

CNF KLayout Guide

Cornell NanoScale Facility 4/23/20 Version 3. Send suggestions for changes to bleier@cnf.cornell.edu

KLayout is a computer-aided design (CAD) program for editing designs or layouts for photolithography, electron beam lithography, or any fabrication process that uses the GDSII graphic design system format. After making a GDS design file with KLayout, the file has to be transferred to an appropriate location for processing with a data conversion application, which will convert it to the format used by the fabrication tool.

KLayout is available as a free download for Windows, MacOS or Linux from <https://www.KLayout.de/build.html>.

This guide explains how to use KLayout at CNF. It assumes you already understand use of cells in GDS designs. For more detailed instructions about CAD and how to use KLayout, see the following tutorial, video and manual:

Tutorial by Rick Bojko

https://ebeam.wnf.uw.edu/ebeamweb/training/cad_tut_main/cad_tutorial_main.html

Tutorial video <https://www.youtube.com/watch?v=aq5BHvxG3Q0> (30 min 35 s)

KLayout Basics <https://www.KLayout.de/doc-qt5/manual/basic.html>

1. Starting KLayout

Running KLayout on your own computer

If you downloaded KLayout and installed it on your own computer, you can use KLayout there and transfer the GDS file to CNF. See section 4 below for file transfer information.

Running KLayout natively on CNF PCs

Double-click the KLayout icon on the desktop of a CNF Windows PC.

Logging into a CNF Linux server that runs KLayout

- from a CNF ThinLinc station or a ThinLinc client on your computer
 - If you are using the ThinLinc client on your computer, connect with the Cornell VPN and start the ThinLinc client application.
 - Log into the ThinLinc server with your NetID or Guest ID and your NetID or Guest ID password.
 - In the Applications menu at upper left, pick **CNF -> Minx** or **CNF -> Korat**. You will be logged into the server automatically.

- from a CNF Windows PC
 - Double-click the **Xming** icon on the desktop to start the X Windows graphics display server on the PC. A small X icon will appear in the system tray in the lower right corner of the screen.
 - Double-click the **Minx** or **Korat** icon on the desktop. This starts a PuTTY secure shell (ssh) session on minx or korat. Log in with your NetID or Guest ID and your NetID or Guest ID password.

Running KLayout after logging into a Linux server

- Type the following command at the prompt in the terminal window:

```
klayout &
```

2. Using KLayout for CNF Lithography Tools

The first time you start KLayout it will show a dialog about showing “top level” or “full hierarchy”. Press **Yes** to show full hierarchy.

To get a local copy of the help system, choose **Help -> Assistant**.

As Rick Bojko writes, “KLayout has two very distinct operating modes: **VIEWER** and **EDITOR**. If you start KLayout and you only see **Select**, **Move** and **Ruler** in the toolbar, but no other options, then you are in **Viewer** mode, and you can’t edit anything. Select **Preferences** (File -> Setup for you windows [and Linux] folks), then under **Application:Editing Mode**, check the box ‘Use editing mode by default’, quit and restart KLayout and you should be in edit mode with 9 different options in the toolbar.”

When you create a new layout from the File menu, you have to give a name to the top cell, for example mywafer.

Before you can draw anything, you have to create layers using **Edit -> Layer -> New Layer**. Give each layer a name such as BOUNDARY or MASK1, and enter a layer number from 1 to 62. Layer numbers outside this range may not work with some data conversion software. **Create a layer for the boundary (more about this later) and layers for each lithography exposure.**

The best way to organize a layout is to **make each layer in the design file correspond to a lithography step**. Data conversion software reads in all the layers, and then extracts one or more layers to make a mask or to use in an e beam exposure. If there will be only one exposure on a physical layer of the device, such as metal or oxide, you can give that layer the name of the physical layer. **Every layer should have a unique GDS layer number and you should write down the layer numbers for future use with the data conversion software.**

For the Heidelberg laser writers and JEOL e beam lithography systems, **designs are required to be bounded by a polygon centered on the origin of the coordinate**

system. If you will use a stepper or e beam system, create one device in a rectangle, and later you will program the lithography system's software to make arrays of the device on the substrate. If you will use a contact aligner, you can make a bounding circle to represent a wafer, and instance the device cell as an array on the wafer in KLayout.

Everything else you draw should be on a layer that is not the boundary layer, because you will discard the boundary layer after reading it into the data conversion software. The boundary layer *is* needed to establish the coordinate system.

