12 Cross-Section Viewer

Implementation

L-Edit cross-section views are intended to help the circuit designer visualize the vertical structure of an integrated circuit. This view does not provide a completely accurate representation of the physical reality. Actual chips have a variety of properties and process artifacts, such as smooth height transitions, bird's beak, and planarization, which L-Edit does not model in cross-section view.

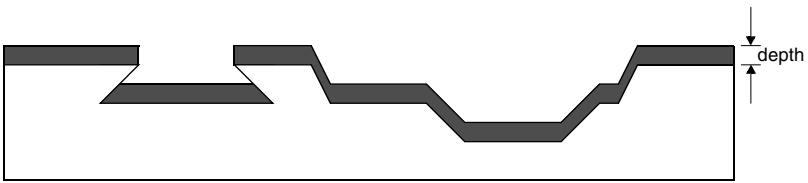
Cross-section views are generated from layout by simulating a set of process (fabrication) steps and building the diagram from the substrate up, one layer at a time. These simplified process steps correspond only roughly to the process steps used by the fabricator to create the chip. The *process definition* is maintained in a separate text file (see Process Definition Files on page 1-492).

The cross-section viewer simulates three types of process steps:

- *Grow/deposit* generates new material.
- *Etch* removes material.
- *Implant/diffuse* modifies the material nearest the surface.

Grow/Deposit

New material is generated uniformly in a grow/deposit step. The substance specified in the process step statement is grown or deposited vertically to the specified depth (measured in technology units) on all upward-facing surfaces. The following figure depicts new material deposited in a grow/deposit step.

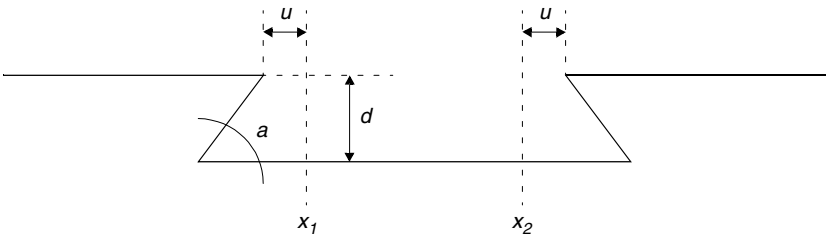


Oxide growth and metal deposition are both simulated with this type of step. (In reality these fabrication layers and the substrate are manufactured with completely different procedures, but for cross-section-viewing purposes, the results may be modeled in the same way.)

Etch

An etch step removes material from all areas covered by the specified mask layer. The etch process model involves up to three parameters: the depth, the undercut offset, and the angle. Depths and offsets are measured in technology units; angles are measured in degrees. A cross-section surface resulting from an

etch step with depth *d*, undercut offset *u*, and angle *a*, between points x_1 and x_2, is shown in the following figure.



Typically, many of the layers to be etched will not be simple drawn mask layers, but will result from logical operations such as AND, OR, and NOT combining several mask layers. Unlike a physical etch that may remove some materials but not others, the simplified etch step removes all materials uniformly. Although nonphysical, the simplified etch captures the important details of most semiconductor fabrication processes.

Implant/Diffuse

To simulate the ion-implantation or high-temperature diffusion process that modifies the type of semiconductor nearest the surface, an implant/diffuse step causes the color of the specified mask layer to replace the existing ones from the top surface down to the specified depth in all areas covered by the layer. The

implant/diffuse process model involves the same parameters as in the etch model, except that the underlying material is replaced rather than removed.

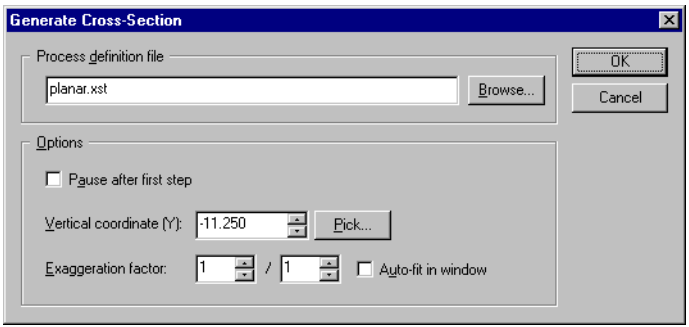
Again, the mask layer may be a logically derived one. For example, the self-aligned polysilicon gate structure requires a combination of the polysilicon and active mask layers to determine where to show the implanted active, which may be blocked by either field oxide (the NOT of active) or by polysilicon. Operations on layers are specified with the **Setup Layers** dialog (see Layer Setup on page 1-155). The derived layers are specified for cross-section views the same way as for DRC and extraction layers.

