

Optimisation of relative dose exposure for critical features

Lithography processes are complex and require iterative calibration before achieving an optimal result. Specifically, many designs are sensitive to dose variations since these lead to the widening or narrowing critical dimensions (CD) within a layout. The characterisation of such behaviour can be time and cost-consuming, and thus, the simulation of an exposure avoids unwanted outcomes. This BEAMER application note describes the simulation of electron exposure of a device and the estimation of the best dose to achieve a target CD.

INTRODUCTION

Structures in a layout have different response to an exposure depending on many factors, for instance, the local density and the feature size. Accordingly, depending on these factors, the dimension of a critical feature can be very sensitive to dose variations. To show the change of CD of a feature as function of the exposure dose, we use a design for an acmos chip, this layout can be found in the exemplary patterns in BEAMER.

Figure 1 shows the layout and zoomed-in is a feature of dimension 0.75 μm .

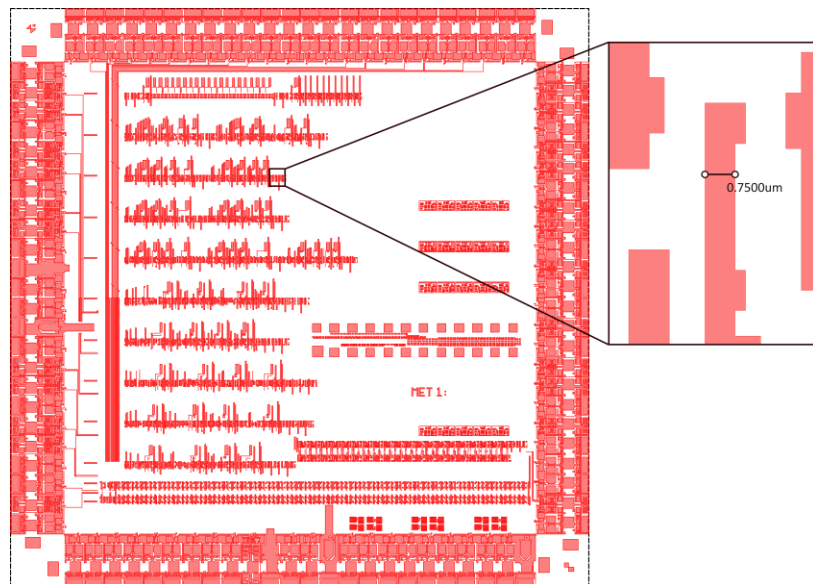


Figure 1. acmos.gds layout and zoomed-in area with CD structure.

PROCESS FLOW

Figure 2 shows the BEAMER flow for the simulation of CD sensitivity to Dose.

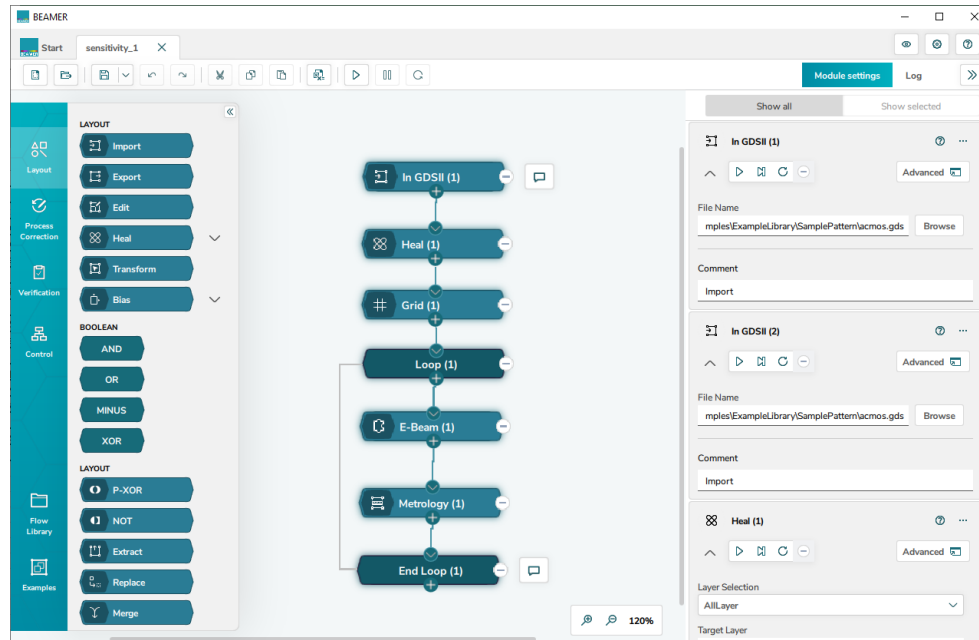


Figure 2. BEAMER flow for the simulation of electron-beam exposure.

