Tanner EDA L-edit (Layout Editor)

Tanner Tools … “Speeding Concept to Silicon”

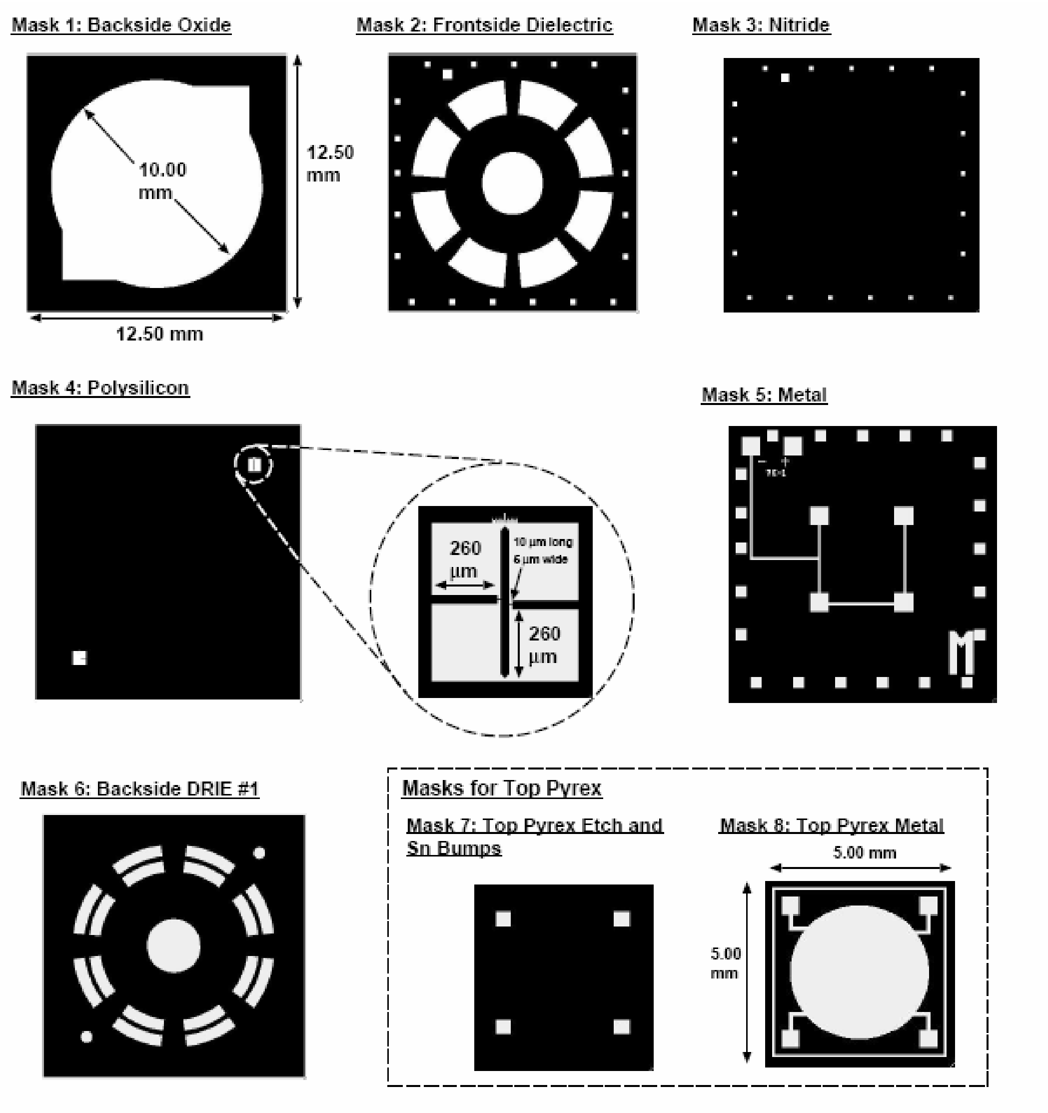
EDA=“Electronic Design and Automation”

http://www.tanner.com/eda/

Layout

Layout is essentially a drawing process. You are drawing the two-dimensional geometries that will end up on your mask. Layout tools are essentially CAD drawing tools, but include additional useful features.

Every area of each mask will be either opaque or clear. That is what you are trying to define… which areas are which.



Files and Tapeout

Your end product is a file which contains the data for your mask. The process of transmitting the data to a foundry who will build your device is called “tapeout”… you are sending your magnetic tape out.

Standard format is **GDSII** (“Gerber Data Stream Information Interchange”). It includes information on the **layers** of your design and the **2D geometries**.

OASIS (Open Artwork System Interchange Standard) is a new (2004) specification which is attempting to replace GDSII. It is more efficient in its storage format (10-50 times) than GDSII.

Other common formats are **CIF** (Caltech Interchange Format), **DXF** (Drawing Exchange Format…AutoCAD), and Gerber (Printed Circuit Board…PCB) files.

Sometimes companies will charge you an additional fee to convert your CAD format into GDSII so they can make your masks.

Layout Editors

Commercial Code:

Cadence "Virtuoso"
Mentor Graphics "IC Station" → IC Industry Leaders

Tanner EDA "L-edit" → MEMS Centric

Freeware:

Magic → IC Centric, established Gnu software

Layout Editor → IC and MEMS, Freeware, Reads/writes GDSII, CIF, DXF, OASIS

Why Tanner EDA L-edit?

MEMS Centric : Includes curved features!

License is less expensive the Cadence/Mentor Graphics.

Runs on PC (not UNIX).

Better than freeware (although Layout Editor looks pretty good!)

But… any of them would work just fine (except for Magic, maybe). I did my PhD work in Mentor Graphics. Tufts ECE uses Cadence for VLSI work.

Goal:

We have a 3 layer process with a 4 micron minimum feature size.

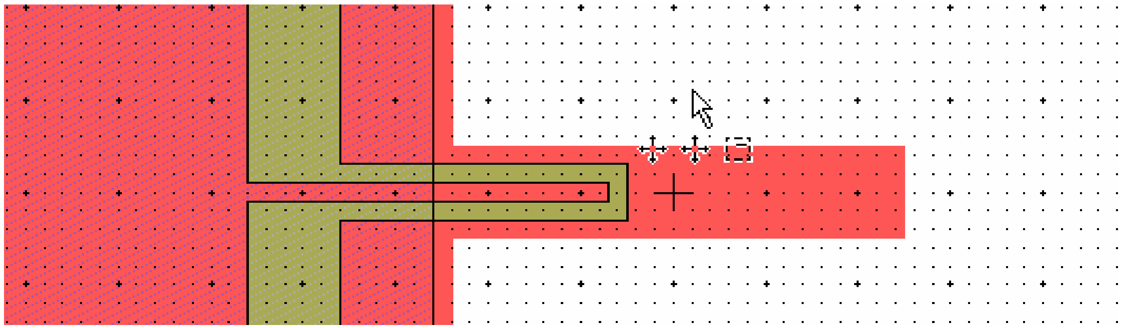
The three layers are:

(1) A silicon nitride structural layer (“nitride” GDSII layer 1)

(2) An anchor layer where we etch through our oxide to attach the beam (“anchor” GDSII layer 2)

(3) A metal layer for use as a strain gauge and as electrical connections (“metal” GDSII layer 3)

I want to design a cantilevered beam with a metal strain gauge on it.



