SHORT GUIDE TO MASK LAYOUT

CMJ 15-Juni-2004

Based on Roger de Reus "std_mask.txt "
Thanks to: Peter Rasmussen and Anders Jørgensen

BEFORE YOU BEGIN

Discuss all processes and process sequences with process experts before doing any actual layout editing.

If you are doing some simple tests please browse through the old masks and see if any of these are suitable for your experiment (e.g. Ole Hansen's test mask).

DATA FORMATS

- CIF (Caltech Intermediate Form): ASCII files.
- GDSII (Calma stream): Binary files containing mask data. GDSII is normally avoided due to conversion difficulties, due to the risk of emailing a binary file, and because the sizes of the files very often are very large.
- L-Edit internal format (TDB: Tanner Data Base): for your PC at MIC only.

GENERAL RULES AND MASK FABRICATION LIMITATIONS

- If you need to dice the final product, make sure your layout does not conflict with the design rules for dicing (we cannot cut metal).
- Center layout around (x,y) = (0,0).
- Die size for step-and-repeat 10 x 10 mm^2 maximum (Not for Delta Mask).
- Avoid wires (definition of ends not clear). This might lead to short circuits or open circuits so do not use wires use boxes instead.
- GDSII wires and polygons maximum 200 vertices. There is no maximum for cif polygons
- Think about your ALIGNMENT MARKS! For a clear field mask just draw your alignment marks. For a dark field mask, draw the outline/contour of the alignment marks. Then you will get an open frame around your alignment marks on the mask, which makes it possible to find the alignment marks during alignment. Make some pointers pointing towards your alignment marks to make them easier to find.

Electronic Vision aligner, alignment mark location

Vertical location: -5 < y < +5 mm from center.
Horizontal location: Between 25 and 90 mm apart (5" masks).
Alignment area: 300 µm x 200 µm.

Karl Süss aligner, alignment mark location

Vertical range: -75 mm < y < 25 mm.
Horizontal range (for alignment i.e. using both objectives): |x| > approx.15 mm.
Alignment area: With the x20 objective the height of your field of vision is approx. 350 µm (The aligner is fitted with three objectives: x5, x10, x20).

For back side alignment please position the alignment marks in the area: 16 mm < |x| < 45 mm and -8 mm < y < 8 mm.

For compatibility with EVC aligner place alignment marks on y = 0 with |x| > 25 mm.

Anodic bonder, alignment mark location

Vertical position: y = 0 (Should be centred).

Horizontal position: |x| = 35 mm (70 mm apart).
Prebonding using the EV Aligner might be a possibility for higher precision and easier alignment.

ORDER REQUIREMENTS FOR EACH MASK

See also sample text file at the end of this document.

1. Size (usually 5" masks for 4" wafers).
2. Material (usually chromium, glass type usually soda lime).

   Note: Glass type is important for transmission and thermal expansion.

   Note: Delta Mask only supplies soda lime glass.
3. Clear field or dark field.

   With clear-field all drawn features will be made in chromium, and all surroundings will become clear.

   With dark-field all drawn areas will become clear, and all the surroundings will be made in chromium.

   The choice is process dependent. For front side alignment a clear field mask is easiest. For backside alignment this does not matter.

   Note that some mask manufacturers might use “geometry” instead of “field”. This has the annoying effect of flipping the polarity. For example if you want a “dark field” mask from a supplier using geometry it should be ordered as a “Clear geometry”.
4. Orientation: Right/wrong reading --- Chromium up

   The reading is connected to the front or backside properties of the layout. As long as all of the masks on the front have the same reading and all the ones on the back have the opposite the masks will work. Any text on the masks should be able to handle the "reading" (wrong reading will mirror any text written parallel to the flat).