PREPARATION OF THE DATA FOR THE SIMULATION

Firstly, the *Import* module loads the layout of interest into **BEAMER**'s environment. Secondly, the *Heal* module removes the overlaps created in the pattern during the design, and finally, the *Grid* module decreases the grid database, in this case the mesh is set to 0.1 nm (see Fig.3). The *Grid* module avoids the simulation snapping to a rather large grid, which leads to inaccuracies in the simulation. Additionally, a small grid mesh results in smoother results.

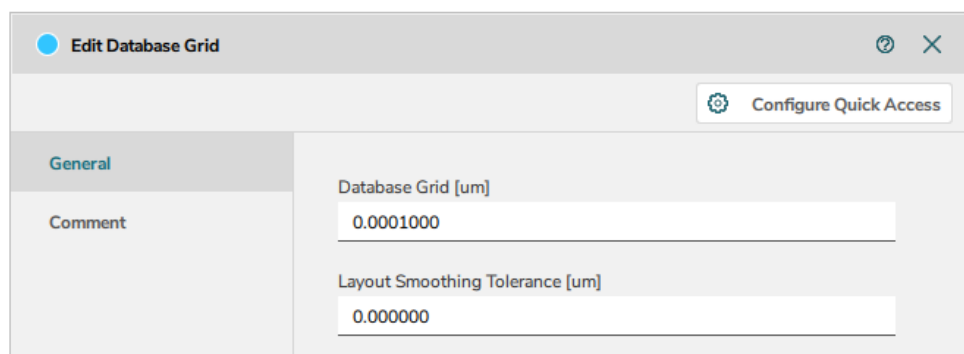


Figure 3. Grid module setting resolution to 0.1 nm.

Once the pattern is optimised, the following part of the flow runs the simulations (*E-Beam* module) and the measurements of the results (*Metrology* module); however, we want to obtain many simulations results in a single run. For this, the *Loop* module facilitates the task by taking the doses for testing.

LOOP MODULE

In the *Loop* module is changed the default `%VarName%` for `%dose%`, this name will be used later within the *E-Beam* module. Later, the module provides the option to *Generate List*. Here, the starting, ending and the step of the dose list are defined. In our example, the *Start Value* equals 1, *End Value* equals 2 and *Step* is 0.1 (see Fig. 4).