Launch L-edit

File and Cell Name

Location

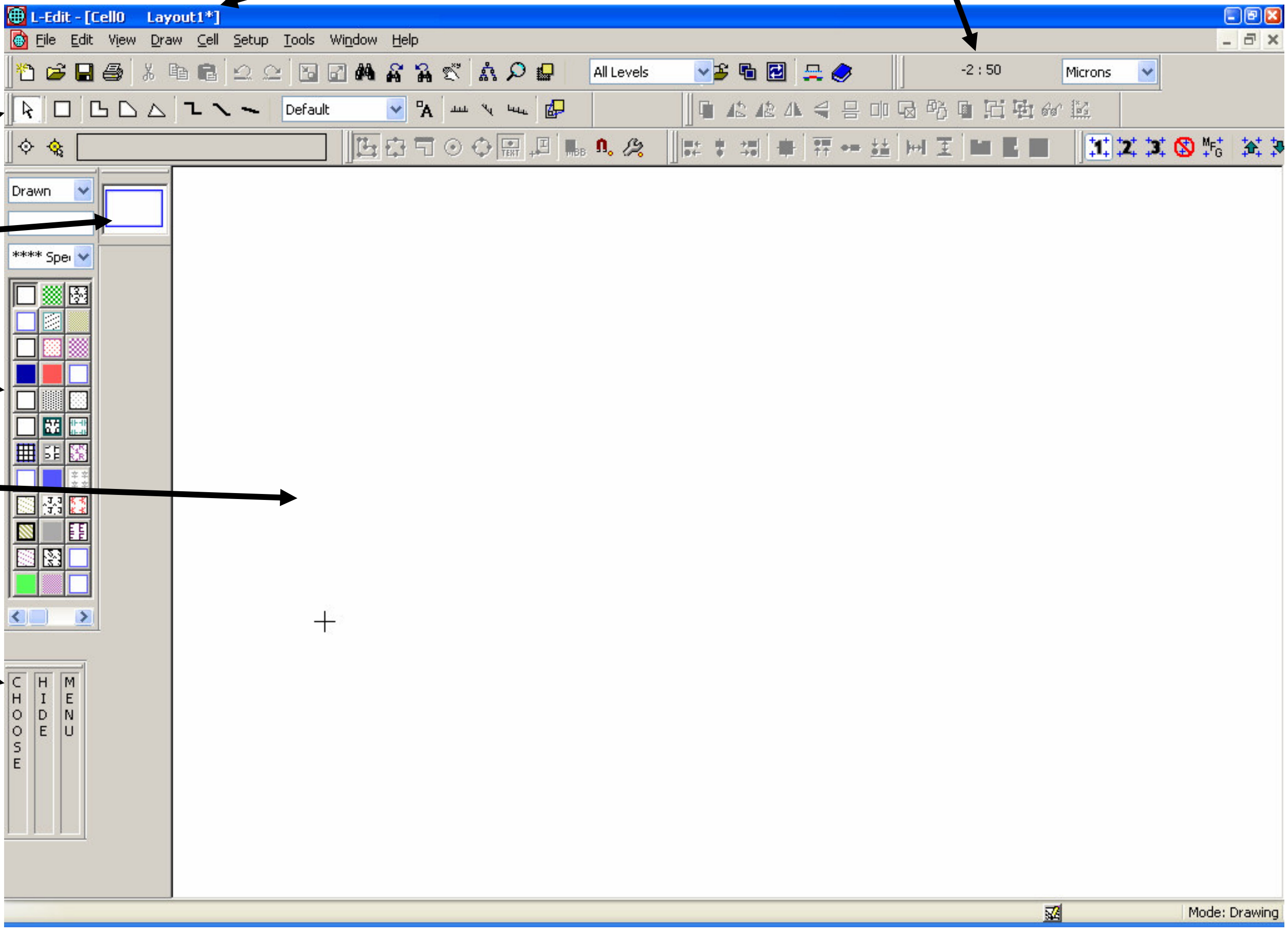
Toolbars

Aerial View

Layer Palette

Drawing Window

Mouse Buttons

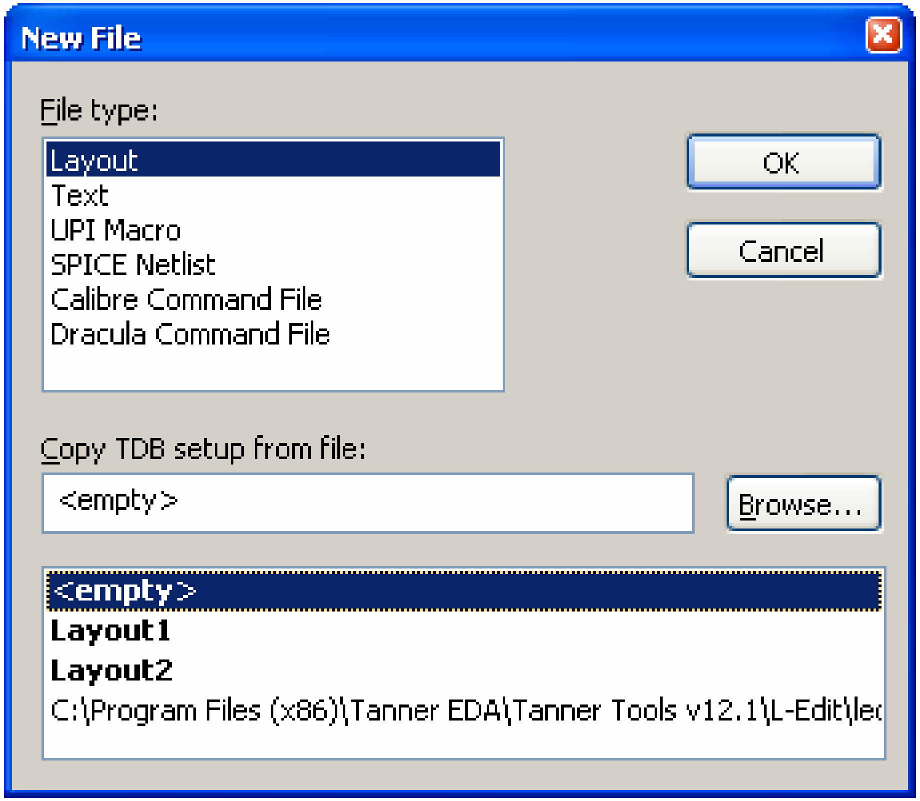


Start Menu

Engineering and Science Apps

L-edit v12.1

Make a New File



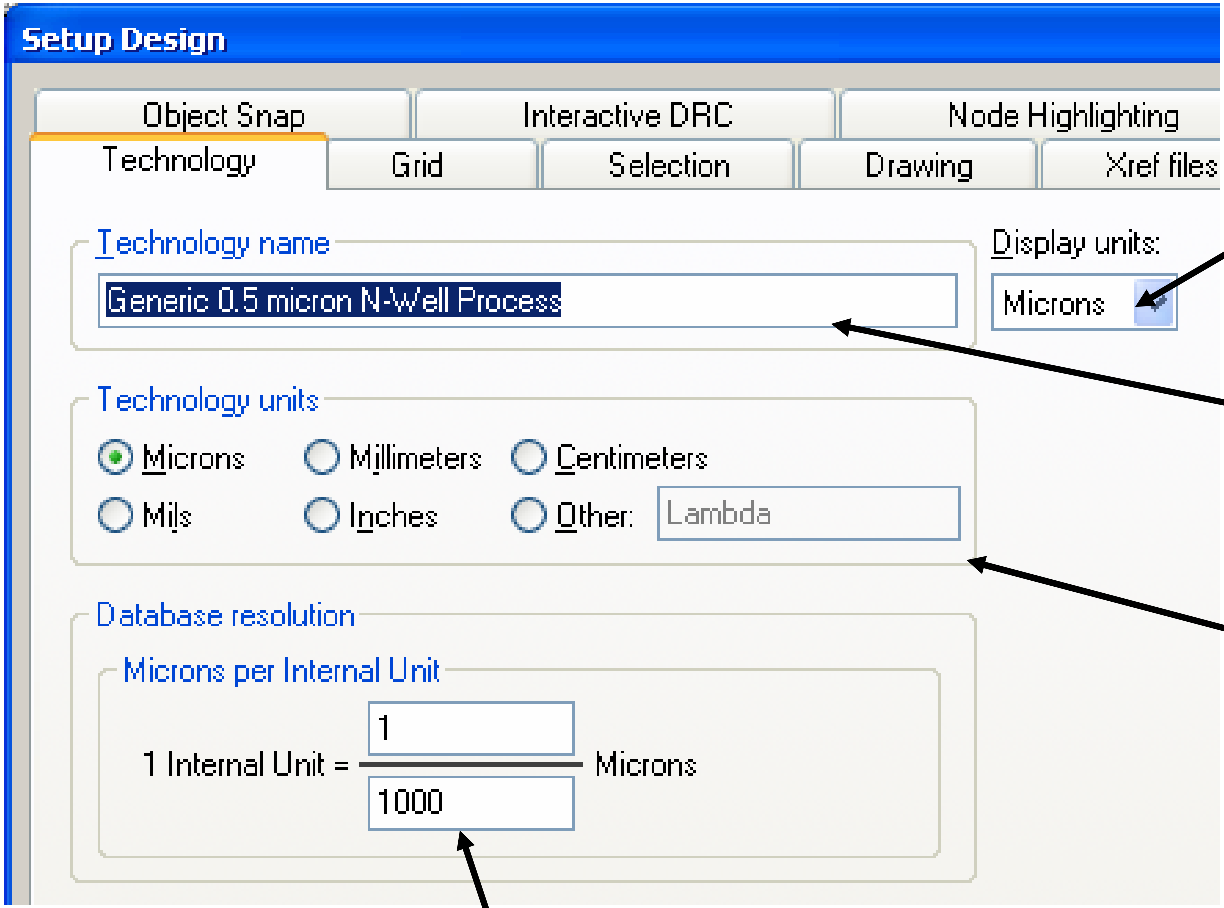
This will create a new layout with a name like "Layout1" and with a single cell, "Cell0".

Make a new file of type "Layout".

"TDB" is "Tanner DataBase"… your layout will be saved in a TDB file, a proprietary Tanner format. If you want to copy setup information from an existing TDB file, browse to it. (For instance, this could copy Design Rules and Layer Names). Select <empty> for a new file with no setup information.

Setup Technology

Go to Setup | Design. Technology tab.



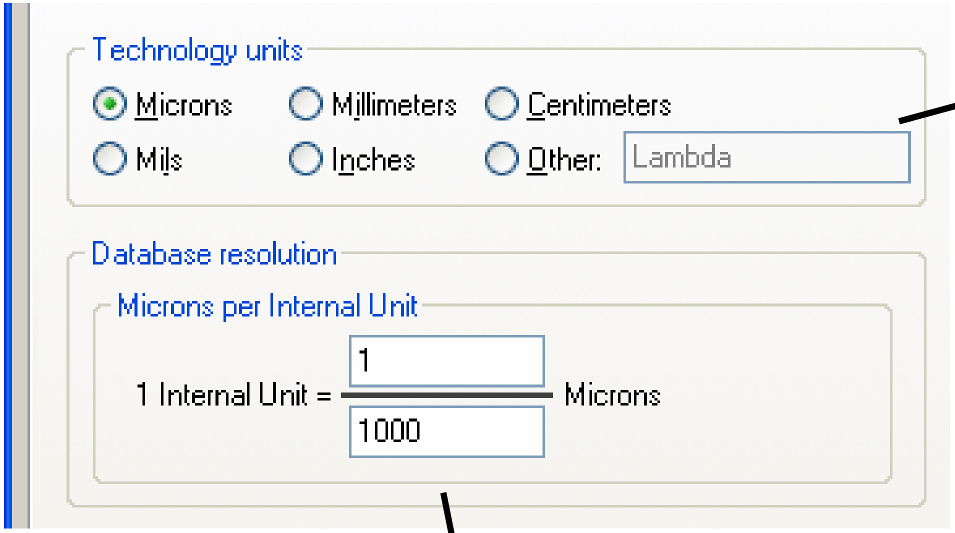
As displayed on screen. Microns is a good default.

Create a name for your fabrication process.

This is the unit in the technology…that is, the fabrication process. What is the natural unit to work in? For 0.18 micron process, it would be 0.18 microns.

Internal units are what is actually used in L-edit to store the information. This is **not** what is displayed to you (see display units above). However, you need to know this when you export your final design to GDSII. The default for GDSII is that one database unit is 1 nm (1/1000 microns).

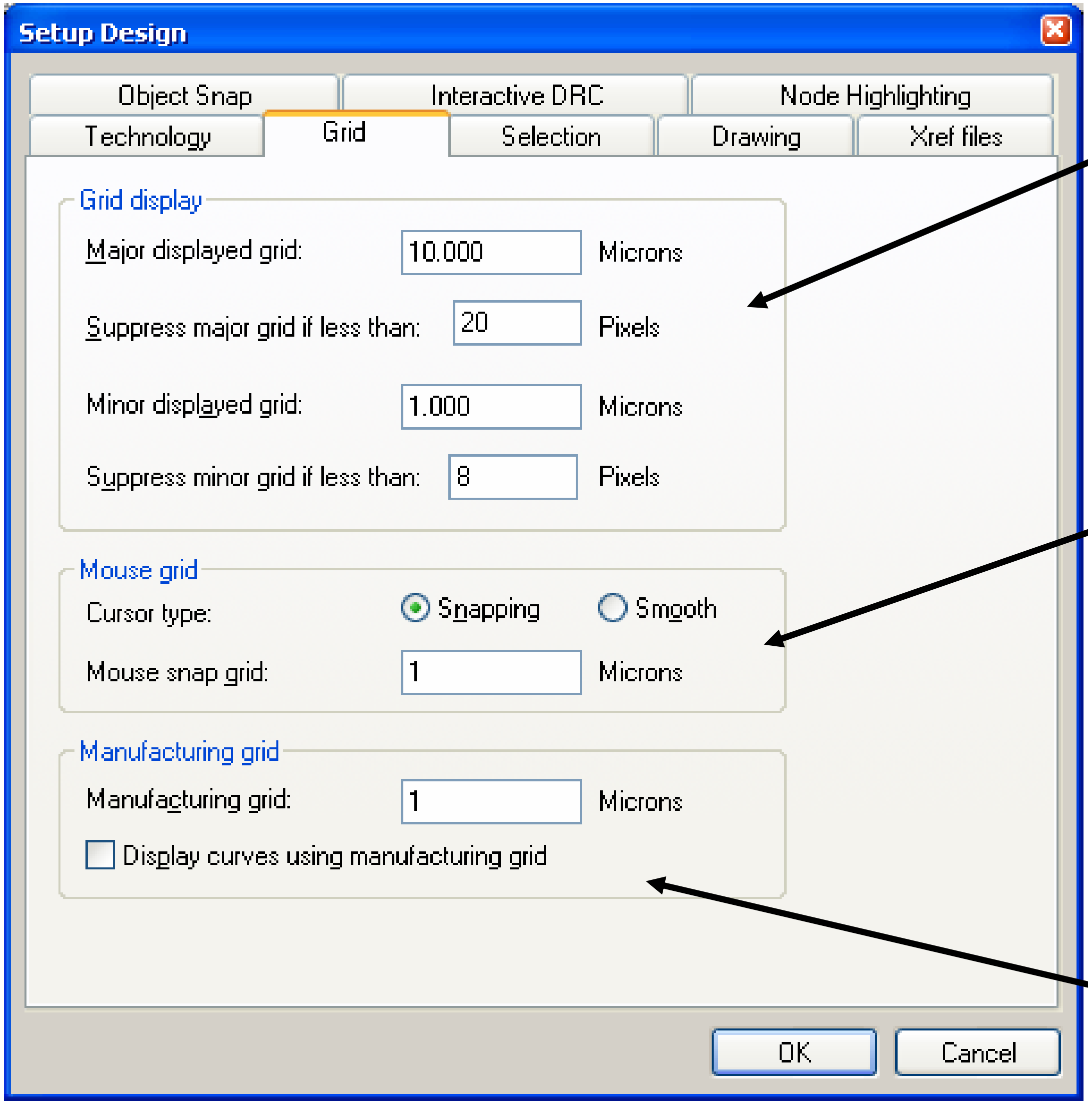
Setup Technology



This is the unit in the technology…that is, the fabrication process. What is the natural unit to work in? For 0.18 micron process, it would be 0.18 microns. Then you would have “technology units” of lambda, where 1 lambda=0.18 microns. **For our purposes, it is best to leave technology units as 1 micron.**

Internal units are what is actually used in L-edit to store the information. This is **not** what is displayed to you (see display units above). The default is 1 nm (1/1000 microns), which is the same as GDSII default. This will be the smallest increment you can store, and will also determine the max size of your design (L-edit max size is -536,870,912 to +536,870,912 units)… at 1 nm = 1 internal unit, this is something like 42 inches on a side. **Keep default of 1 nm per internal unit.**

Setup | Design | Grid

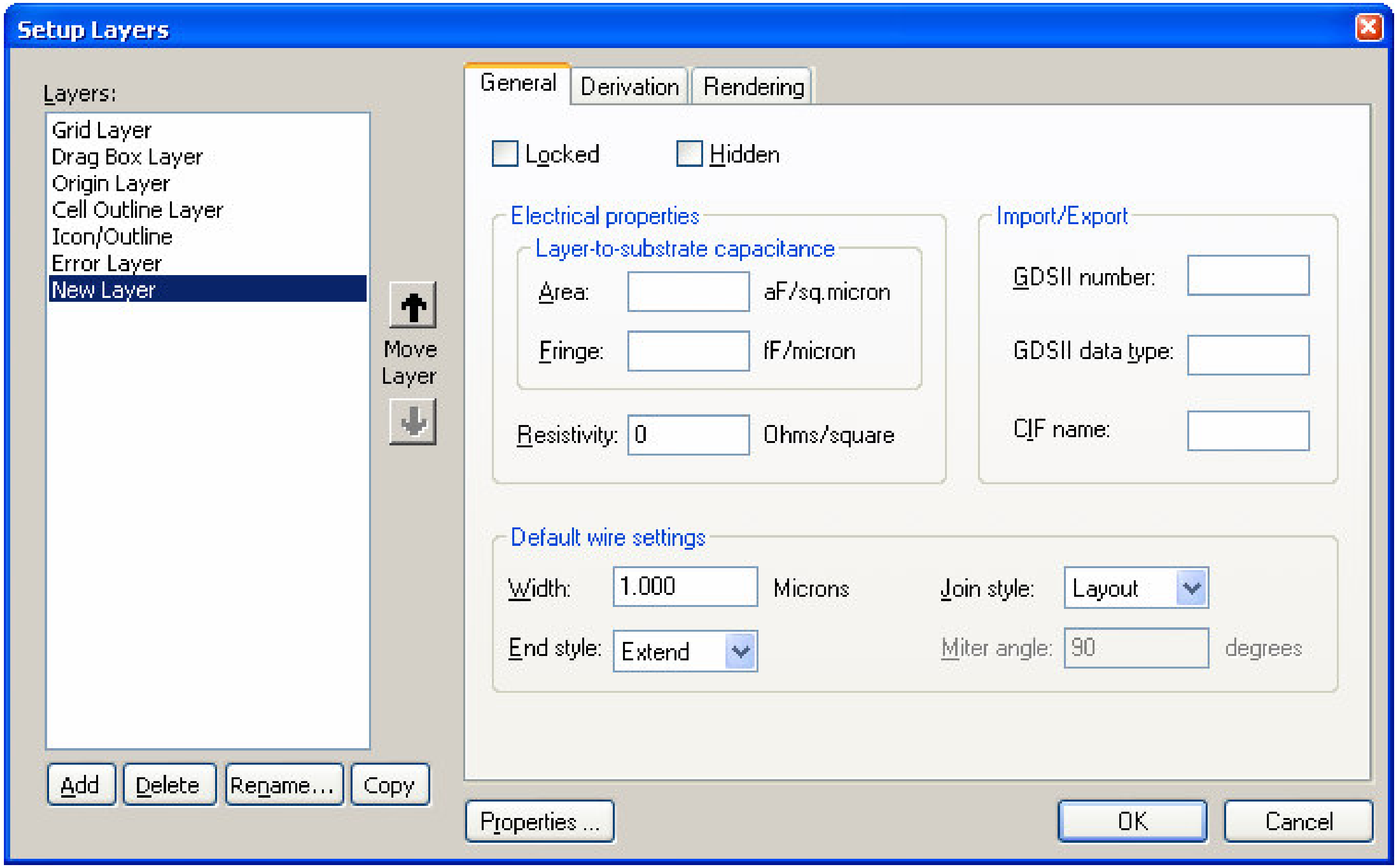


These are just the dots shown on the screen.

This is where your mouse will snap to. If you want to make sure you don't make anything smaller than your minimum feature size, set the mouse snap grid to your minimum feature size.