   Notice that in aligners the chromium layer is turned down towards the wafer. Here “wrong reading” should be chosed to have correctly written text at the front side of the wafer.
5. Identifier (e.g., MIC - Your Name - Date - Project - Layer)

   Do not put these data on the edge of the layout, the mask manufacturer will place them.
6. Dark or clear periphery, see also Delta Mask specials

DELTA MASK SPECIALS

- The masks are made by laser writing and as such do not have any limitations with respect to arbitrary angles, sharp corners, etc.
- Step-and-repeat: Just instance the cells in your layout
- CIF files (multiple layers including cell hierarchy).
- Unless indicated otherwise: Dark periphery.
- Minimum feature size is approx. 2 micron, positioning error better than 0.2 micron. At this size a hole is not a perfect dot, and a rectangle has rounded corners, due to the resolution of the writing lens.
- Quartz masks can be ordered instead of soda lime. It costs approximately € 500 extra for the first one and then the next 4 are at the same price as soda lime. Basically you pay for the quartz as you get the first mask.

ORDERING MASKS

- It is optional to let an L-Edit super-user check your layout.
- CMJ orders the masks at Delta Mask via e-mail. Mail the cif-file and the txt-file to her (cmj@danchip.dtu.dk).
- Usually the time of delivery is about one week.

FABRICATING A CIF FILE FROM L-EDIT

Check that your design is centred on (0,0). Check that your layers all have a CIF name, and check the physical dimensions of your masks (a factor 100 off in either direction has been seen before...)

1. Make a backup copy of your layout file (Called “original.tdb”).
2. Open a new layout file where you copy the TDB setup from your old file (The option in setup is available through the dialog box). This file will now only contain “cell0”.
3. Save the new file with an appropriate filename (Called “fabrication.tdb”).
4. With “cell0“ active in “fabrication.tdb“, choose "Cell->Copy" (or c). At the top of the dialog box there is a dropdown menu. In this menu you choose the file “original.tdb“. Then you choose the cell containing your wafer-scale layout (called cell: “wafer”). By copying the cell in this way only the cells which are actually in the finished design will show up in the cif file. Otherwise a lot of junk might be carried over.
5. Open cell “wafer“ in “fabrication.tdb”
6. Delete “cell0“ in “fabrication.tdb”
7. Choose “Cell->Fabricate...” and the cell “wafer”. This tells L-Edit which cell you plan to use for the actual masks. If you choose the wrong one, just repeat this step. There can only ever be one fabrication cell in a TDB file. In the cell list you can see which cell it is by the purple script F to the left of the name.
8. Hide all layers you do not plan to use for mask making. It is often easier if you hide all and the specifically choose which ones you plan to make.
9. Choose “File->Export Mask Data” and an appropriate filename and continue.
10. Open your cif file in L-Edit or CleWin (http://www.viewweb.com) or another cif viewer to validate that the conversion was successful.

ADDITIONAL INFORMATION AND TRICKS

Processing

- For KOH etching dark field masks should be used. (They are less sensitive to dust).
- KOH-etch back side protection: Front side pattern (towards the KOH) must not exceed the innermost 88 mm of the wafer.
- KOH-etching makes your wafer fragile, so: Avoid long coherent <110>-directed lines, minimise the number of holes to be etched, and minimise the size of any membranes.
- If you want to measure membrane thickness, include test membranes in your layout.
- If you need to align your masks to the flat of your wafer, include a structure, which will allow that. None of the chucks for the aligners (EVC or Karl Süss) can be counted on to give the correct alignment to the flat.
- The RIE systems have an optional aluminium protective carrier offering some edge protection. The ring will cover 5-7 mm of the rim of the design.
- If possible include a large feature (such as Logo or name) on all masks so that positioning the masks in the aligners become easier (There have been cases where masks were designed with alignment marks which allowed mirroring).
- If possible consider not using the part near the primary flat for anything important. Then you can use this area when gripping the wafers with tweezers and you will always know that this action does not ruin anything important.

