of the field.

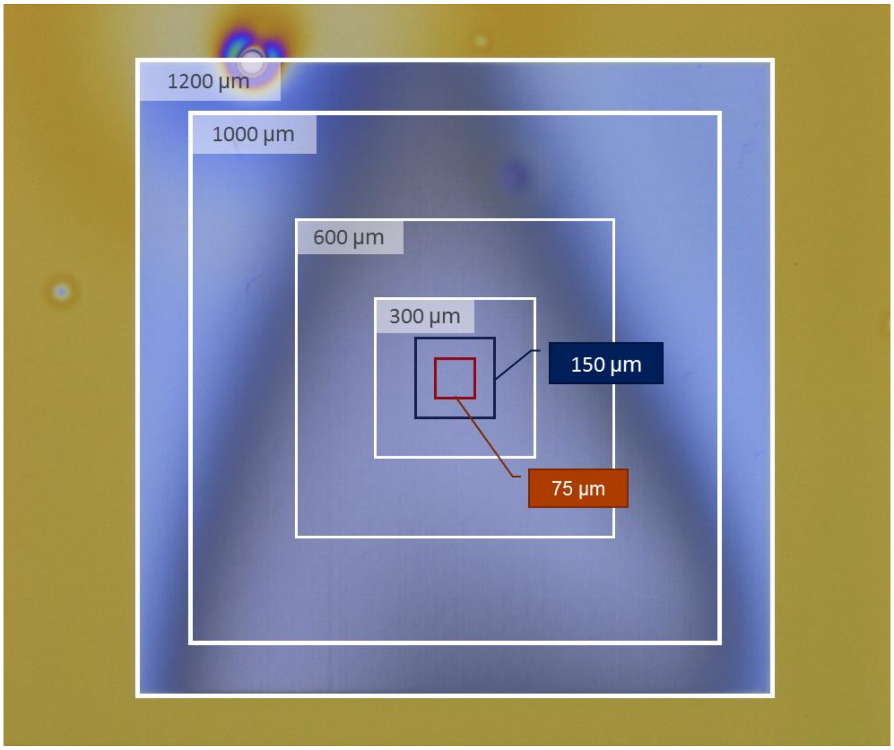
In the images below, field uniformity as a function of aperture is show for an 80nm line and space pattern. The pattern was exposed using 200pA. As expected, field uniformity across a 1200um field size worsens and the aperture size increases.



In the images below, using a 30um final aperture, distortion is apparent as a function of critical dimension. Reading from left to right, the line width increases. Optically, the image with the 300nm lines appears more uniform (except for some slight vignetting in the top left and right corners). As features scale down (reading right to left), the lack of dynamic focus in the tool becomes apparent.



In the final image, field uniformity for 80 lines on a 160 nm pitch can be seen optically. One can deduce that the largest recommended field size to print critical features ≥80nm is roughly 150 µm to maintain reasonable CD uniformity throughout the field.



Conclusions:
Determining field size depends on the constraints in one's pattern. Large feature sizes (≥300nm) are less vulnerable to a fixed focus beam. As expected, as the final aperture increases, field uniformity decreases. In our study, uniformity for feature sizes ≥80nm could be guaranteed for field sizes roughly 300um and smaller for our given process for 200nm ZEP520A atop Si.