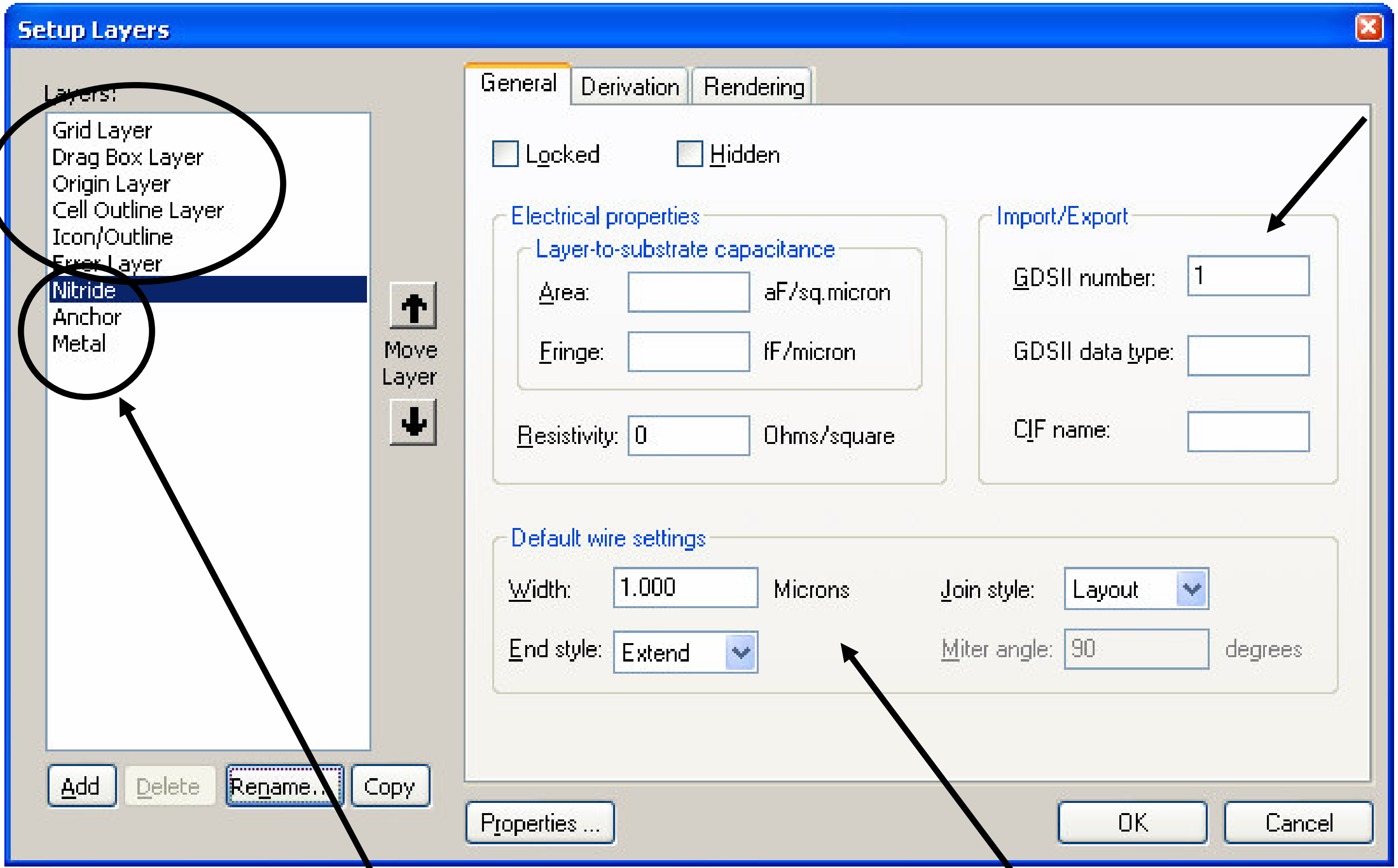
This is the minimum feature you can make in your process.

Setup Layers



Create all the layers you want in your design. Easiest thing would be one layer per mask. You can set the appearance of the layer (color and pattern) under "rendering". We will talk about derived layers later.

Setup Layers



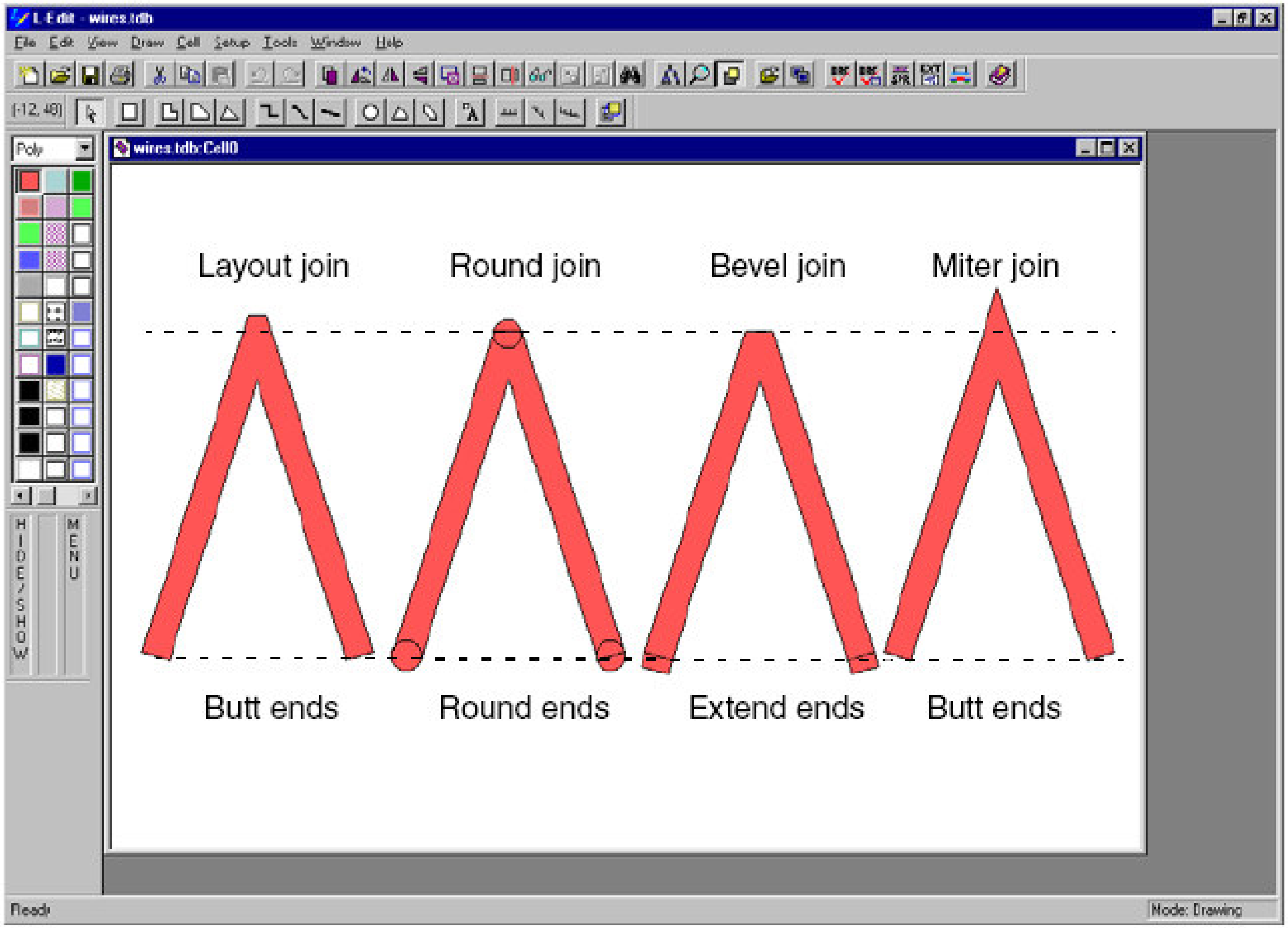
When you export to GDSII or CIF, this layer will be exported as that GDSII or CIF layer.

Used by L-edit… don’t mess with them.

Add layers you want… define their name and rendering.

If you plan to make wires in that layer, you can set a default wire width and end/join style.

Wire Default Meanings



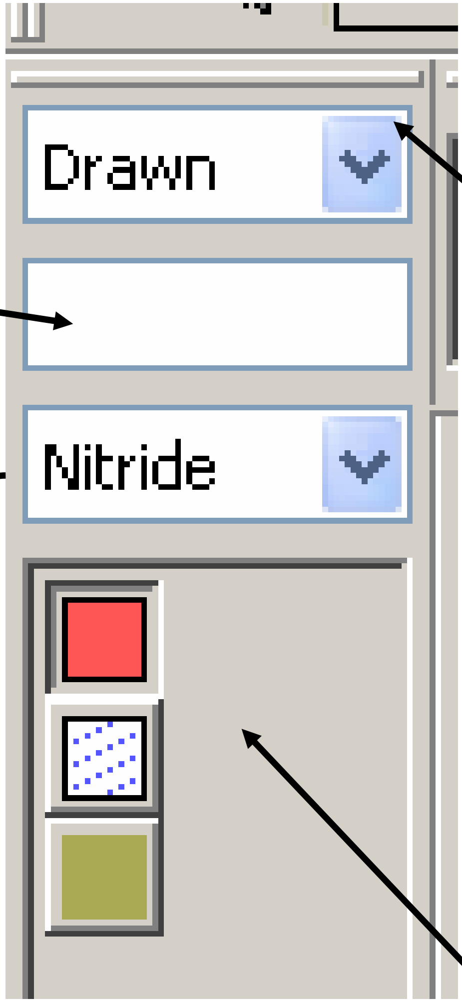
Do This:

1) Create a new layout with an <empty> setup.
2) Make sure working units are microns and internal units are nm.
3) Set mouse snap to 1 micron and manufacturing grid to 4 microns.
4) Define three layers: nitride, anchor, and metal. Give them some interesting color/pattern so you can tell them apart.
5) Define the default wire width on metal to be 4 microns.
6) Set the GDSII layer numbers to 1 for poly, 2 for anchor and 3 for metal.

Layers

You can also select layers here.

Here are all the layers in your layout. They can **correspond directly to masks**, or they can **correspond to logical units** (such as anchors, holes, structures, channels) which may eventually be group together into a single layer to make your mask.



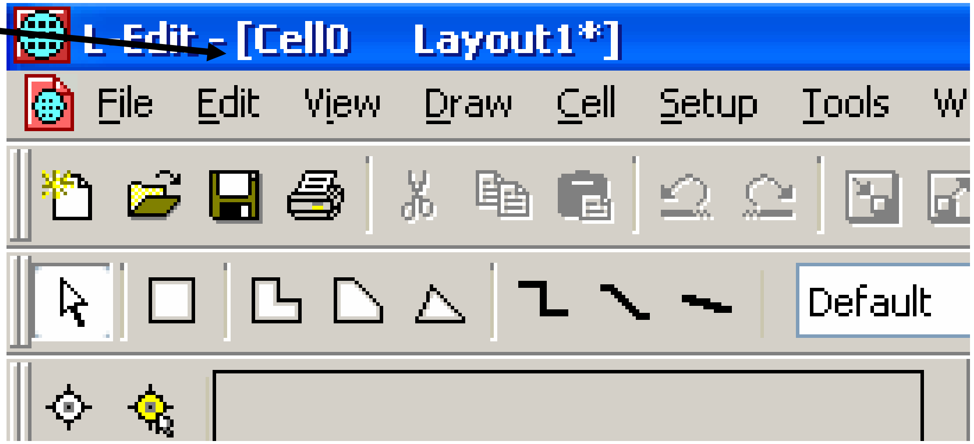
You can select whether Drawn, Generated, Special, or All layers are visible in the pallete.

Right click over layer palette to “show all”, “hide all”, etc.

Mouse over a layer button to make the layer active, and to hide and show it.

Cells

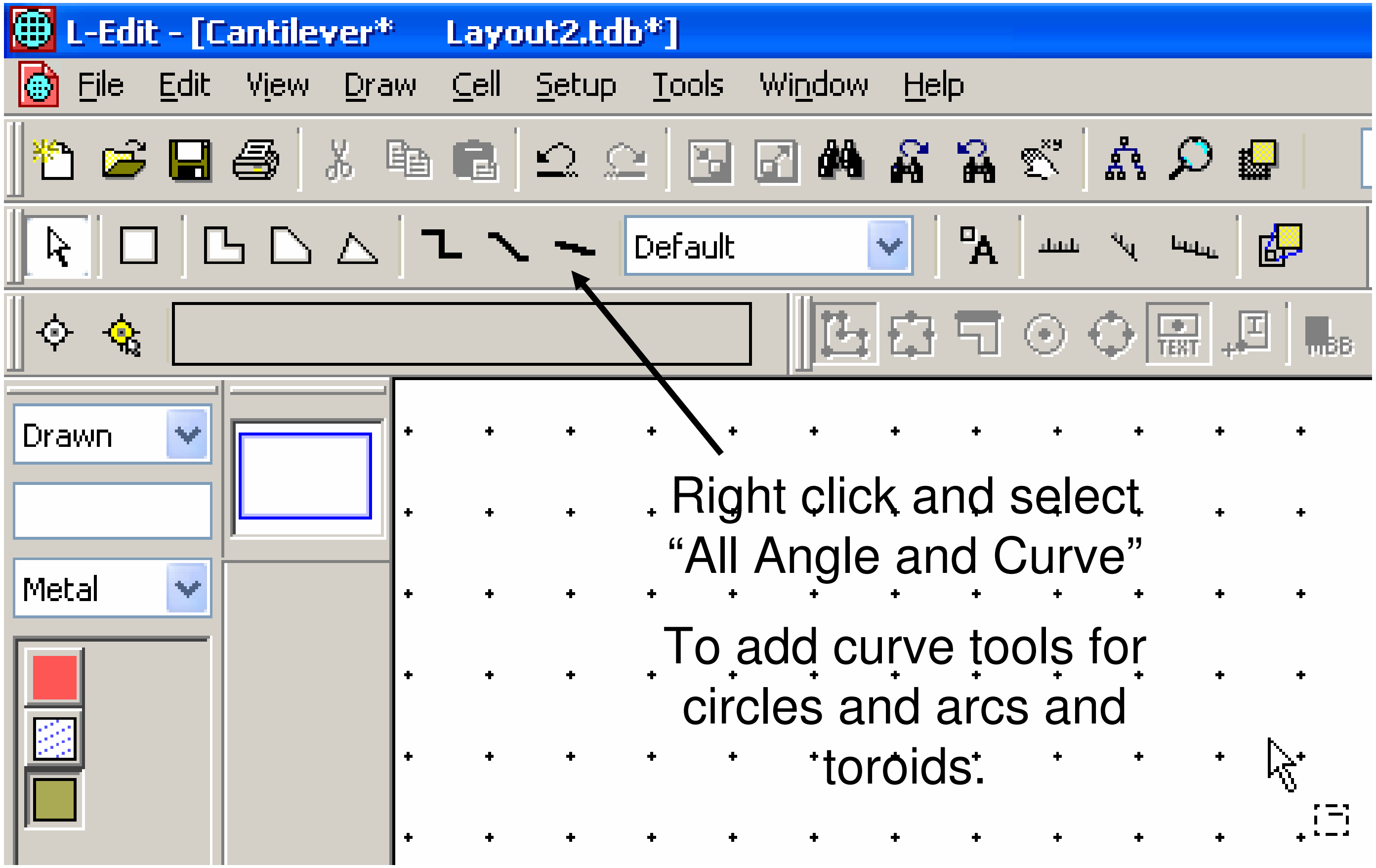
This is the name of the cell within the current layout. You can have multiple cells within a single layout