L-Edit

- Latest version (v11.0) in I:\ledit\cdrom.v1101 (net use I:\\micsrv1\app).
- MIC has 9 network licenses (and Danchip has 1 network license).

- MIC has one license to Design Rule Check (DRC)
- CMJ has one spare dongle. If the network goes down and you need this dongle, please contact CMJ (you will have to install a small program).
- Additional programs in MIC/SYS: APP/LEDIT/CONTRIB.
- Remember to *backup* your layout regularly. Some operations cannot be undone. L-Edit keeps one backup copy with extension ".TDO". It is recommended to keep a number of old backup versions of the layout. Sometimes an error will be saved which causes the program to crash when the file is opened. Obviously this is disastrous.
- Remember to identify your *layers* (setup layers) and cells (cell info). The layers will already be identified if you use a standard technology (such as SCNAMEMS). For a cif layer the case matters, meaning that cmf and CMF are two different layers. However to avoid confusion it is recommended that your layer names are kept in all caps such as CMF in the example.
- Use plenty of *cells* and *instances*, this will eventually help you a lot. A cell containing only a 20 by 20 micron square might seem like a waste but consider if this is a contact hole repeated 100 times on your design and you find out you would prefer to change it to 15 by 15 microns instead. Using a cell it would take a few seconds, using copies would take you much longer.
- Transferring a structure from one layer to another: Choose the structure, copy with ctrl-c, choose the target layer in the palette, and put the structure on that layer using alt-v.
- You can use layers for keeping track of processing. Especially when making masks with deep etches for membranes etc. is it useful to outline where the membrane will actually be considering the sidewall slope and expected under etch.
- If rescaling and subsequent editing of a cell is desired, one approach is to instance the cell (in a new cell) and *rescale the instance* using *Edit->Edit object(s)* (ctrl-e). Then *flatten* (removes all hierarchy information) the new cell to which it was instanced and then carry on editing.
- *Distance measurement*: Use `Q' to define temporary zero point. All distances are in *locator units* so make sure you know how large the unit actually is.
- *Grid settings* are a matter of personal preference. So play around with them until you get something which works for you. One place to start is to use Microns as *technology unit* in Setup->Setup Design->Technology and choose 1 internal unit equal to 1/10 (one tenth) micron. In Setup->Setup Design->Grid *Display grid* and *Mouse grid* can then be set to *one locator unit* and finally the locator unit can be set to a number of *internal units* depending on what scale you are drawing. For details you might want to choose one locator unit to be 10 internal units giving you a grid of 1 micron on the other hand for structuring the wafer-level design you might want to use 1 locator unit equals 100000 internal units giving you a grid of 1 cm.
- Be careful when changing the *technology units* (in Setup->Design). L-Edit will assume that you wish to resize your layout. In most cases you probably want to maintain physical size (unless working with lambda units).
- Import weird structures (from e.g. Olympios or others). Open the cif file containing the new structure. Delete all layers not needed. Rename all layers in the new file to conform to the layout file. Copy the weird structure cell into the design.
- "*Derive layers/ Generate layers*". Although possible and highly useful, many of the designs at MIC are too big for deriving and generating (it simply takes too much time). A relatively simple derivation incorporating cross-hatching of a whole layout took 6 hours to calculate on a Centrino 1.5 GHz.

TEXT FILE EXAMPLE

```
Lyngby 15.6.04

All layers:
  5" chromium mask
  Soda-lime Glass
  Dark periphery
  Chromium up

CIF-file: nychip_24.cif

Layer: CEL
Mask type: CLEAR field, wrong reading
Text: MIC - Niels Nielsen – June 2004 - Nice Device - wiring

Layer: SIL
Mask type: DARK field, wrong reading
Text: MIC - Niels Nielsen - June 2004 - Nice Device - metal

Layer: CAA
Mask type: CLEAR field, right reading
Text: MIC - Niels Nielsen - June 2004 - Nice Device - back side

Yours sincerely
Niels Nielsen
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