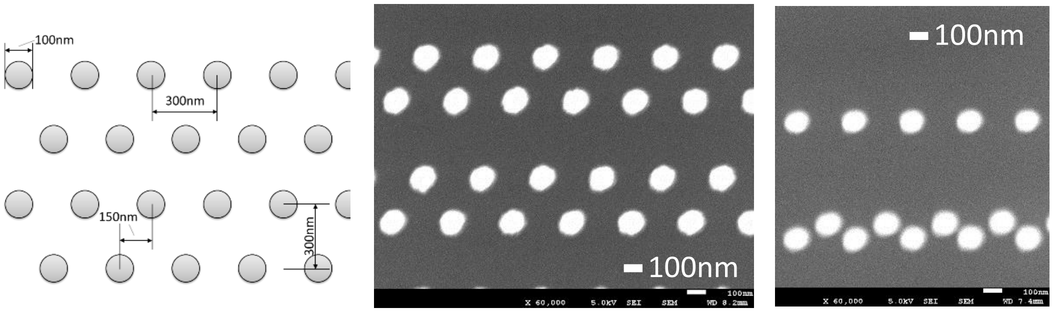
Shape Positional Accuracy Optimization via Writing Order Correction

G. Lopez, M. Metzler, S. Wood, C. Elliott, G. Kim
Singh Center for Nanotechnology, University of Pennsylvania,
Philadelphia, PA 19104

S. Stammberger, R. McCay
GenISys, GmbH, Eschenstr. 66, D-82024 Taufkirchen Germany

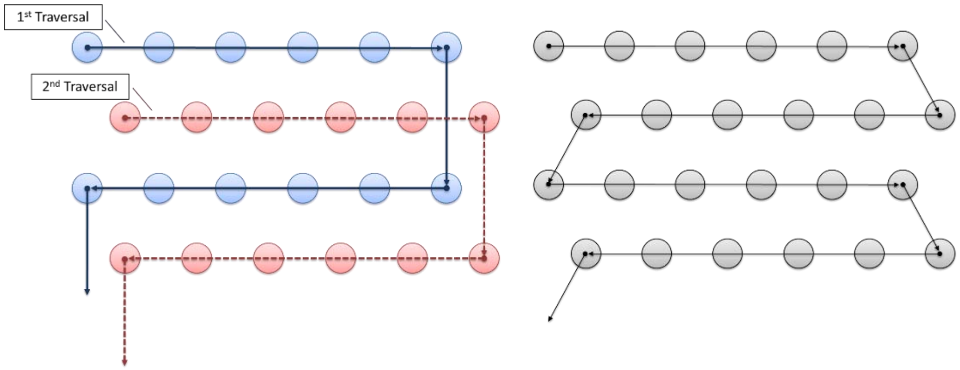
Drift represents a significant processing challenge for shape positional accuracy during exposure. The sources of drift are varied. For example, noise in the environment can introduce error in the positional accuracy of the beam, or the thermal expansion of the substrate or substrate holder can contribute to the distortion seen by drift. However, these sources of drift represent processing challenges that must somehow be tolerated. This paper demonstrates the impact of drift on a hexagonal array pattern of 100nm dots at various pitches. The patterns were exposed on 300nm of ZEP520A on a Si substrate using a 50kV electron beam lithography tool at 1nA with a 60um final aperture and a 20nm beam step size. Samples were developed using o-xylene for 70 seconds at 21˚C, then soaked in IPA at 21˚C for 30 seconds followed by a N_2 blow dry. Using an electron beam evaporator, samples were mounted to a carrier platen to deposit 10nm of Cr (2 Å/sec) and 40nm Au (2.5 Å/sec) at a base pressure of 1 e-7 Torr. Using 1165 stripper at 60˚C for 10 minutes, metal lift-off was performed. Figure 1 shows an image following lift-off of a sample a pattern highlighting poor positional accuracy.

The root cause of the poor shape positional accuracy was due to tool drift during the writing, which correlates in time to writing order of the pattern. The hexagonal array was designed such that a single array was referenced twice where the second reference was offset in X and Y to create the final hexagonal structure. This ordering influenced the final exposure order as illustrated in Figure 2a. In this instance, the first referenced cell was exposed in the first traversal, and then the beam was deflected back to the starting position in the corner of the pattern to expose the shapes in the second referenced cell. Any drift of the tool between the first and second cell exposure yielded poor positional accuracy of shapes. BEAMER by GenISys was utilized to resort the data such that each successive row is exposed as illustrated in Figure 2b and thereby resolve the issue. The resulting center and corner of the pattern after metal lift-off is illustrated in Figure 3. In the text that follows, we will discuss the algorithm employed to resort the data and its applications for proximity effect corrected structures.



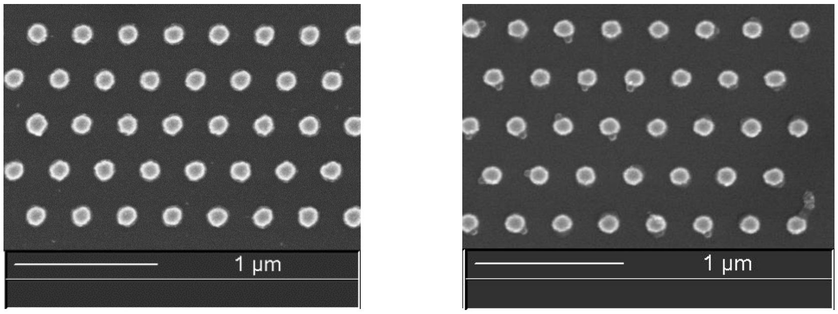
(a) *(b)* *(c)*

Figure 1: Pattern and SEM Image: (a) An example pattern that was exposed in 300nm of ZEP520A atop of bulk Si. Dimensions are shown above. The resulting image after metal lift-off at the center (b) and corner (c) of the array pattern. Loss in shape positional accuracy is apparent especially in the pitch along the Y-axis.



(a) *(b)*

Figure 2: Writing Order: The original pattern had a writing order that exposed the shapes in using two traversals as shown in *(a)*. The writing order obeyed the hierarchical design of the pattern in which a cell reference to an array of dots (blue) was overlaid atop the same cell reference (red to indicate separate traversal) to create the design in Figure 1a. *(b)* Data resorted by BEAMER is ordered such that each row is exposed in succession.



(a) *(b)*

Figure 3: SEM Image Results of Improved Writing Order: The positional accuracy is optimized by the writing order using BEAMER as shown in the center (a) and corner (b).