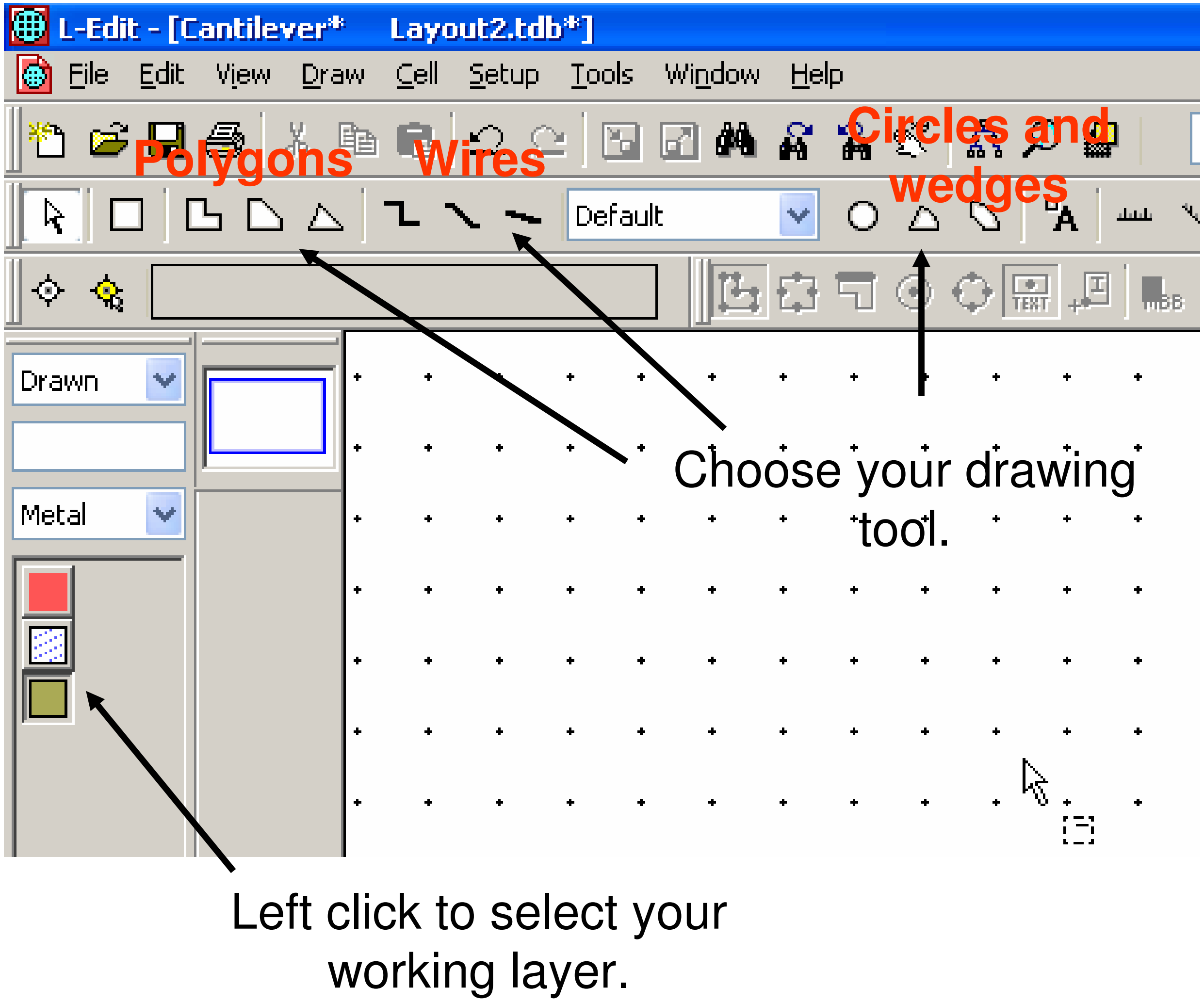
A cell within your layout is some **logical entity**; often **something you want to duplicate many times**. For instance, if you have a layout with many identical chips in it, you may design the chip as a single cell, and then array the cell many times to create the overall layout. Then if you need to make a change you just change the cell and all the instances of that cell update.

Make a new cell called "Cantilever"

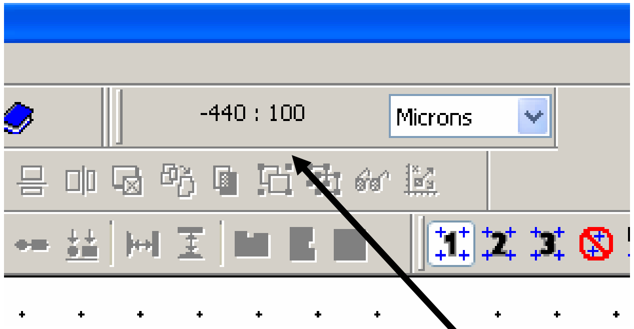
Drawing


L-Edit - [Cantilever* Layout2.tdb*]
File
Edit
View
Draw
Cell
Setup
Tools
Window
Help
Default
Drawn
Metal
Right click and select "All Angle and Curve"
To add curve tools for circles and arcs and toroids.

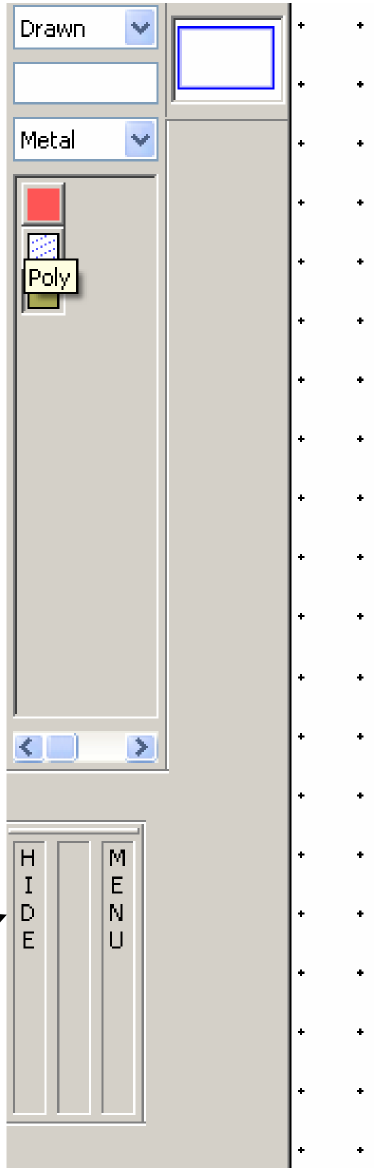
Drawing


L-Edit - [Cantilever* Layout2.tdb*]
File Edit View Draw Cell Setup Tools Window Help
Polygons
Wires
Circles and wedges
Default
Drawn
Metal
Choose your drawing tool.
Left click to select your working layer.

Mousing



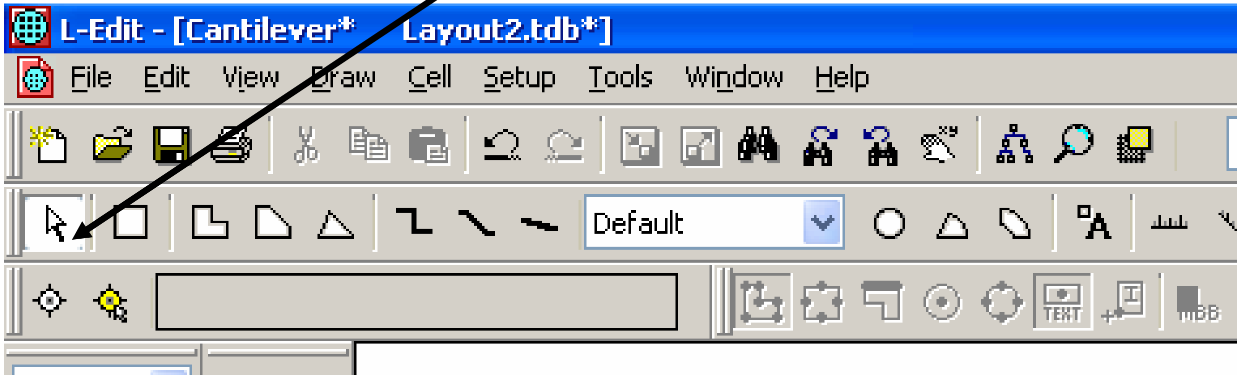
This will display the current cursor location.

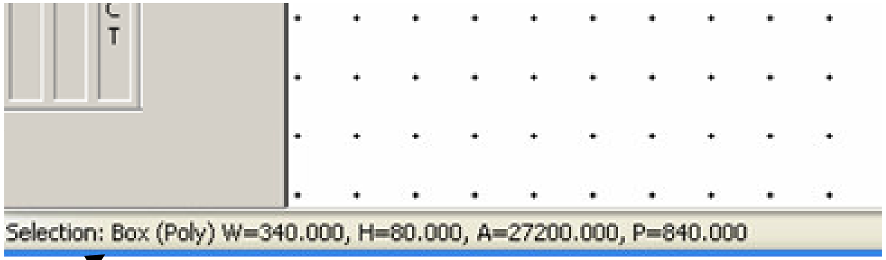


As you mouse around, this spot shows which each mouse button does. If you hold down shift, control, or alt, you will get different options.

Selecting

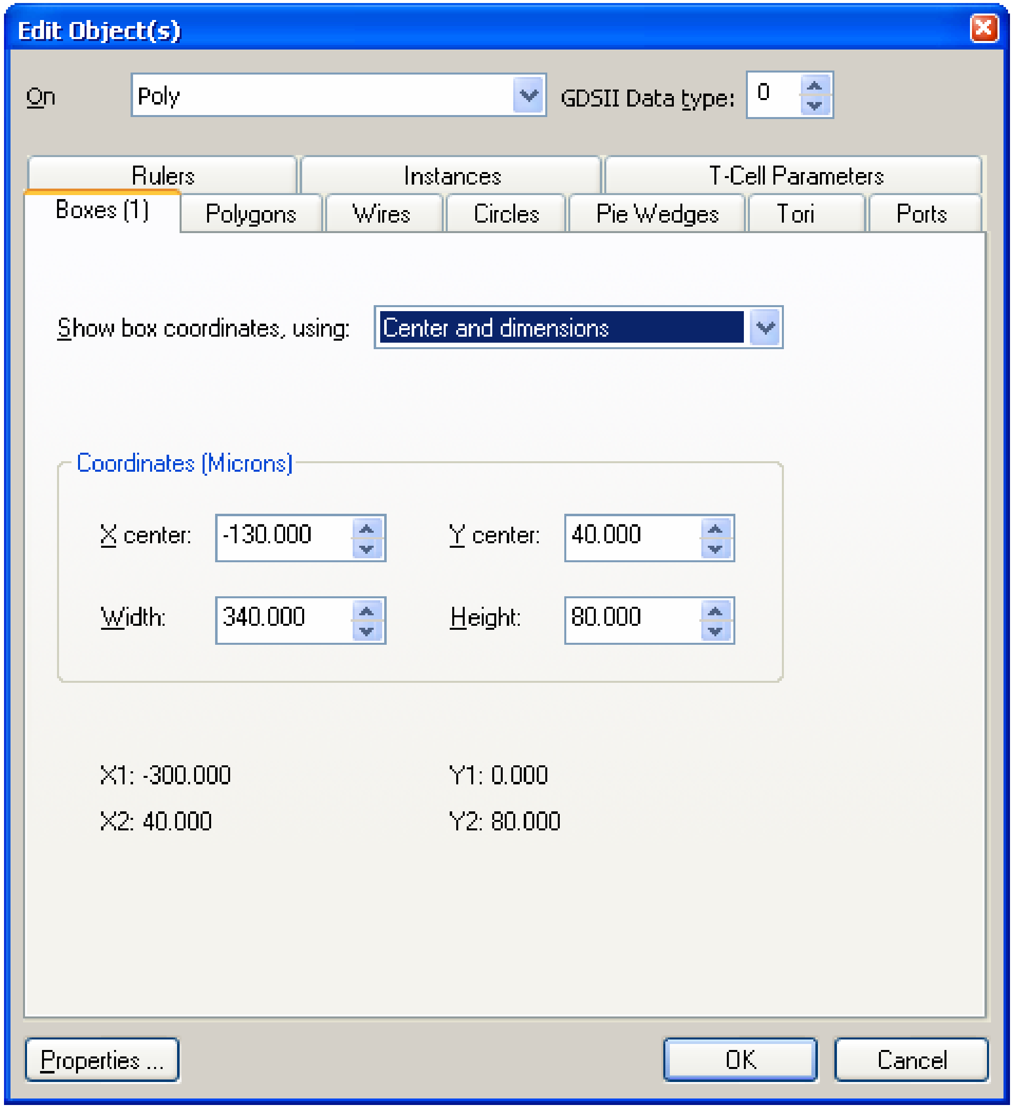
Choose your select tool. You can only select items on visible layers.