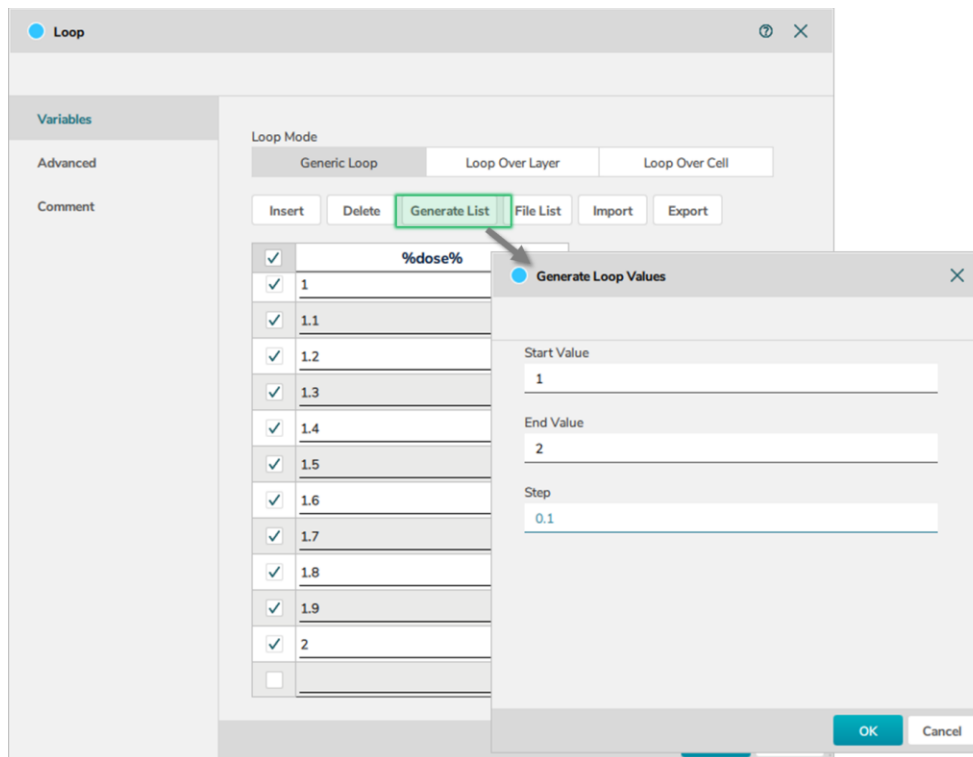


Figure 4. Loop module with settings to generate a list from 1 to 2 in steps of 0.1 for a variable `%dose%`.

E-BEAM MODULE

Next, we use the *E-Beam* module to perform the simulations. In this case, a *Gaussian Approximation* is selected for the PSF representation of the beam. Alternatively, a *Numerical* or *Archive PSF* can be used. Importantly, we use the variable created in the *Loop* module `%dose%` to modify the *Exposure Dose* within the module (see Fig. 5).

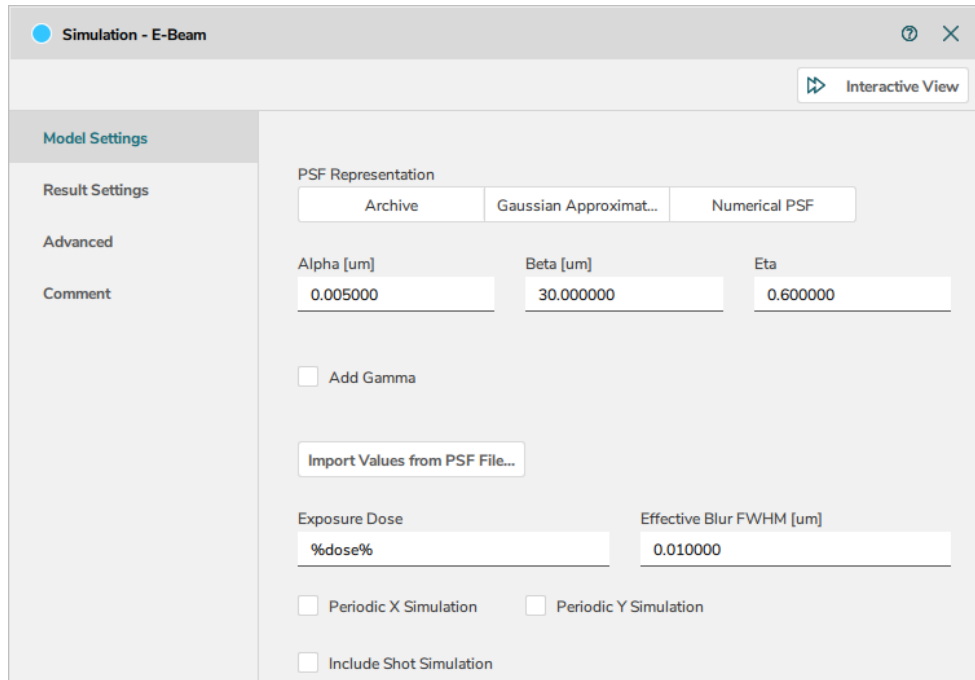


Figure 5. E-Beam module using a Gaussian Approximation and the %dose% variable in the Exposure Dose box.

In the *Result Settings* tab, we select the feature to simulate. For this, the *Interactive View*, which opens the layout in the viewer, we drew a region by using the shift key + left mouse button. Here, we selected a region that is a line that covers the width of the feature of 0.75 μm . Finally, *Contour* is selected as well as the *Perform Line Simulation* (see Fig. 6).

