520.495/580.495 Microfabrication Laboratory

Laboratory Assignment

Mask Design

Objectives: To learn how to do mask design.

Production grade photolithography masks are made of quartz plates (transparent to UV light) that are coated with chrome (opaque to UV light). A CAD tool such as LEDIT, MAGIC or some other mask layout is used to design the desired pattern(s) and then lithography is done on the chrome plate to define the pattern; this process costs between $400 to $1,000 per mask. We have several sets of quartz/chrome masks in the lab; if you would like to see one ask the T.A.

In this course we will take a different approach and we will make masks at a fraction of the cost compared to quartz/chrome masks. Our masks will be made out of plastic film and will be done locally by printing the pattern on a high resolution printer available in one of the local art design shops. This shop has the capability of printing designs at 3386 dpi (dots per inch). To create masks of such high resolution, we must design the masks in a very specific format to be able to transfer the design on the film with no loss of information. This stringent requirement constrains the type of program that is used to create the design. We will use Photoshop to do the art work.

The design that you will be creating is a set of electrodes connected to bond pads. The electrodes will be patterned in aluminum and eventually be transformed into silver/silver chloride electrodes. A “well” of thick SU8 photoresist will later be formed on top of the wafer. This well will confine solutions to the area containing the electrodes and keep the solutions away from the bond pads. The electrodes must extend from the bond pads into the well to provide for measurements of the solution. The well interior will be a square with corners at the coordinates (200, 600) and (3300, 3500).

The basic structure has been defined for you with die size, bond pads and alignment marks. Download the classframe file (Right click and "Save As" “yourname.tif”) containing this basic structure. It is your job to add electrodes. Choose the geometries carefully, such that testing will allow you to extrapolate properties for arbitrarily sized electrodes. The electrodes are the ONLY thing that you will add. Modification of any of the existing structures will result in immediate rejection of your design.

I. Prelab Work:

1. If the printer resolution is 3386 dots per inch, what is the size (in microns) of each individual dot on the film.

2. Download the basic file from the website. This file contains bond pads and alignment marks.

II. Lab Work:

1. Sketch out the existing bond pads and well area on paper. Add your design on paper, including all of the dimensions. You will turn this in to your TA along with your .tif file. It doesn't need to be to scale, but it should be neat and clearly marked. (You may want to use graph paper.)
2. Remember to think carefully about the size and orientation of the electrodes. Your electrodes should be designed to gain information about how the geometry of the electrodes will effect the measurements that will be preformed later in the course.
3. Again, you may NOT change anything that is already included on the file. Add the electrodes connecting them to the bond pads. Open Adobe Photoshop and open the file. You will want to save the file under another name in case you want to return to the original.
4. Do NOT change the file properties. File properties:
   Resolution: 3386 pixels/inch
   Mode: Bitmap
   Contents: White

4. Create your black and white design only.
5. Save the file as a TIF with the IBM PC byte order and with LZW compression.

Tips on Adobe Photoshop

Adobe Photoshop is not the friendliest environment for this type of design, so it is important to find shortcuts to create your design. The following are just a few hints to help you design your mask.

- Plan your design well before you begin using Photoshop. It is helpful to figure out the "coordinates" of each shape in your design. (Use the coordinates from the features of the downloaded file to get you started.
- The zoom options are found under View. You can also use control&+ or control&-. You will need to zoom in to the actual pixel level and out to create a viable design. When you are zoomed out you may not be able to see disjoints in features. Zoom in to the pixel level to ensure each feature you add is properly connected.
- The ruler and gridlines are toggled on and off under View. Turning these options on is highly recommended.

- The resolution of the ruler is set under File >>Preferences >>Units & Rulers. Under ruler, set the resolution to pixel. This will allow you to use the ruler as a coordinate system for your design.
- The resolution of the gridlines is set under File>>Preferences>>Guides & Grid. Set the grid to "gridline every 1 pixel".
- The easiest way to draw an electrode is to use the "rectangular marquee tool". Show the info window that will display the coordinates of the marquee tool, it is found under window>>show info. If you want to draw a rectangle, place the marquee tool at the coordinates of one of the corners you would like to draw (coordinate displayed in the info window), left click and drag the tool to the opposite corner.
- You may want to explore the help files if you are not familiar with Photoshop.

III. Postlab Work:

1. Do a search on the web and get quotations for a 6 x 6 inch quartz/chrome masks with feature size of 1 micron.
2. Explain why we design the patterns as dark areas on the first mask and as white (transparent) areas on the second mask.
3. Given the resolution of the printing process do you think you have enough dots in your patterns to achieve reliable processing? Explain.

Original lab procedure prepared by J. Blain, Fall 2000; modified Fall 2002.