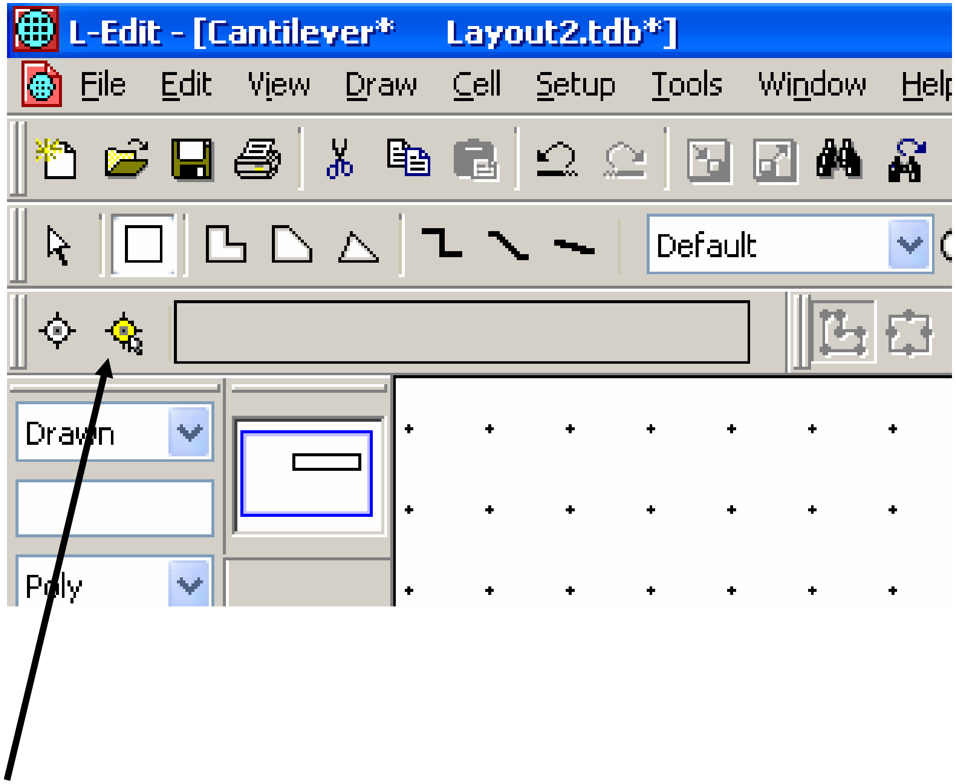
At the bottom left of the screen it will tell you what you selected.

Editing



Select the object you want to edit and press **"Ctrl-e".** A dialogue box will pop up… you can change the layer the object is on, the dimensions of the object and so forth.

Moving



Left click this to be able to select a base point.

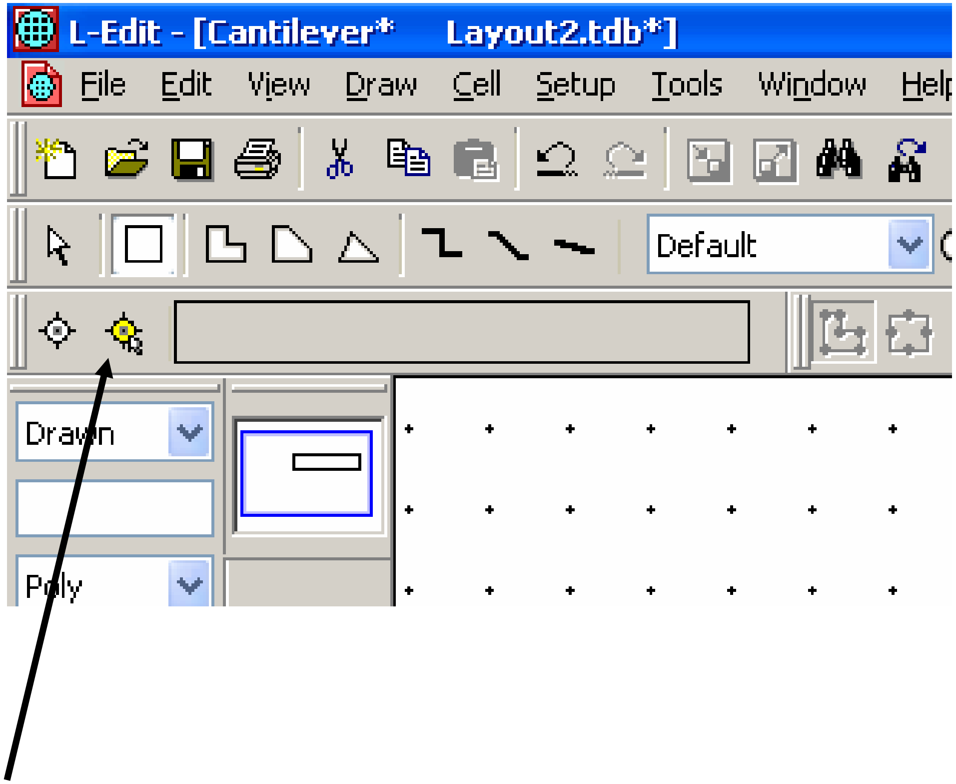
Options:

(1) Select the object and drag it with the middle button.

(2) Select the object and push "m". You can define an exact move.

(3) Select an object. Set a "base point" at some location on the object. Now middle click where you want that object to move to… that point on the object will move there.

Copying



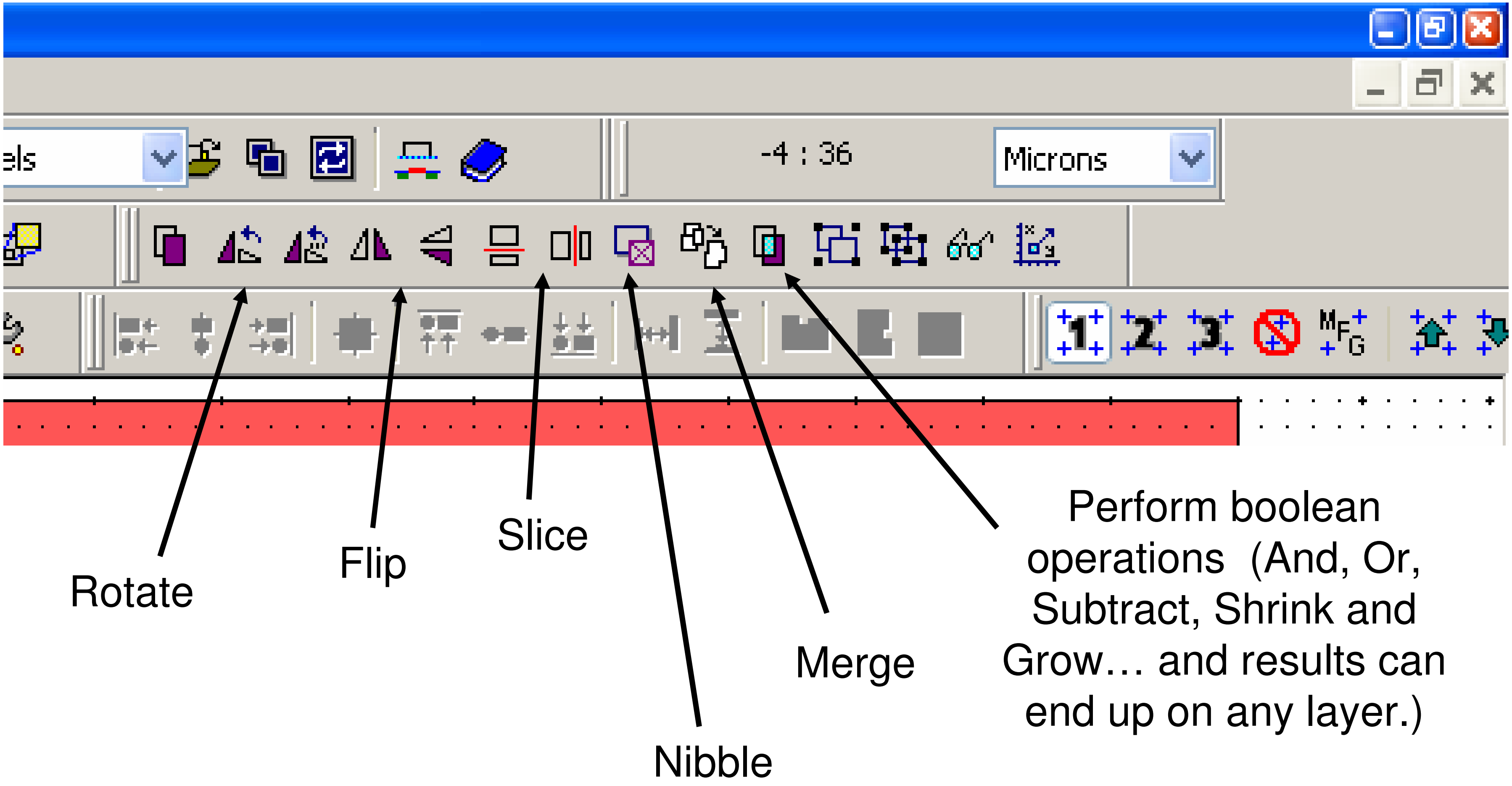
Left click this to be able to select a base point.

Options:

(1) Select an object, duplicate it (Ctrl-d), and then move the new object.

(2) Select the object set a base point. Push "Ctrl-c" to copy the object. Push "Ctrl-v", and then middle click where you want the new object to appear.

More Editing

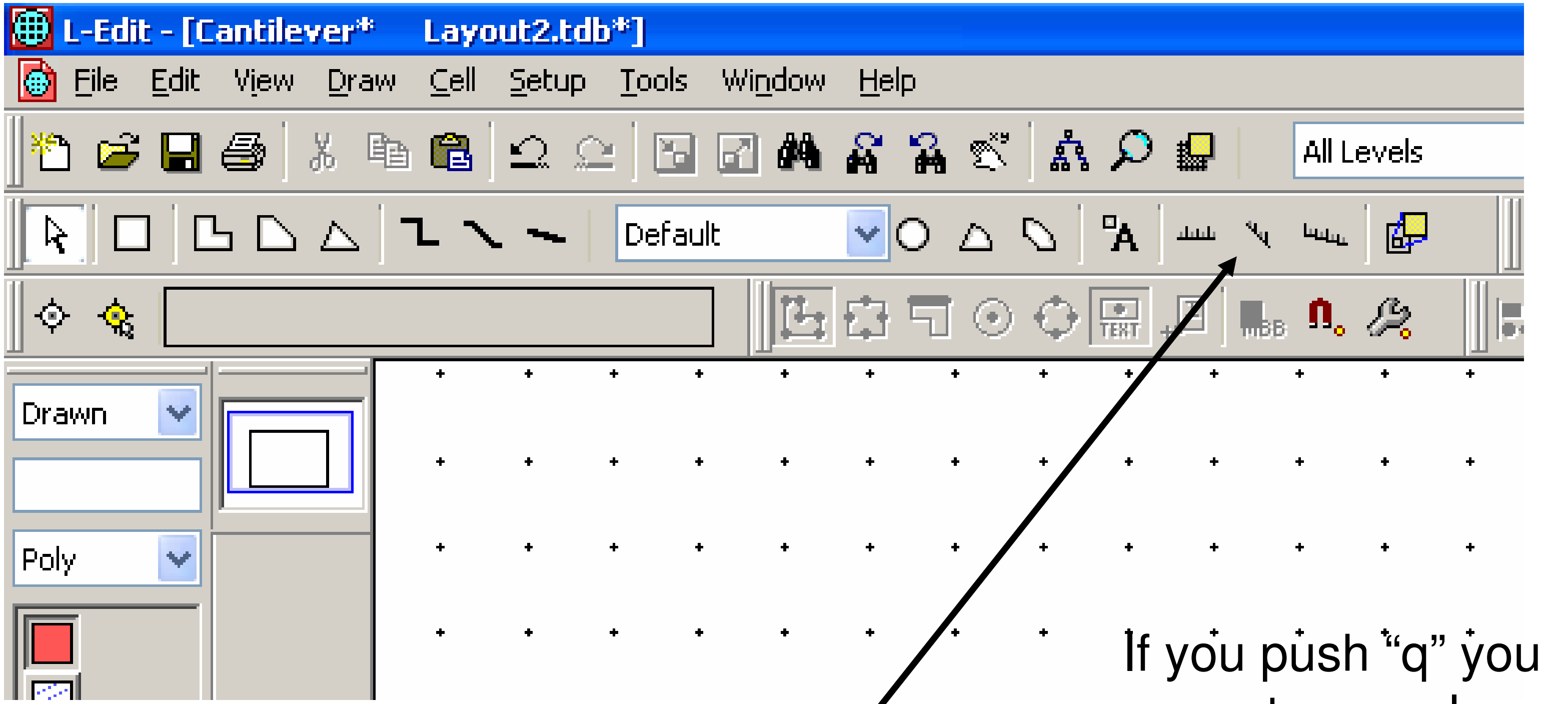


These are all available from the “Draw” menu as well.

Zooming and Panning

- + and – keys zoom in and out.
- “Home” key zooms to see everything.
- “z” key puts you in zoom mode, then left button zooms in on a boxed area, middle button pans, right button zooms out.
- Arrow keys pan around the design.

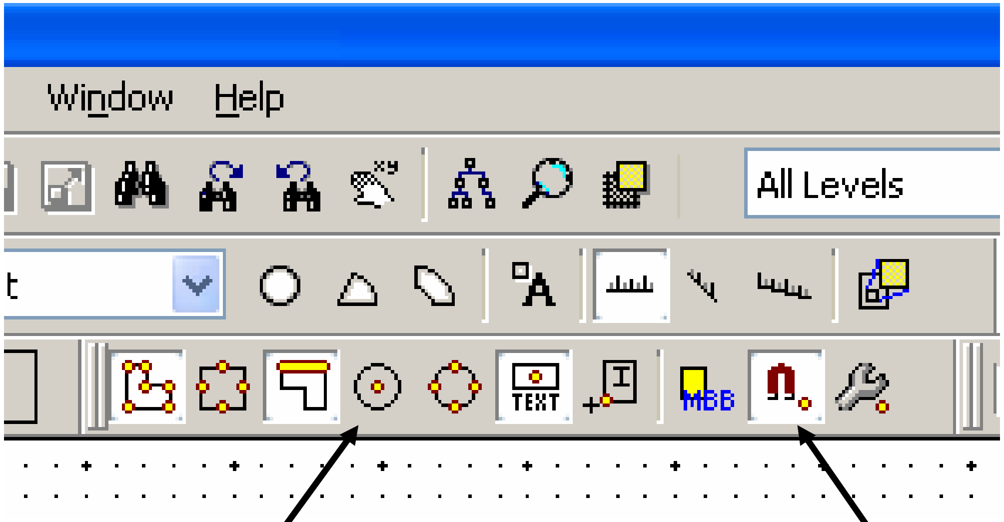
Measuring



You can use a 90 degree, 45 degree or all angle ruler. It will tell you the ruler length at the bottom left of the screen. If you want to read the ruler writing, you may need to select and edit the ruler and change font size.

