E-beam lithography and design principals

JEOL e-beam lithographer

- Exposing a matrix of dots
  - An electrostatic beam-blanker controls the duration of the current pulse at etch point
  - The dose (energy or charge deposited by unit surface) is a function of the pulse duration, the current and the point-to-point distance
- Spot size
  - Increases with the current intensity and is a function of other parameters: the lens used, the aperture, the acceleration voltage, etc.
  - Backscattered electrons also contribute to the dose
  - The effective electron beam has a Gaussian-like shape
  - Proximity effect has to be taken into account is some situations
- Frames and stage motion
  - To limit distortion, the lithographer only exposes in small fields
  - A high precision laser interferometer enables reproducible stage motion.

Drawing principles

- Pattern file system and scripts
  - Scripts are used to position patterns and form the desired wafer/mask layout (JDF)
  - These scripts also handle the dose setup, dose modulation, alignment mark detection, etc.
  - Scripts are used to schedule and set various parameters for the exposure (SDF)
- Pattern conversion
  - Drawings must be converted to a JEOL specific format from a standard DXF format (see specific instructions)
  - Layers: the different layers present in the DXF file will be extracted and filed independently in the JEOL pattern format
  - Layer “0” can be used for drawing aids but not for patterns that should be exposed
- Dose modulation
  - The exposure can be modified for different parts of a drawing using the “dose modulation” capabilities of the system
  - A dose modulation table (in the JDF script) is used to convert the color of the drawing elements into modified exposure dose
  - The dose modulation table indicates the percentage to be added/subtracted from the nominal dose
- Multiple current exposure

- Most tasks use two currents to reduce exposure time:
  - A low current (~0.1nA) for high resolution patterns
  - A high current (~10nA) for large area exposure
- In any case, a slight misalignment has to be expected between the low and high current exposure
- This efficient way of planning drawings requires
  - To used one layer per current
  - To provide sufficient overlap between drawing parts in different layers (a few microns)

❖ Multiple exposure and alignment marks

- The lithographer can perform an automatic alignment on marks present on the sample
- This permits multiple fabrication steps or a better alignment for exposures with different currents
- The marks must have sufficient contrast (ex. 200nm Au film on Si)
- Careful considerations must be accorded to alignment scheme at drawing stage

Using AutoCAD

❖ Use only closed POLYLINE to define the patterns

- For compatibility with the JEOL format, do not use lines, rectangles, arcs or text.
- The use of the "c" key word is recommended to ensure the closure of the POLYLINE
- Do not create POLYLINEs with to many vertices (though the limit is rather large)
- Create small POLYLINEs that can be colored differently for dose modulation purposes

❖ Control the overlapping of drawing elements

- Remember that every POLYLINE will be exposed
- Overlapping areas will receive the cumulative dose of all overlapping drawing elements

❖ Center the drawing on the origin (0,0) or an other known point of the drawing (ex. upper left corner)

Drawing tips

❖ Various OSNAP (F3 key to toggle on/off) modes are available to point to vertices, end-points, mid-points, etc. See also "Tools/Object Snap Settings" to set defaults.

❖ ORTHO mode limits drawing/motion to vertical or horizontal (F8 key)

❖ "Modify/Properties" function shows and enables to modify various properties (color, layer, etc)

❖ There are various measuring tools

- Use DIST to measure distances and AREA for areas
- The DIM set of commands is meant to draw dimensions on technical drawings

- Coordinates can be entered from the keyboard
  - **X ,Y** for absolute cartesian coordinates
  - **Radius < Angle** for polar coordinates
  - Prefix **@** indicates relative coordinates
- Filters can be used to refer to partial coordinates
  - When prompted for a coordinate, use the **.x** filter to use only the x coordinate of the point you will select next.
  - Other filters are: **.y**, **.z**, **.xy**, **.xz**, **.yz**
- Lock or hide layers to make drawing easier
- There are two mode of window selection
  - dragging from left to right selects only elements that are completely included in the selection window
  - dragging from right to left selects all elements that are partly or completely included in the selection window
- In window selection
  - Use key "r" to switch to "remove selected object"-mode and "a" to return to "add selected object"-mode

Drawing tools

- Editing vertices
  - Select the object and then select a vertex. Drag it to move or enter new coordinates (absolute or relative)
- STRETCH command
  - Enables to move a set of vertices at once
  - When requested, select the vertices you want to move by using a crossing window (drag from right to left)
- ARRAY command
  - Creates rectangular or polar (circular) arrays of select drawing elements
- The function EDIT/COPY (≠ COPY command)
  - It copies elements in the usual clipboard memory. They are rendered using the function EDIT/PASTE as a block. Not very practical… but when you want to move a whole lot of things from one drawing file to an other
  - Use EXPLODE command to return to the individual elements.