Even if you will use a reduction stepper which will reduce the size of features on the mask by a factor of 4 or 5, **draw everything the size you want it to be on the substrate.** The data conversion software will scale the layout before making the mask.

To make a rectangle, select a layer from the list of Layers at upper right, then click the **Box** button in the toolbar and click on the locations of two corners to define the rectangle. To edit its size and position, press the **Escape** key on the keyboard or press the **Select** button on the toolbar to get back to Selection mode, and double-click on the rectangle. You can also single-click on it to select the rectangle, and use **Edit -> Selection.** Use the **Center/Size** tab to set the center to (0,0) if it's a bounding box .

- If you are making a boundary for a single device on a stepper, make it larger than the device and smaller than the maximum die size of the stepper.
- If it's for the JEOL 6300, it can be as large as $150,000 \mu\text{m} \times 150,000 \mu\text{m}$ and if it's for the JEOL 9500 it can be as large as $200,000 \mu\text{m} \times 200,000 \mu\text{m}$. But normally you should just make it larger than the device, plus any chip marks that will be used for alignment.
- Use **Display -> Zoom Fit** or **F2** to view the entire layout.
- If it's for a contact aligner, you can make a circle representing the wafer by first making a box with width and height the same as a wafer, then round its corners:
 - Make a box with center at (0,0) and size $100,000 \mu\text{m} \times 100,000 \mu\text{m}$, for example, then press **Esc** to get back to selection mode, and click on the box once to select it.
 - **Edit -> Selection -> Round Corners.** Set outer corner radius to $50000 \mu\text{m}$ and Number of points (for full circle) to 100.

3. Common operations

Function	Method
View entire layout	Display -> Zoom Fit or F2
Move the view of the layout (pan)	Arrow keys on keyboard
Zoom	Scroll with scroll wheel on mouse
Switch from drawing to selection mode	Select button or Esc key
Select a shape	While in selection mode, single-click on shape
Move a selected shape	Click Move button in toolbar, then click and drag, then click again

Function	Method
Toggle display and use of a layer	Double-click on layer name in layer list at upper right
Define a rectangle	Click Box button in toolbar and click on two corners
Define a polygon	Click Polygon button, click on polygon vertices, double-click to create the last vertex
Define a path or wire	Click Path button, click on path locations, double-click to create the end point
Edit a shape	While in selection mode, double-click on the shape, or select the shape by single-clicking on it and use Edit -> Selection
Display a cell	Right-click on cell name in the cell list at upper left and pick Show as New Top

4. Transferring Design Files from KLayout to Data Conversion Systems

After you save the design and quit KLayout, you have to put the GDS file in the right place for conversion to the fabrication tool format.

Transfer for conversion with Heidelberg mask maker software, for photolithography

- If the GDS file is on a CNF PC, copy it to the Heidelberg DWL200 folder or the Heidelberg DWL66fs folder on the lab transfer file system, which is mounted as the V: or Z: drive on the PC.

- If you used KLayout on a Linux server, you can copy it by typing

```
cp YourFilename.gds /cnflab/Heidelberg\ DWL2000
```

or

```
cp YourFilename.gds /cnflab/Heidelberg\ DWL66fs
```

Transfer for conversion with GeniSys LayoutBEAMER, for E beam lithography or for mask making with a Heidelberg laser writer

LayoutBEAMER can import GDS files (and many other file formats) and export files for JEOL e beam lithography systems or for Heidelberg laser writers.

LayoutBEAMER runs on the Linux servers, so it can import GDS files from your home directory or subdirectories. If you made the GDS file on korat or minx, just put it in your private folder or a subfolder.

If you made the GDS file on a CNF PC, put it on your W: drive in the private folder. The W: drive is the same as your home directory on the Linux servers.

File transfer from outside CNF

There is a firewall between the CNF cleanroom, where the Heidelberg laser writer folders on /cnflab are, and the Internet. One method for getting around the firewall is to upload to box.com from outside the firewall and then, inside the firewall, download from box.com.

- Use a web browser to upload the GDS file to box.com or to cornell.box.com.
- Use the Cornell VPN and a ThinLinc client to log into a CNF ThinLinc server and run a web browser to download from box.com.
- If converting with Heidelberg software, put the file into
 - /cnflab/Heidelberg DWL2000 or
 - /cnflab/Heidelberg DWL66fs
- If converting with LayoutBEAMER, put the file in your private folder on the ThinLinc server.