Geometry assisted PEC for electron beam direct write nanolithography

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ABSTRACT

The proximity effect correction (PEC) in electron beam lithography has been extensively researched for the past thirty years [1- 3]. In spite of this there is a need to revisit PEC for nanostructures below 30 nm. The existing PEC paradigms impose constraints such that PEC is hardly used for features this size. The problem is that in conventional PEC the assumption is that the feature layout, which is supposed to be the final product of the fabrication process, is also the input and boundary condition. This over restricts the possible locations of dose and causes most features below 50 nm to look round and have no sharp corners.

In the optical lithography proximity effect arena, serifs have been used to modify the aerial image to print geometries that are sharper than the incident wavelength [4]. In optical lithography serifs are the only means to create localized dose variations to improve patterning performance. In electron beam lithography the use of serifs, or geometry alterations to modify dose, has been proposed and used already [5, 6] but not for nanoscale structures that need sharp corners. However, it is unlikely that PEC alone, nor serifs alone will be able to deliver high resolution solutions that sub-50 nm lithography requires.

Therefore this paper proposes the combined use of serifs and PEC to achieve pattering performance not attainable before. In this paper a series of design rules will be proposed so that squares and triangles can actually look like squares and triangles all the way down towards the limits of electron beam patterning resolution, i.e. in the 10 nm scale. Examples of the effect of geometry assisted PEC for electron beam direct write nanolithography is illustrated in Figure 1 and 2. We have been able to pattern in HSQ resist squares and triangles down to 25 nm dimensions with corners that have radii of curvatures of the order of 5 nm.

References

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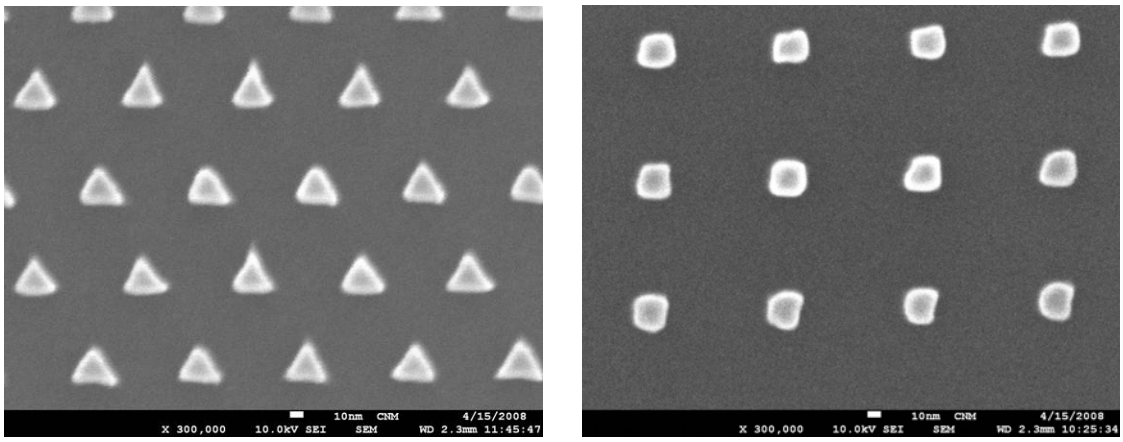

Figure 1. Sub-50 nm triangles and squares patterned in HSQ using serifs in combination with PEC. (left) 25 nm triangles, (right) 25 nm squares.

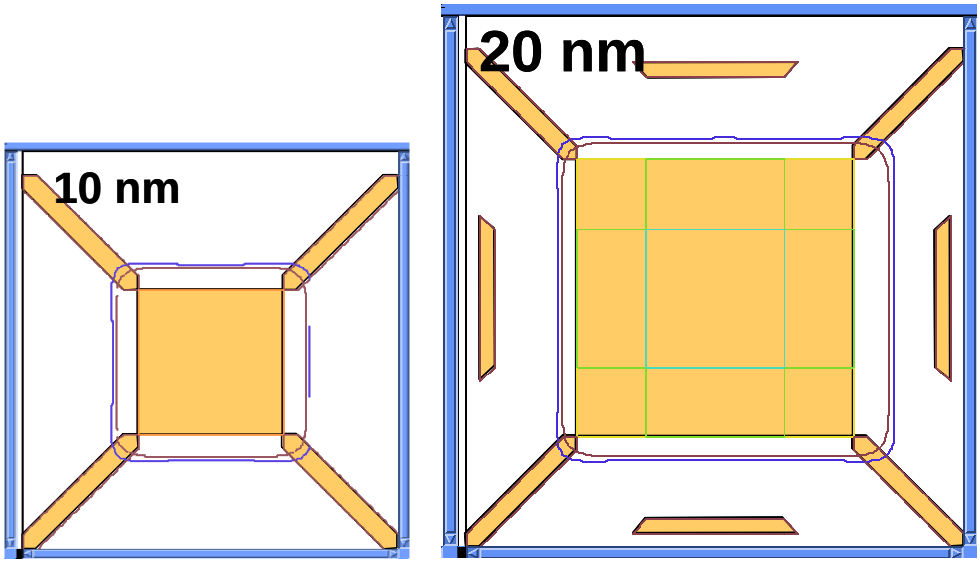

Figure 2. Comparison of PEC with serifs for 10 nm and 20 nm squares. Images are screen shots from Caprox PEC program and scaled to match design square size. Design pattern and dose contour after PEC (smooth curve) are overlaid. A 10 nm square will result in a circle without combining serifs and PEC.