If you push “q” your current cursor location will become 0,0 and you can move to a new spot and see where you are. Push “q” again to go back to global coordinates.

Object Snap



You can determine what kinds of things (vertex, edge, center, etc.) you snap to by selecting these buttons.

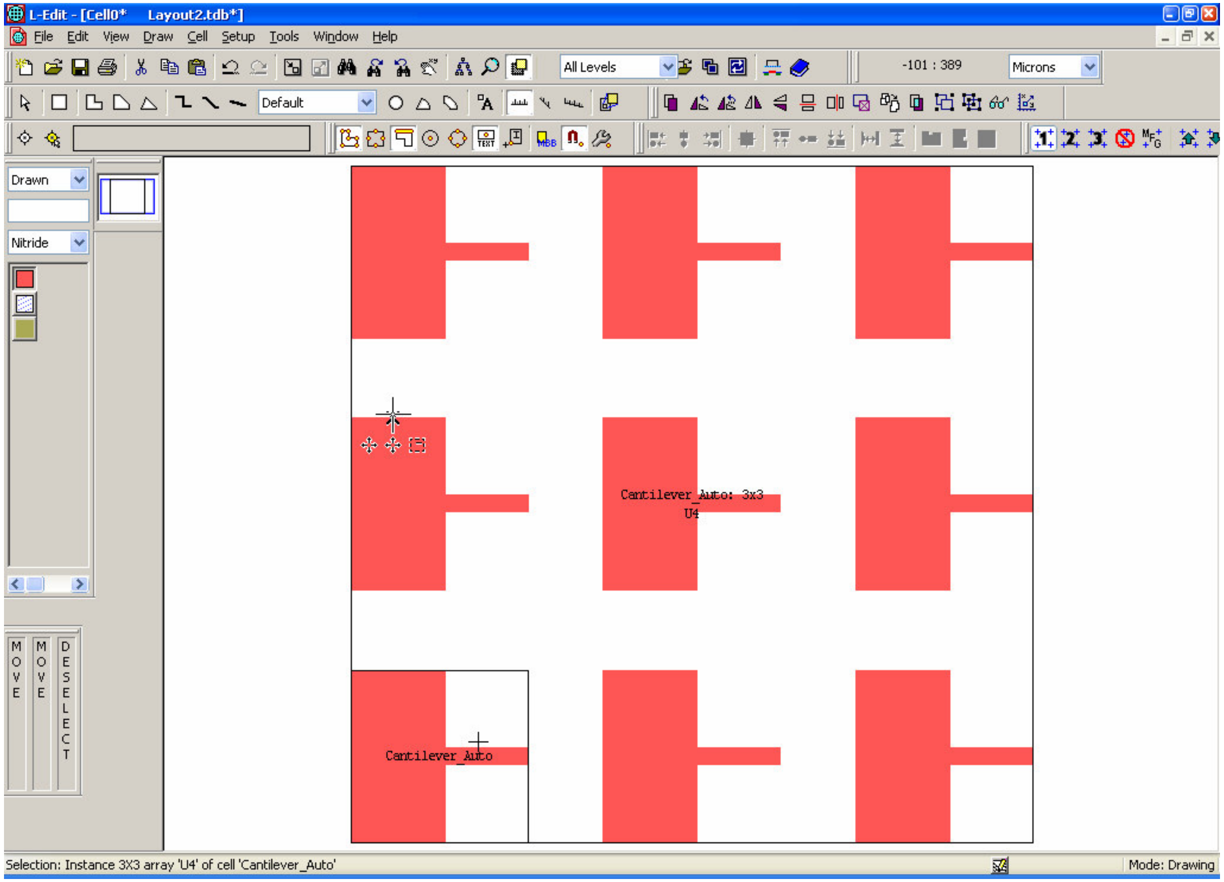
Turn on object snap if you want it by clicking this magnet button.

Arraying Cells

Once you have a cell designed, you can array it. Go up to your top level cell (Cell0). (Use "window" menu)

Say "cell|instance" and select the cantilever cell.

Then push Ctrl-e to edit cell parameters, including arraying.

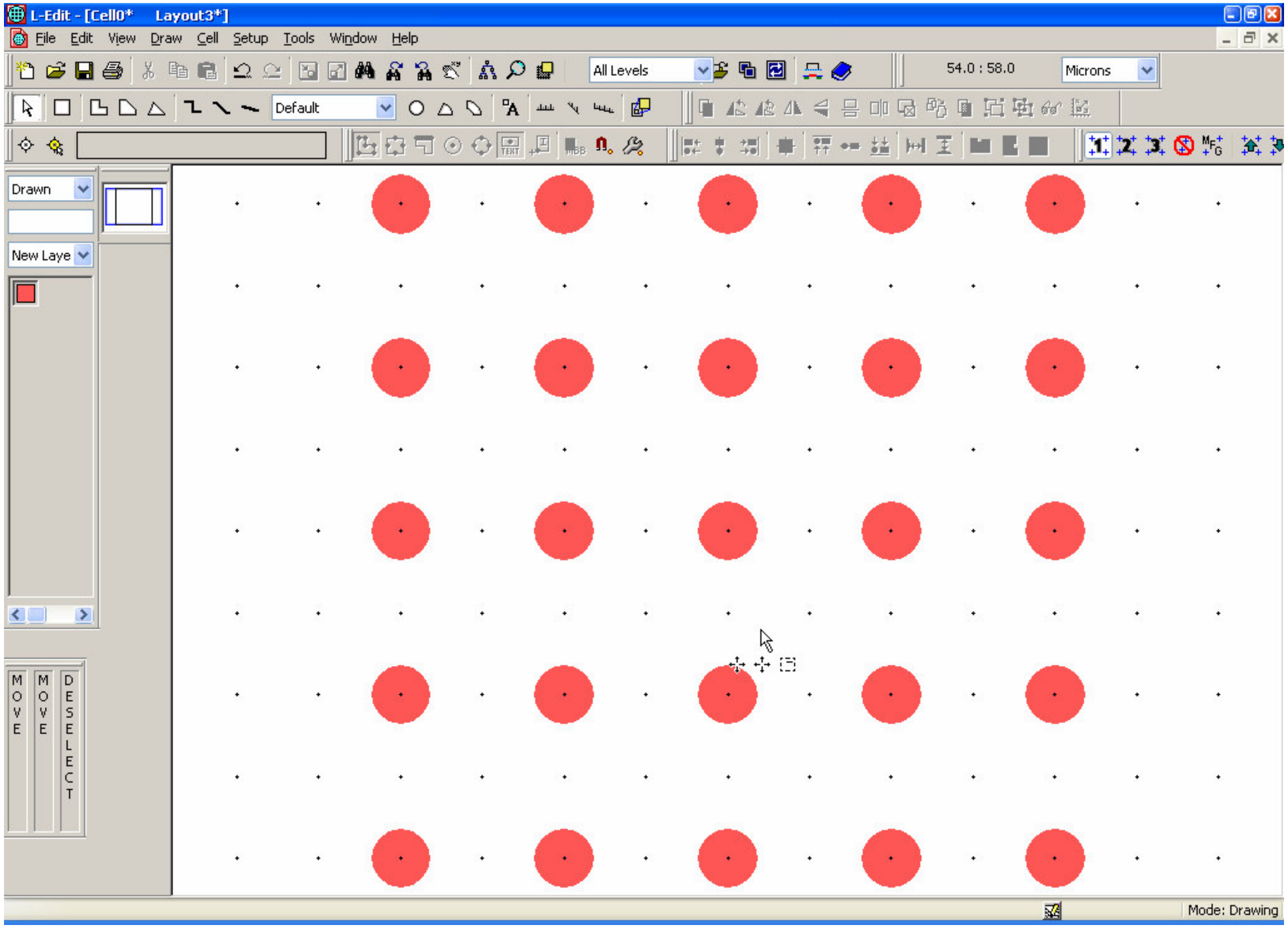


Grouping Objects

You can group objects that you have already drawn together to create a new cell. Select the objects and push “Ctrl-g”.

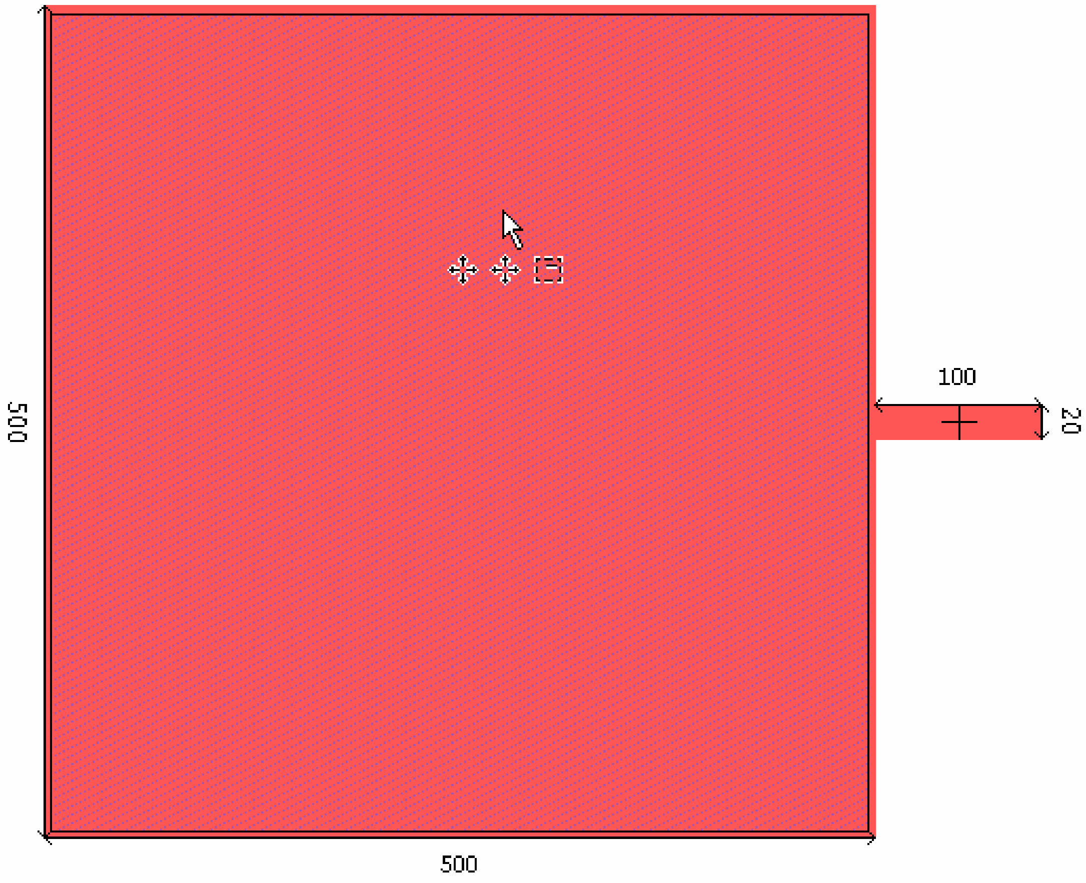
Then if you want to array them, go ahead and do that by editing the cell.

To swap back so those objects are now part of your top level existing cell as polygons rather than as arrays of cells, ungroup them “Ctrl-u” twice.



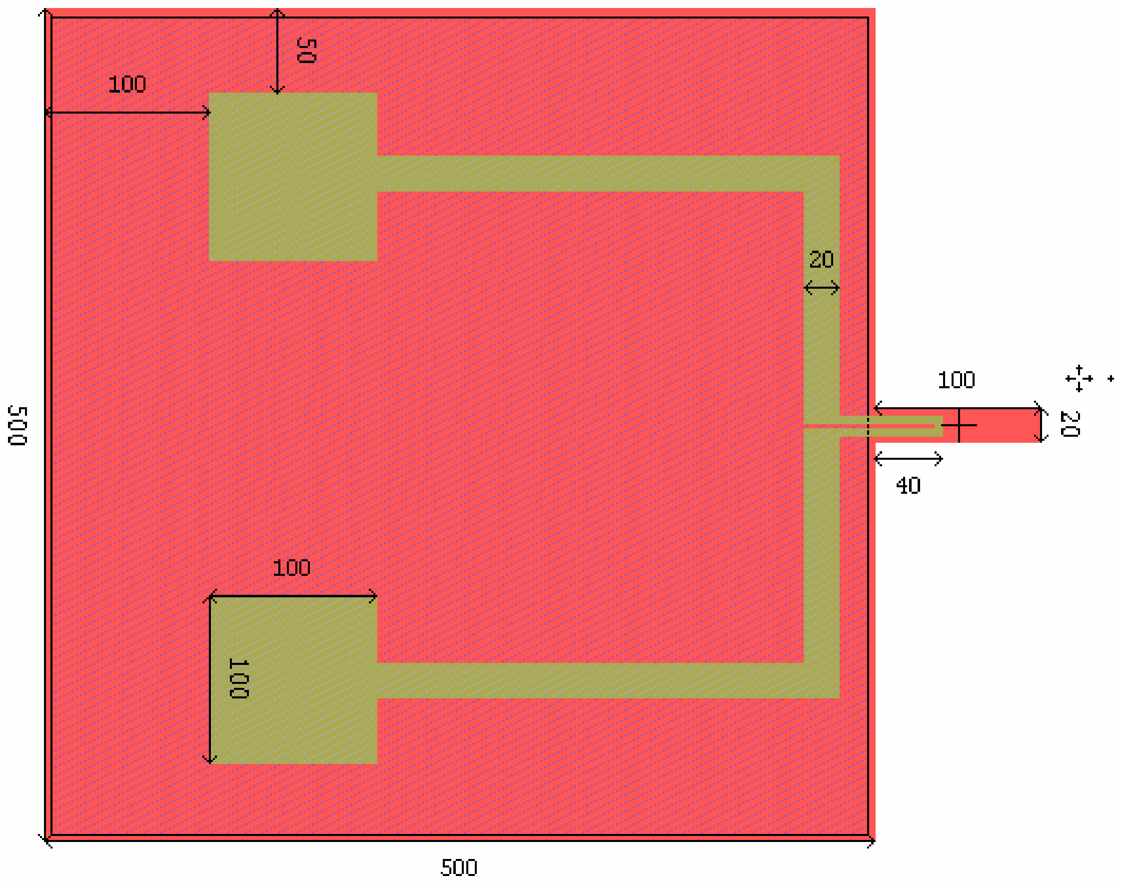
Do This:

1) Draw a cantilever in the nitride layer. Make it 100 microns long, 20 microns wide.
2) Draw a box in the nitride layer which is attached to the base of the cantilever. Make it 500 microns square.
3) Create an anchor (where the nitride will go down to anchor to the substrate) in the "anchor" layer by shrinking the 500 square micron box by 4 microns.