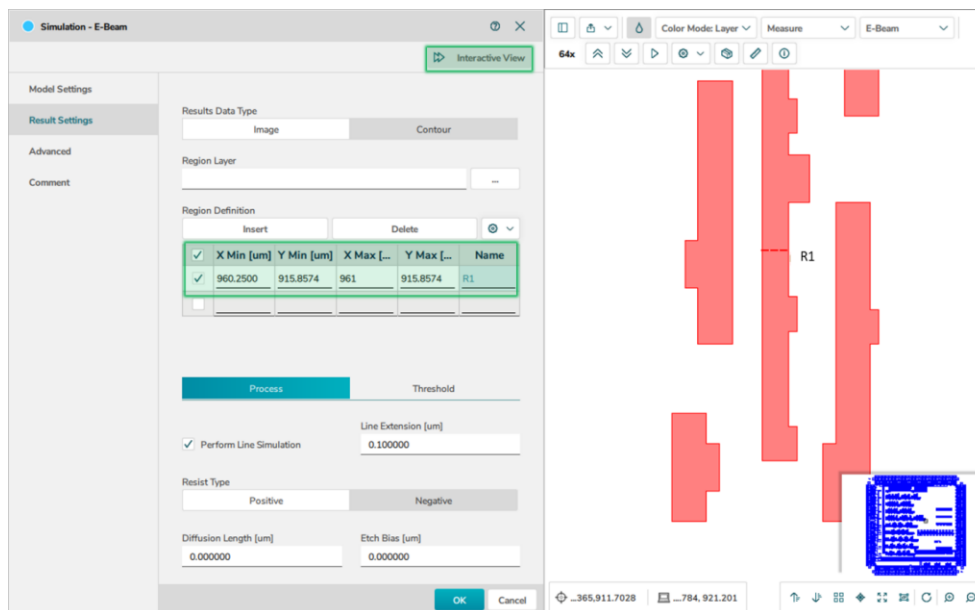


Figure 6. E-Beam module opening the Viewer to draw the region for simulation.

METROLOGY

Afterwards, the coordinates of the line defined in the *Metrology* module are inherited from the *E-Beam* simulation module. However, the values in the x-direction are extended by 50 nm on either side of the region to avoid numerical errors (see Fig. 7).

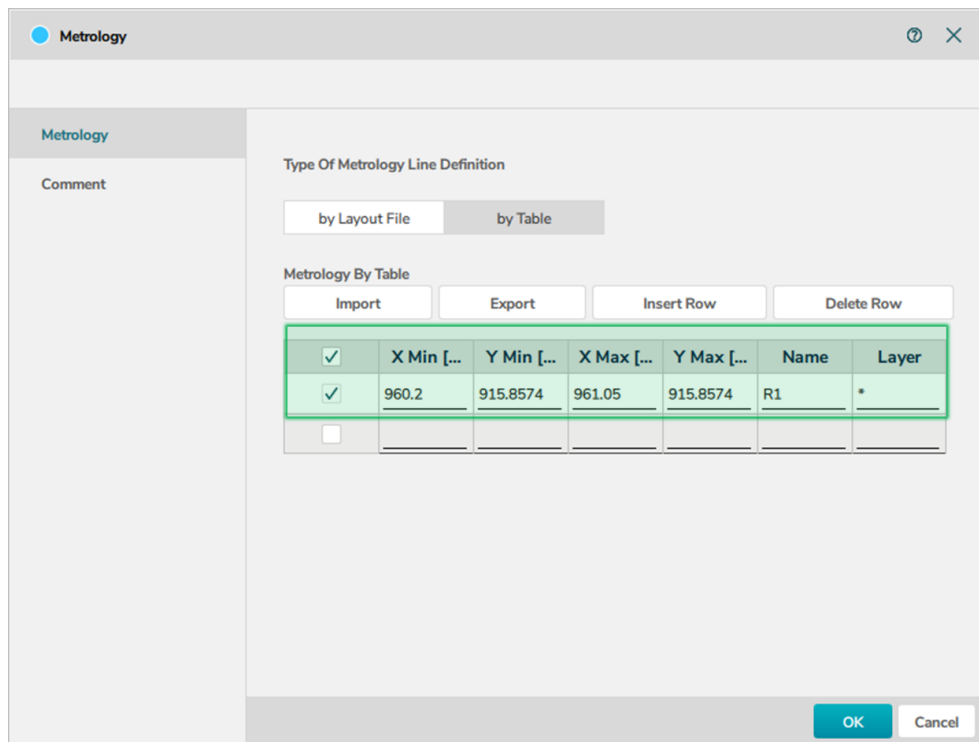


Figure 7. Metrology module increasing the line extension by 100 nm.

