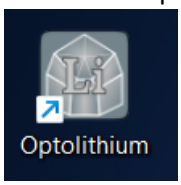
Optolithium Lithography Software Installation Instructions and Example Simulation

1. Download and Install Python 2.7.10. from https://www.python.org/downloads/
   Scroll down and find the appropriate version.
   a. https://www.python.org/downloads/

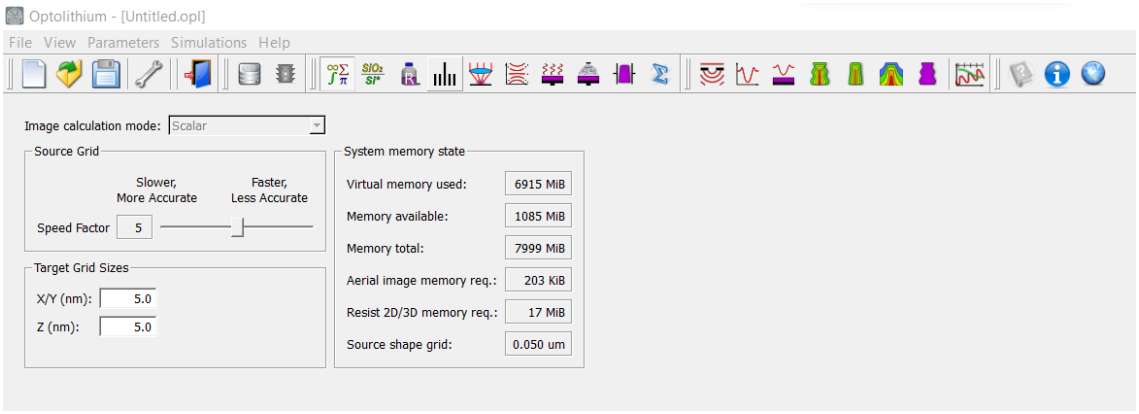
   Alternatively, you may download and install anaconda from https://www.anaconda.com
   Please note that anaconda installation may take significant memory space on your computer.

   Please note that the installation has been tested only on computers running MS Windows 10 and 11.

2. Download Optolithium-0.3.1.msi from
   https://github.com/xthebat/optolithium/releases/download/v0.3.1/Optolithium-0.3.1.msi
   and Install.
3. After install the Optolithium, you will see the desktop icon in your PC.



4. Now launch the program. GUI module will be open. Explore all icons.



5. An example setup file (example1.opl) for running simulations is attached. You can open the setup from file => open => DIR\example1.opl, where DIR is the directory where you have saved the file. Descriptions of various setup parameters of interest are given below. The parameters can be accessed by clicking on “parameters” from the top pull down menu. Various parameter blocks can also be accessed by clicking on the icons below the pull-down menus. For the example exercise, the students
   a. **Numerics**: You may set the x and y resolutions and the speed of calculation (faster the calculation, the error is likely to be more). I recommend that the values are not changed by the students.
   b. **Wafer Processes**: The layers seen by the light as it falls on the wafer surface can be specified here. Different layers (like SiO2, Si3N4, … can be added here). The complex

refractive index of the material being added at the wavelength of light used for exposure should be provided. For this exercise, you may leave these unchanged.

c. **Resist**: Students who are interested in more details about the models mentioned below may explore more in the literature. The model values used in these examples are typical values from the literature.
    i. Tab **Exposure/PEB**: Under this tab, the wavelength for which the resist is optimized (usually provided by the manufacturer of the resist), the refractive index of unexposed resist, and the Dill model for photoresist exposure can be added. The post exposure bake is modeled using an Arrhenius expression and the parameters can be set under this tab.
    ii. **Development**: The Mack model parameters for resist development can be adjusted under this tab. The development rate as a function of photoactive compound concentration calculated using the model mentioned is shown in the graph on the right.
d. **Mask**: One among 4 different masks can be chosen for simulation experiments by clicking on "Load mask". For this example, we will choose "1D Binary – Space". The mask dimensions can be varied for these mask designs. We have not been able to figure out how to specify custom mask designs.
e. **Imaging tool**: The specifications of the lithography equipment like, the wavelength of light, numerical aperture, reduction ratio (of the projection lens), and flare can be specified. Different source shapes and pupil shapes can be selected under this menu.
f. **Exposure and focus**: Exposure dose and the position of the focus can be specified under this menu.
g. **Post exposure bake**: The temperature and duration of the post exposure bake can be specified here.
h. **Development**: Resist development time can be specified in this case.
i. **Metrology**: The 2D results are displayed based on the parameters set under this menu.

The results of the simulations can be seen under "Simulations" pull-down menu.

a. **Diffraction pattern**: Fraunhofer diffraction pattern for the mask feature can be observed here.
b. **Arial image**: Shows the arial image formed on top of the resist during exposure.
c. **Image in resist**: The image formed with in the resist (as a function of depth).
d. **Exposed latent image**: The relative concentration of the PAC in the resist cross section after exposure.
e. **PEB latent image**: The relative concentration of the PAC in the resist cross section after post exposure bake.
f. **Develop Time Contours**: This shows how the resist develops (or removed) with time.
g. **Resist profile**: The profile of the resist after the specified development time can be seen.
h. **Simulation sets**: Suppose that many of the parameters of the lithography process are well set. You would like to explore what happens when a particular parameter is varied.

Exercise: Explore the tool by varying various parameters systematically.

Disclaimer: Please note that the various parametric values are chosen to illustrate the lithography process and may not correspond to lithographic processes you may want to execute in experiments. For realistic simulations corresponding to any particular use case, the parameters provided by the supplier of the lithography system, and the supplier of the photo resists, and/or other reliable sources should be used.