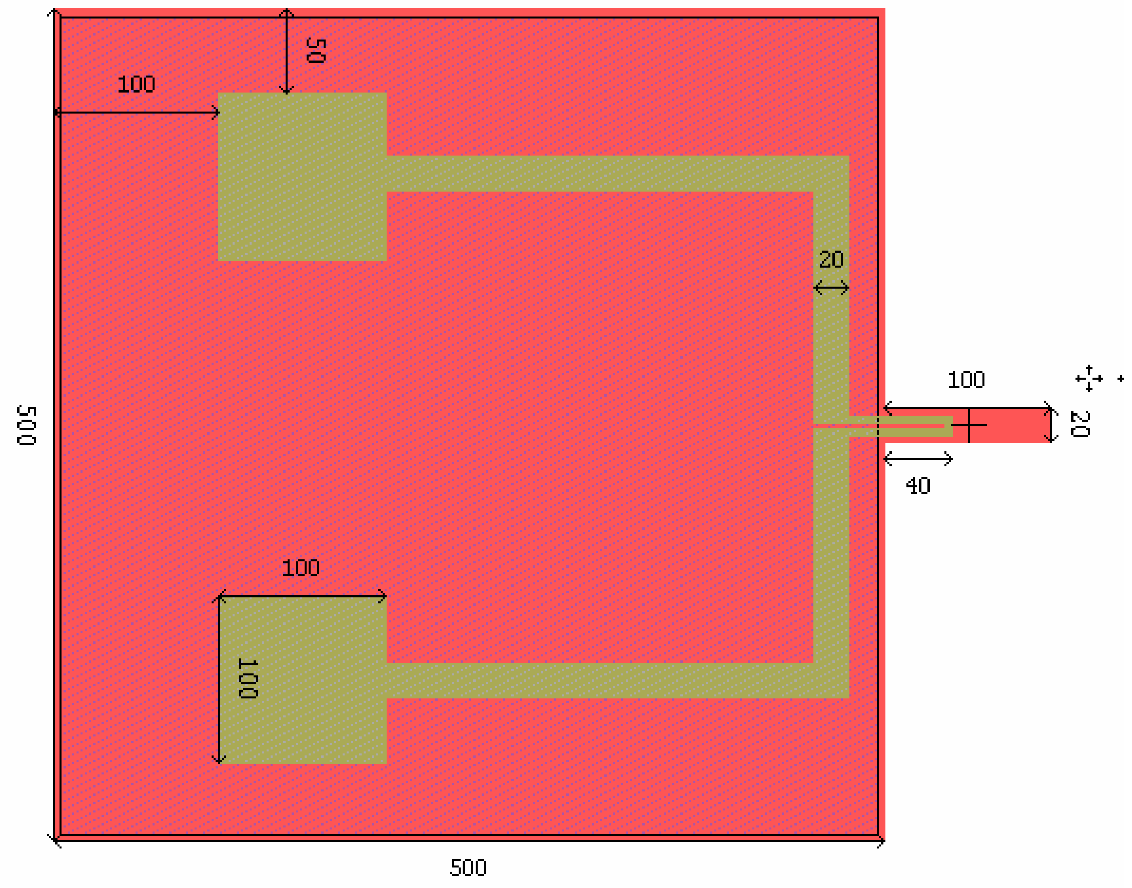
Do This:

1) Create 100 micron square "pads" within the anchor region which are offset 100 microns in x and 50 microns in y from the back corners of the anchor large nitride region.
2) Create a four micron wide wire in the metal layer , spaced evenly by four microns, that extends down 40% of the beam length and comes back off the beam. Wire it to both pads with 20 micron wide wires.
3) Merge all the wires and the pads into one single metal polygon.



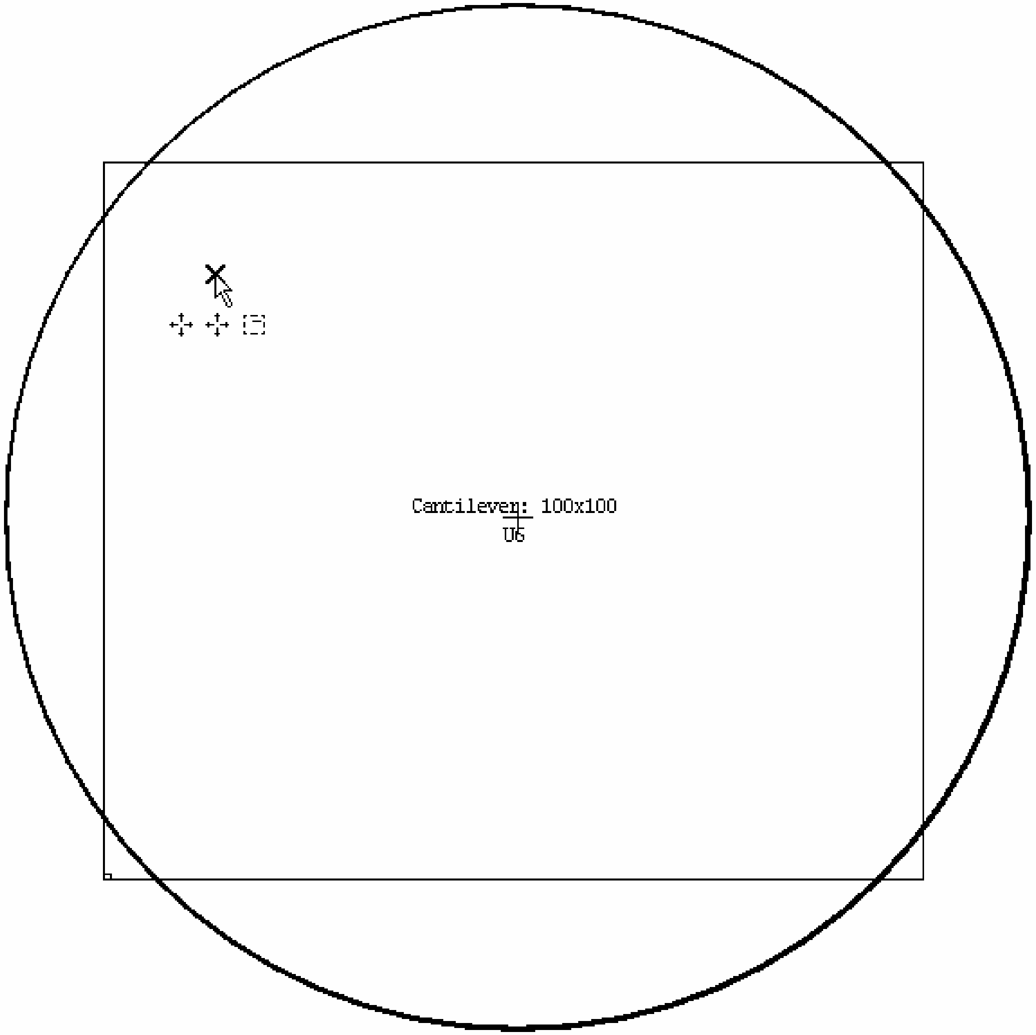
Do This:

1) Create a new layer called “Ruler” which is black in color.
2) Use object snap to draw rulers in that layer to show all the dimensions as done below.



Make a Cell Array

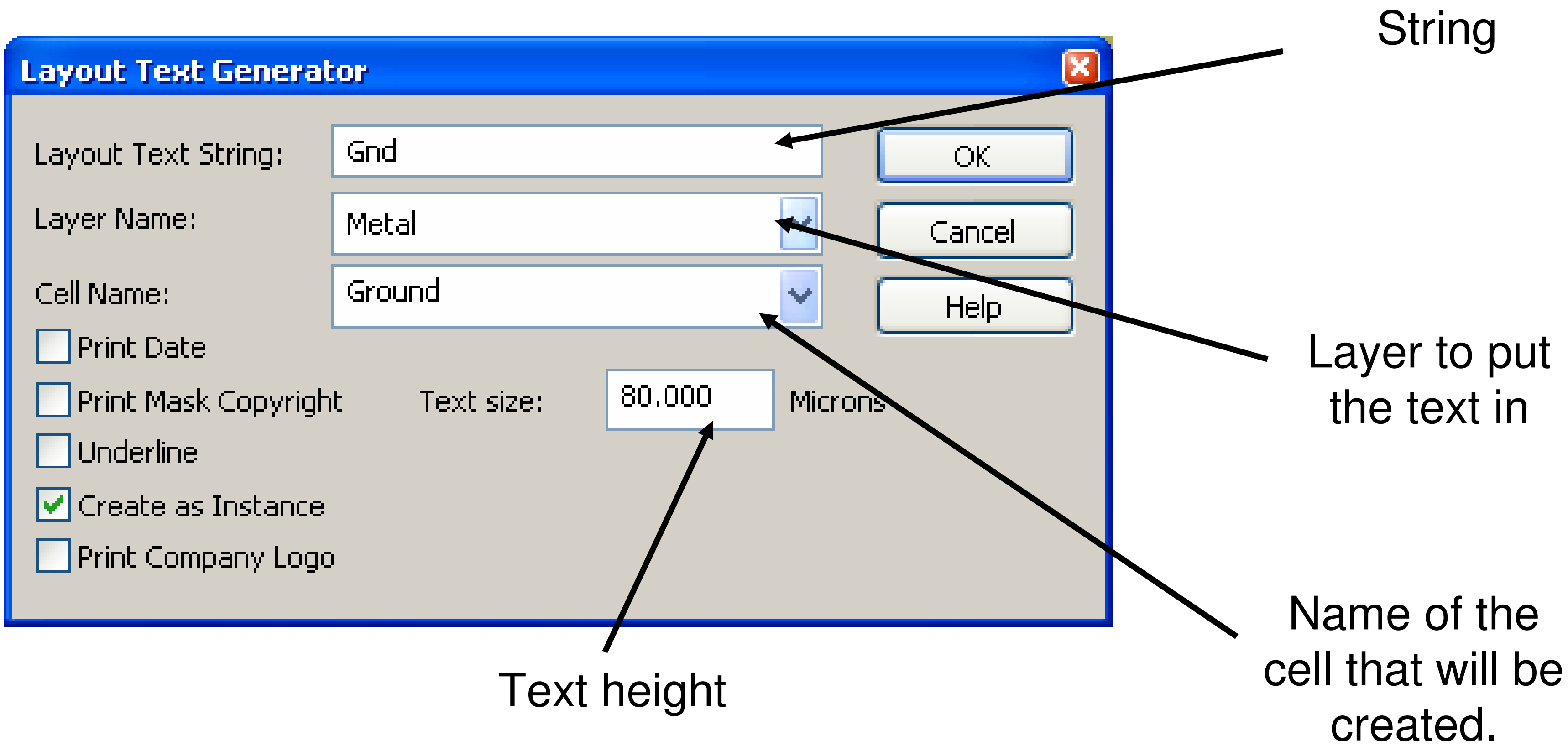
1) Go back up to Cell0.
2) Create a new layer called “wafer”. In that layer, draw a 100 mm diameter circle centered at 0,0. This is the full size of a four inch wafer.
3) Create an instance of the cantilever cell.
4) Array the instance with a spacing of 800 microns in x, 700 microns in y. Make a 100 x 100 array.
5) Move the array by half its size back so it is centered on the wafer.



Generating Text

Text can be auto-generated by using the command:

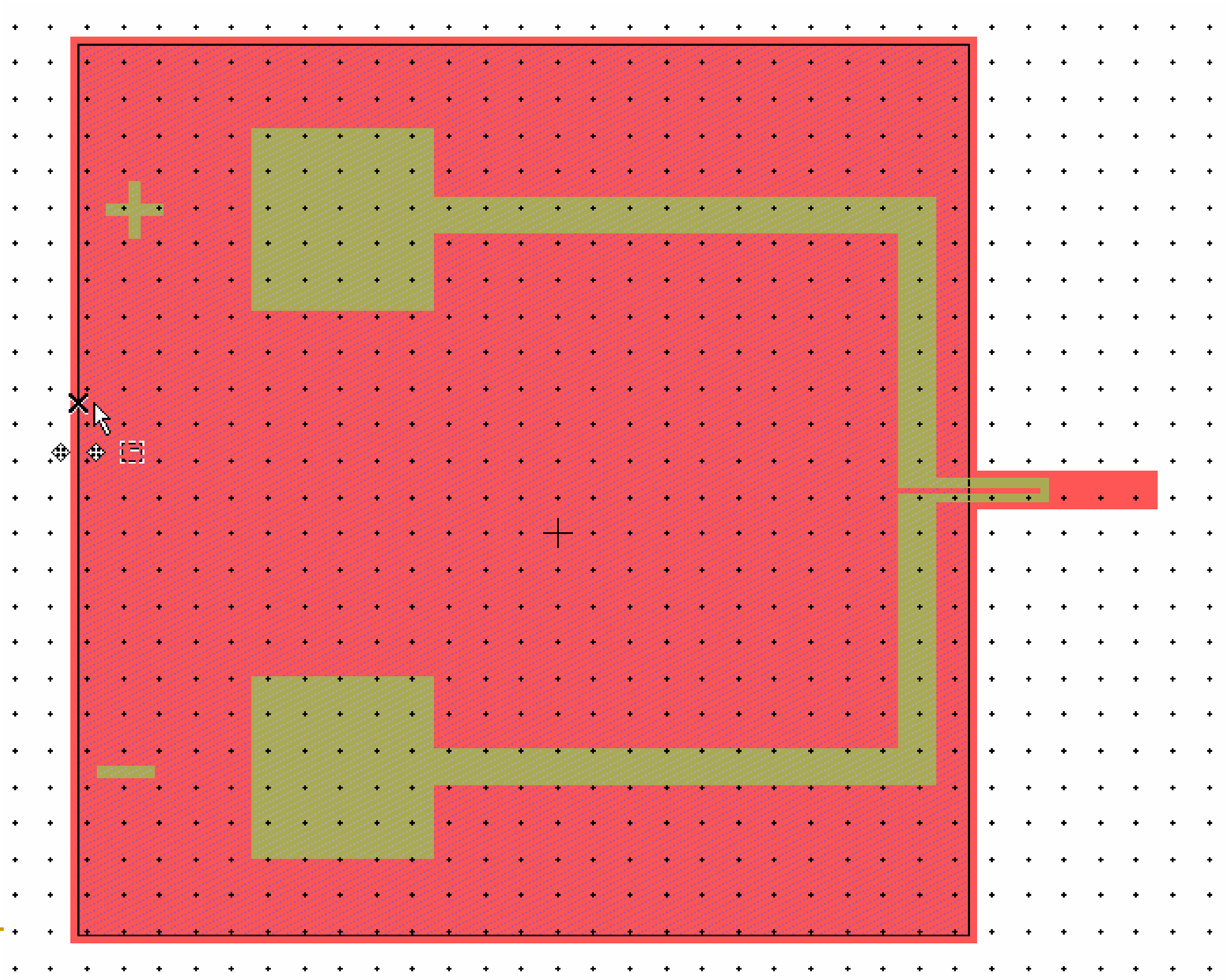
Draw|Layout Generators|Layout Text Generator