The flow is ready to be executed with the settings of all the modules established; therefore, the *Run To* in the *End Loop* is clicked (see Fig. 8 left). After executing, the white mark on the module turns green.

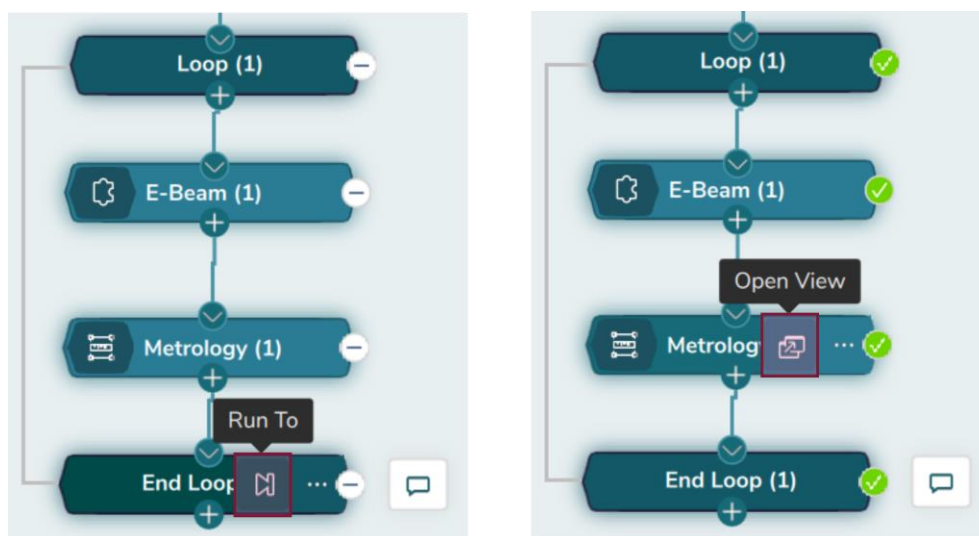


Figure 8. (Left) *Run To* button to execute the flow and (Right) *Open View* to review the simulations results.

RESULTS

Finally, the results are displayed by clicking on the *Open View* icon of *Metrology* module (see Fig. 8 right). Figure 9 shows the results obtained from this simulation. The relative dose varies from 1 to 2 as such that the CD variation goes from 0.743 μm to 0.754 μm . Accordingly, a relative dose of around 1.5 gives a closer CD target of 0.75 μm (see Fig. 9).

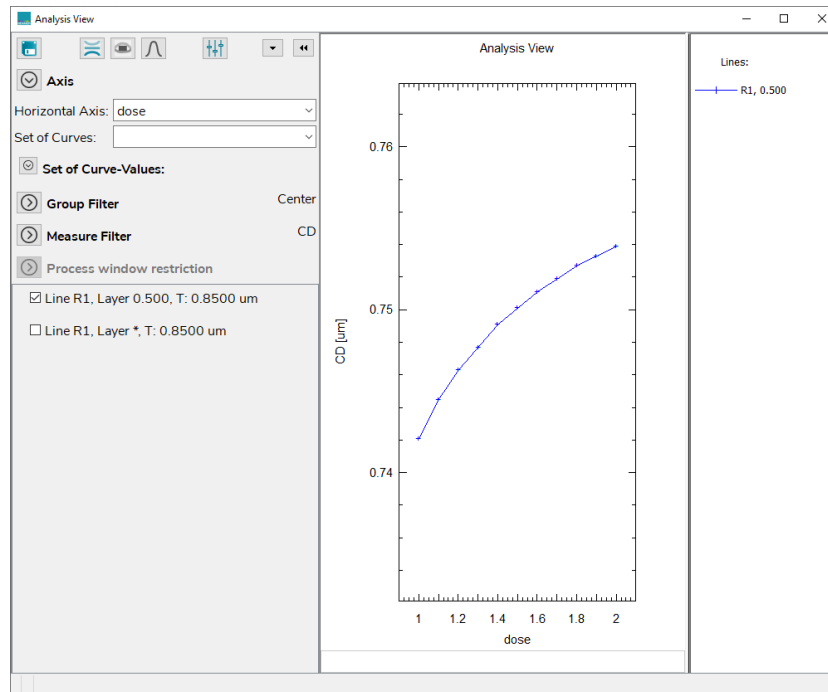


Figure 9. Results of the simulations viewed in the Metrology module.