

**A tutorial on
Mask-drawing in AutoCad
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How to start AutoCad

Click on the AutoCad icon. It will open a blank drawing file and a dialog box called 'AutoCad Today'. Close the AutoCad Today' and start working in the drawing file. In AutoCad, you do not have to specify the units of length. It works in relative units. Hence, you can draw with dimensions in any units (m, cm, mm, micron, inch etc.). Just make sure that all your dimensions have been consistently converted in that unit.

For drawing masks in AutoCad you only need to learn 2D sketching. You need not learn 3D modeling. On the left you will find a lot of drawing tools. All these tools can also be accessed from the command prompt. It is essential to use a combination of commands and tool-buttons to make your drawings fast. When you click on a button, the command associated with this button is shown in the command prompt. That's how you can learn the commands. Command prompt is very important. Always keep an eye on the command prompt.

Most useful drawing tools

I have found the following tools to be the most useful. All these tools are located on the left hand side.

Construction line: These lines are used as reference line.

Polyline: Most of the linear features on your mask will be made with polyline. You can control the width of these lines and thus create features of different width. Width can be specified through the command prompt. Otherwise, the property box of any object can be opened by double-clicking on it.

Rectangle: Press the button and look at the command prompt for options.

Circle, arc: Press the button and look at the command prompt for options.

Region: In order to close a region created by separate lines. You must not leave any regions open on your mask otherwise your feature might get broken.

Hatch: Most of the times, you have fill the space inside a close region. Use 'hatch' command of the tool-button for options.

Text: To enter the text

Copy object: To create copies of an object. Look at the command prompt for options.

Mirror: To create the mirror image of an object

Offset: To create another closed region with an offset

Array: To copy an object in a 2-D rectangular array

Move: To move an object

Scale: To scale the units up or down

Trim: To trim a line

Fillet: To round the sharp corners

Snap Settings

Most generally, it is easier to place new features relative to the old features rather than knowing their absolute coordinates. This relative placement is achieved by using the snap tools available in autocad. Look at the bottom of the window. You will find the following buttons:

Snap, Grid, Ortho, Polar, Osnap, Otrack, LWT, Model

Following is the description of these tools

Snap: Allow snapping to the grid points, You can keep it off most of the time.

Grid: Displays the grid. Grid spacing can be reduced or increased by typing '*grid*' in the command prompt. You can keep it grid display off most of the time.

Ortho: Allows only horizontal and vertical snapping. You can keep it off most of the times.

Polar: Allows snapping at any angle. Always keep it on except when you need Ortho snap.

Osnap: Allows snapping to the old features. Always keep it on.

Otrack: Keep track of object snap points. Always keep it on

LWT: Displays the line width. Always keep it on.

Useful note: Width of any line (circle, arc, rectangle, text etc.) except the polyline can be controlled globally. Look at the **Line-width control drop down menu** on top or control it through the **object property box** on the right hand side. Object property box is opened when you double click on an object.

Model: Control the display of the drawing window. Always keep it on

Zoom, Pan, Select, Deselect

Zoom-in: Roll the middle wheel forward

Zoom-out: Roll the wheel backward

Pan: Press the pan button on top and then use left mouse button to drag the drawing laterally. Or press right click, a menu opens, choose pan from the menu and then use left button to drag.

Select: Click anywhere on an object with the left mouse button in order to select it. Keep on clicking different objects for multiple selections.

Deselect: Press the escape key to deselect all selections.

Centering the features around origins

It's a good idea to center all your features about the center of the drawing. Select all the features by pressing Control+A, then press the 'Move' button, choose a 'base point' at the center of your features, type '0,0' in the command prompt. It will move all your features such that they are centered about the origin.

Measuring Dimensions

Go to Dimension menu on top. Choose 'linear' for measuring most of the dimensions. Click on the two points to measure the linear dimensions between them. You can explore

other options in the 'Dimension' menu for other type of features (for example 'radius' for circular features).

Dimension Style

In order to control the height, font and style of the dimensions, go to Format->Dimension style. Create a 'New' dimension style for yourself and 'Set it current' so that it can be used for all later dimensions.

Text Style

In order to control the size and font of the text features, go to Format->Text style and create a 'New' style for yourself, and 'Apply'.

Layers

Many a time, you need multiple masks which have corresponding features. It is a good idea to draw all these masks in the drawing so that you can align them with respect to each other. AutoCad allows us to have multiple layers in the same file. We can assign different names different colors to different layers so that it is easy to recognize them. We can also selectively turn on or off the display of a particular layer in order to make our work more convenient.

You will find a tool-button for layers on the top left portion. Press this button to open the layer control box. Here you can create new layers, change their names, color, display, line width etc. You can also set any layer 'current'. Before drawing a feature, please make sure the desired layer is set 'current' so that the new feature will automatically be on the desired layer.

Purge

Go to File-> Drawing utilities-> Purge. It is used for purging unnecessary objects from the drawing. You might leave unnecessary objects and layer on your drawing which might mess up the mask printing. In order to remove these unnecessary objects and layers, please always purge your file after you finish drawing all the layers.

Some tips for drawing masks

When you draw masks, make sure that all your features are contained in a region not bigger than the size of the opening in the mask holder. For example, the opening (or the exposure area) in a 4 inch mask holder is a square of side 3 inch. Therefore, you have to make sure that all your features are within a region of 3 inch square.

It is also a good practice to put some inverted text on your masks. It helps you when you develop features on glass and forget which side it was on because the glass is transparent.

Alignment marks: Always make sure that you draw several alignment marks on your layers so that you can align different layers during photolithography in the clean room.

Most of the people in MEMS field use chrome masks for their photolithography needs. There are a couple of chrome mask vendors but Photo Sciences Inc. is the most popular vendor. Chrome mask vendors require the mask files to be in dxf or gdsII formats. AutoCad can easily convert dwg files to dxf. If you need to convert dwg to gdsII, then you have to use a software called LinkCad. However, you might just convert dwg to dxf and not need LinkCad.

Please look at the attached flier from Photo Science to avoid some mistakes which might mess up your mask.

Some tips for drawing transparency masks

Transparency masks are incredibly cheaper than chrome masks (\$20 vs. \$500). However, transparency masks are not so good if you have features smaller than 50 microns and you care too much for their accuracy. In such cases, go for chrome masks.

In order to prepare your AutoCad file for a transparency print, take the following steps.

1. Separate all the layers so that they do not lie on top of each other. You can arrange the layers side by side in a 2-D array. Remember that you can print upto 4 layers on the same transparency. Thus, you can get a transparency mask for \$5.
2. After separating the layers, go to File->Plot. On the Plot Device page, choose your Adobe Acrobat distiller as the printer name. In the Plot style table (Pen Assignment) menu, choose 'monochrome.ctb'. This pen will convert all your layers to black. That is the color you want on your transparency. Now go to the Plot Settings page and provide a correct plot scale. For example, if you have drawn in mm units, then choose 'mm' for the paper and provide a scale of 1:1 for the Plot Scale.
3. You can also center your plot. See a preview of your drawing in order to make sure that all the settings are appropriate and the drawing is to the correct scale and centered.
4. Now press OK to print the drawing to a pdf file. You have to send this file the mask printing vendor in downtown. Following is their contact information:

Grayphics
1114 State St. #7
in the La Arcada, Santa Barbara

Hours: 8:30 a.m. to 5 p.m. M-F
805) 899-2387

<http://www.grayphics.com>
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