Generating Text

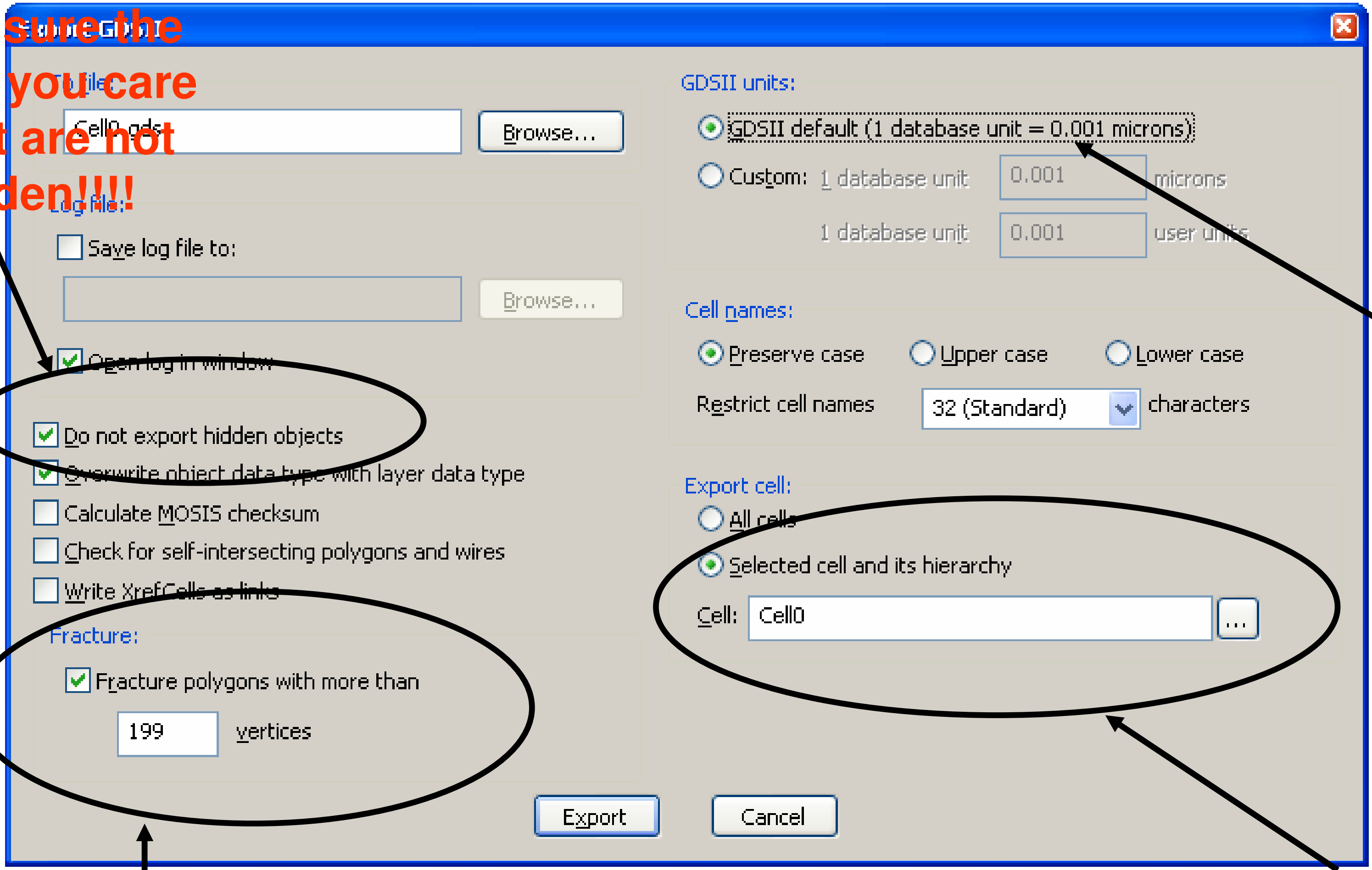
Add a plus and minus sign to the metal layer in your layout to distinguish your two connection pads.

Since this cell is instanced in an array on Cell0, all the instances will update!!



Generating the Final GDSII

Make sure the layers you care about are not hidden!!!!



Use default GDSII that one GDSII database unit is 1 nm.

Choose which cell to export. All sub-cells will be exported too.

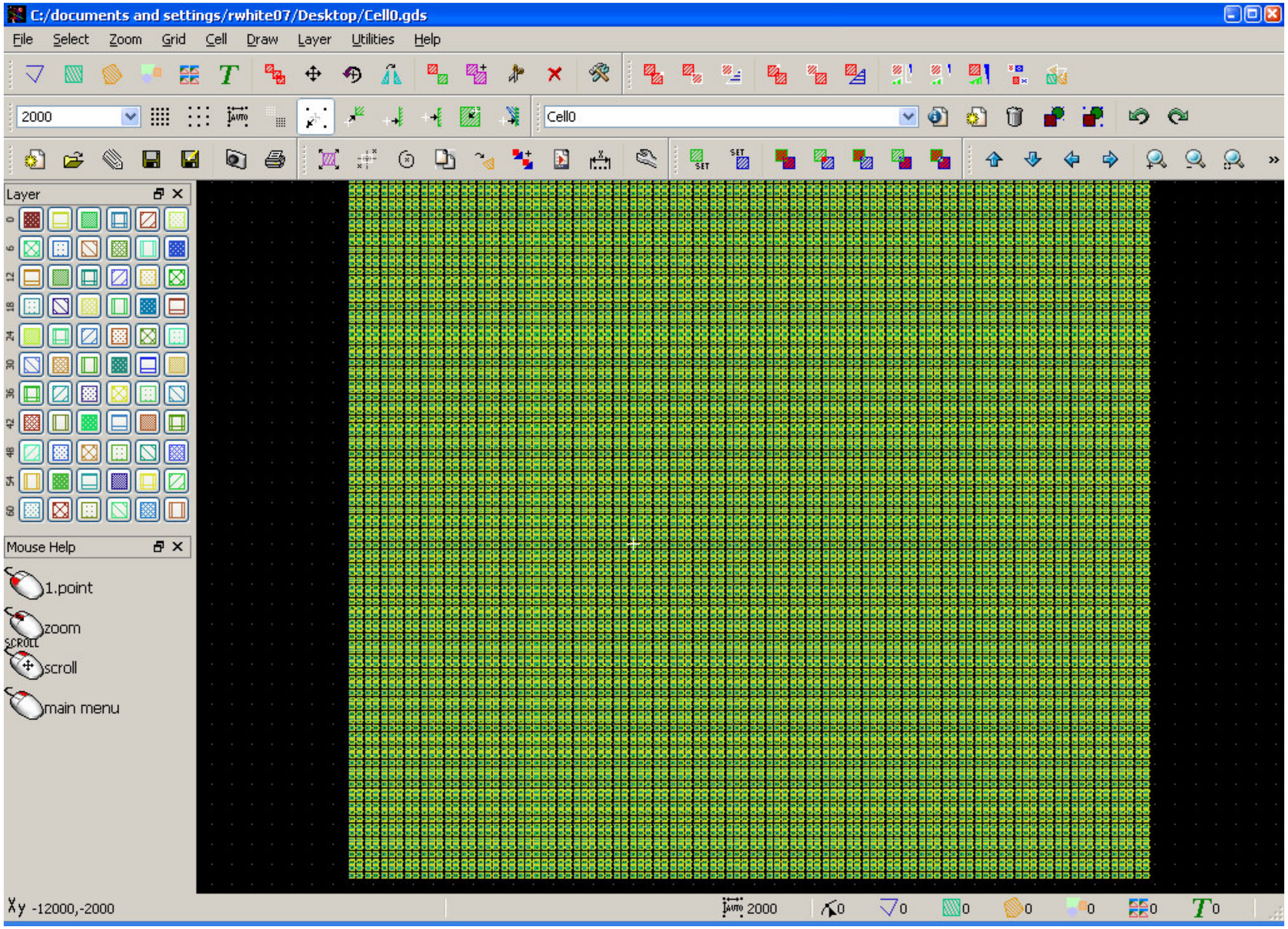
GDSII polygons have a maximum # of vertices… this will break up any huge polygons (especially curves!) into manageable smaller pieces.

```
GDSII Export...
TDB File: C:\Documents and Settings\rwhite07\Desktop\Layout2.tdb
GDSII File: C:\Documents and Settings\rwhite07\Desktop\Cell0.gds

Option Settings:
Do not export hidden objects: ON
Overwrite data type on export: ON
Calculate MOSIS checksum: OFF
Check for self-intersecting polygons and wires: OFF
Write XRefCells as links: OFF
Preserve case of cell names: ON
Restrict cell names to 32 characters.
Only cell "Cell0" and its hierarchy is being exported
Use default GDSII units:
     1 database unit = 0.001 microns,
     1 database unit = 0.001 user units.
Fracture polygons with more than 199 vertices.
Manufacturing grid for circle and curve approximation: 4.000 Microns
All ports with port boxes will be converted to point ports

Checking X-Ref Cell links ...

Checking GDSII Numbers ...

Checking for Hidden Layers and Objects ...
Warning #3: Found Hidden objects in the Layout (Action: Hidden objects will be ignored)

Writing actual GDSII data ...

Completed writing actual GDSII data ...

Summary:
Export completed - 0 error(s), 1 warning(s)

Elapsed Time: 0.00 seconds
```

Ln 2, Col 13

Check the log that pops up for errors or warnings.

Generating the Final GDSII



You can look at the final GDSII in Layout Editor to make sure everything looks right. The units in layout editor are also microns.

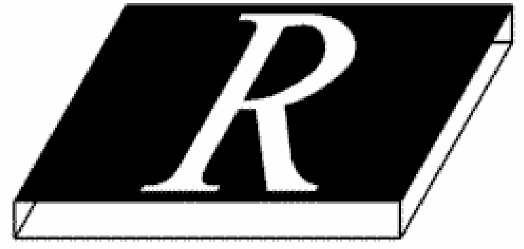
The layers of your final mask polygons were defined by the GDS layer you set up at the Layer Setup stage.

Darkfield/Lightfield

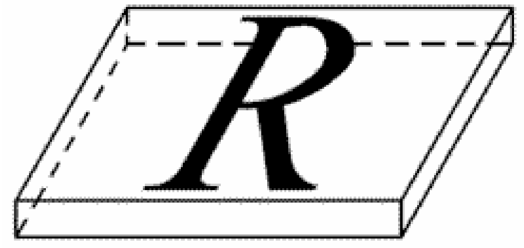
Make sure you are clear on your vendors conventions!!!

Do you want the regions that you "digitized" (colored in) to be opaque? That's *probably* a lightfield mask (the "field" is transparent).

Do you want the regions that you "digitized" (colored in) to be transparent? That's a darkfield mask (the "field" is opaque).



"Digitize clear"… Darkfield



"Digitize dark"… Lightfield

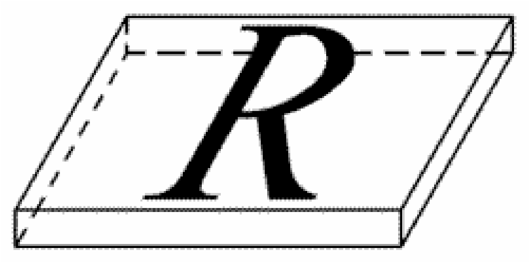
These particular conventions are from the "photoplot store" who I will be using to make your masks.

Mirroring

If you do not ask the vendor to mirror your design, the mask will be manufactured so that when you look at the Chrome side, you will see what you drew on the screen.

Mask has been mirrored

This will get flipped over when you expose the wafer, so the pattern on the wafer will be the mirror image of what you drew. If you do a molding step, or are working on the backside of the wafer, you get mirrored again.



Mask has not been mirrored

Tell the mask vendor if you want the design mirrored or not.

Derived Layers

- To create a derived layer:
  - Go to ‘Setup’ – ‘Layers’
  - Select the layer you want to make a derived layer or create a new layer
    - If you create a new layer, make sure you go to the rendering tab under that new layer and give it a color
  - Click on the ‘Derivation’ tab and then click on the ‘Derived’ button
  - You can enter in the derivations you would like in your new layer
    - ***Look at the ‘Layers’ list on the left side of the menu. Your derived layer must be <u>below</u> the layers you would like to use in your derivations.
  - Click OK
- To derive the layer:
  - Go to ‘Tools’ – ‘Generate layers’
  - Make sure the ‘Standard derived layers’ box is checked in the top menu.
  - Select your derived layer from the bottom list
  - Click ‘Run’ and your layers should be created

Thanks to Andrew Mueller

Additional Features

Design Rule Checker (DRC)

The fabrication process, particularly if you are using a foundry, will have a large number of design rules. The design rule checker can automatically check if your design violates any of these rules. This can be useful for MEMS.

Schematic Capture

Used mainly by IC designers. Taking a schematic drawing and turning it into a layout automatically. Some MEMS people have worked on this, but it is harder because all MEMS structures are very different, there really aren't standard components.

Parameter Extraction

Once you have your layout, you can extract parameters (usually electrical ones) like resistance, capacitance, and inductance of lines.