From dose statistics to line edge roughness

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The throughput of a lithographic system is an important parameter. It is tempting to choose the most sensitive resist with the lowest possible illumination dose. In that limit, however, an increase of line edge roughness (LER), is observed.[1] This increase of LER, primarily caused by fundamental quantum noise (shotnoise) effects, becomes the dominant mechanism in the formation of LER.[2345678]

In this theoretical study, we first create a 3D resist pattern with side wall roughness and then image the pattern with a CD SEM. Our goal is to get a direct relation between input parameters such as resist properties or illumination profile and output parameters from typical measurements.

The initial distribution of photo acid generators (PAGs) is found by using a sophisticated simulator for electron-matter interaction.[9] The distribution of PAGs is then used to determine the breaking of bonds in the resist by considering a diffusion like process in the post exposure baking (PEB) phase. We now proceed similarly to the work of Refs. 4-6, where a threshold determines the boundary between exposed and unexposed resist (Fig. 1). In reality, there is also a development phase, which we so far have ignored in this study. We acknowledge that this is a simplified view of post lithographic processing. The exposed resist gives rise to a three dimensional feature which is then fed into our scanning electron microscopy (SEM) image simulator, again using the Monte Carlo simulator. The line edge roughness in the resulting two dimensional top-down image is further processed using power spectrum density analysis of Palasantzas.[10]

We find interesting ways of improving measured LER.

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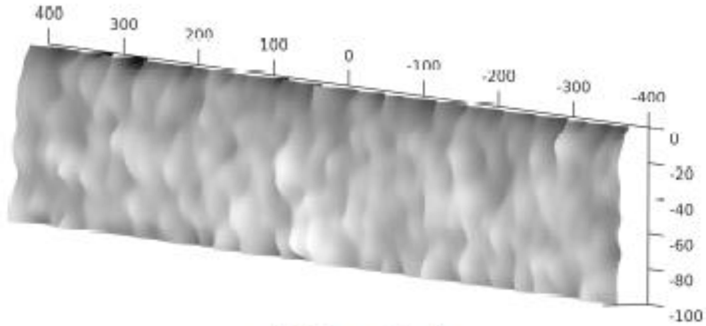
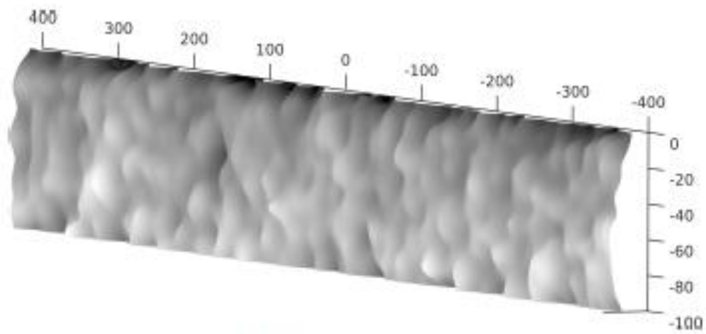
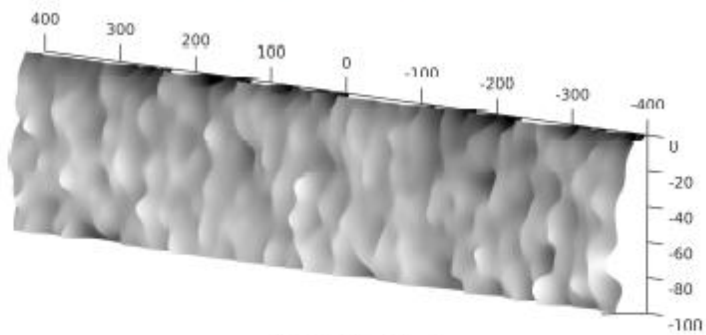


(a) D=80 µC/cm^2



(b) D=60 µC/cm^2



(c) D=40 µC/cm^2

Figure 1: A three dimensional view of the boundary between exposed and unexposed resist. The surfaces are obtained from a simulated exposure of a 100nm thick layer of CAR, which is located on a infinitely thick silicon substrate. The three subfigures (a)-(c) correspond to a Poisson distributed exposure dose of respectively 80 µC/cm^2, 60 µC/cm^2 and 40 µC/cm^2.