Simulating geometry impact on ultra-high resolution pattern collapse

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Today, high resolution dense patterns printed either with Extreme Ultra Violet (EUVL) or Electron Beam (EBL) Lithographies are far from matching ITRS specifications for the 32 nm node realization. Therefore pattern collapse needs to be thoroughly described and simulated, in order to implement pertinent solutions.

In a previous paper[1], we adequately described experimental critical height (H_c) of sub-60nm EUVL and EBL dense lines at which pattern collapse, thanks to a No Deformation Adhesive (NDA) model. It takes into account only adhesive properties of the ESCAP resist considered to the HMDS primed silicon substrate.

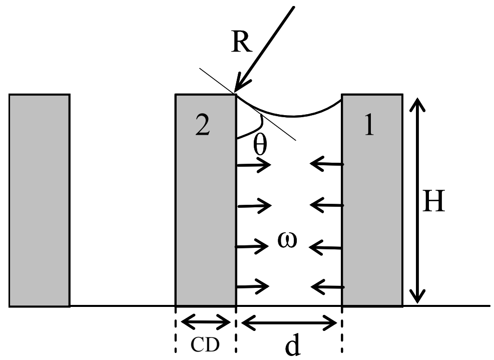
However, in this 2 dimensional model we supposed the simplest geometric configuration of the system at collapse (figure 1), when maximum capillary pressure is exerted on only one side of the resist line. By comparing simulated to experimental results for varying sub-120nm pattern pitchs and geometries (dense versus semi-isolated), we prove here that this classical hypothesis is correct: collapse occurs indeed when the rinse liquid fills the space on one side of the pattern, while no liquid is left on the other side.

Based on this validated model, we furthermore investigate the pattern's shape influence of sub-60nm dense lines on collapse mechanism. Usually, resist lines are considered as perfectly rectangular, whereas SEM observation of EUV and EB patterns show that it is not the case (figure 2).

Thereby, we have calculated, using NDA model, how the slope and the top rounding of the pattern can affect the collapse phenomena. It shows that re-entering slope deteriorates the pattern's holding (figure 3) whereas top rounding improves it (figure 4).

Finally, exposure defaults due to the tools properties, such as stitching (EBL) or exposure dose heterogeneity (EUV-IL), are shown to considerably influence pattern collapse.

[1] A.Jouve et al., Proc. of SPIE, Vol. 6154, to be published.



R : Radius of curvature of the rinse liquid
θ: Contact angle of the rinse liquid on the pattern
ω: Linear capillary pressure
d: Distance between two dense lines
CD: Critical Dimension of the lines
H: Height of the patterns

Figure 1 : Cross section of the geometrical configuration used in the NDA model: The rinse liquid is trapped in the space between line 1 and 2 while the outside spaces do not contain any rinse liquid.

Figure 2: Cross section of 100 nm pitch dense lines printed with EUV-IL.

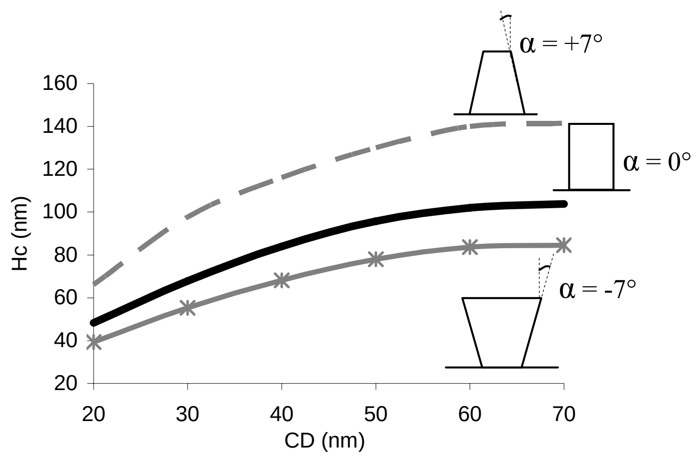


Figure 3: Theoretical critical height (Hc) variation of 120 nm dense lines depending on the Critical Dimension (CD) and the pattern's slope (α). Calculations have been done with the NDA model for MET1K.

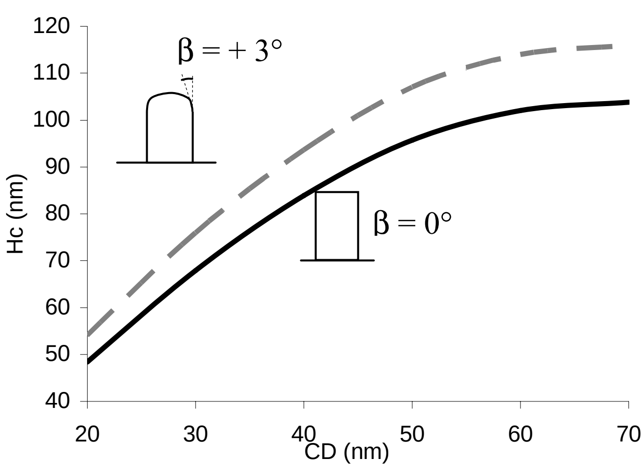


Figure 4: Theoretical critical height (Hc) variation of 120 nm dense lines depending on the Critical Dimension (CD) and pattern's top rounding (β). Calculations have been done with the NDA model for MET1K.