Operation

A process definition file must exist prior to generating a cross-section. The layer names in this file must exactly match the layer names in the layout that you wish to view in cross-section. Sample process definition files are provided in the **tech** directory, which is located in the default L-Edit install directory. The process definition files are described in the file **Index.txt**, which is located in the same directory. For information on the syntax of a process definition file, see Process Definition Files on page 1-492.

The cell for which you wish to generate the cross-section must be open. Arrange the display such that a small region of interest (usually a few transistors) is centered in the upper portion of the layout view.

When you choose **Tools > Cross-Section** or press the cross-section button ( ) L-Edit displays the following dialog:



Options include.

Process definition file — Type in the name of the process definition file, or use the **Browse** button to select the file.

Pause after first step — Pauses cross-section generation after the first step in the process. To resume cross-section generation, click the **Next Step** button ( )in the cross-section window.

Vertical coordinate (Y)

Sets the vertical coordinate along which the cross-section is generated.

Pick

Allows you to set the vertical coordinate graphically. The cursor becomes a horizontal line that can be dragged up or down in the layout. Clicking the mouse button over the desired position reopens the **Generate Cross-Section** dialog, with the graphically selected *y*-coordinate in the **Vertical coordinate (Y)** field.

Exaggeration factor

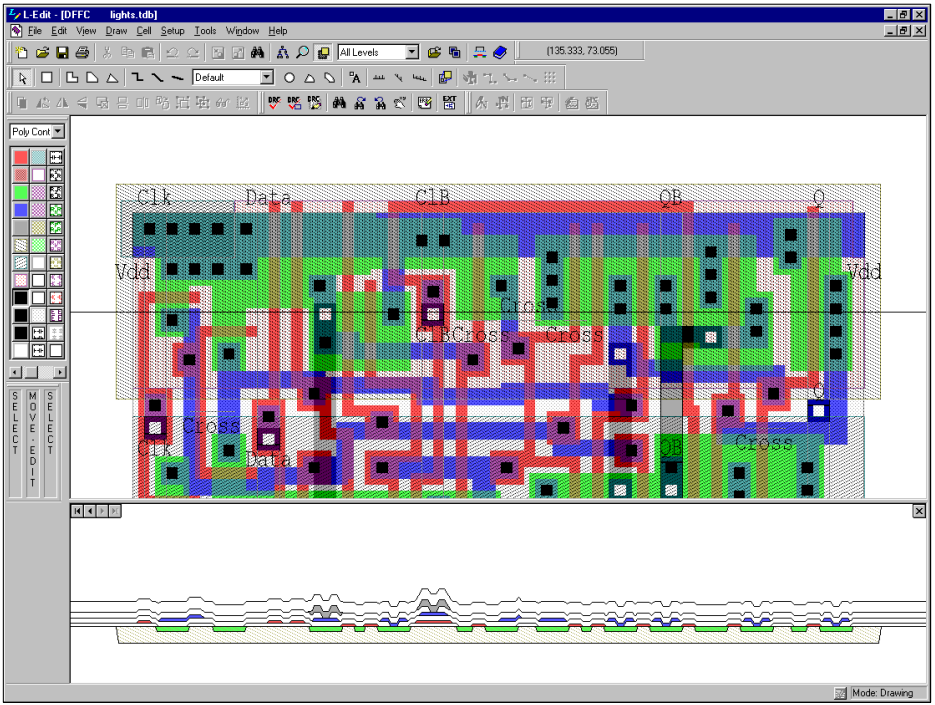
Sets the magnification factor for the cross-section along the *z*-axis in terms of a ratio. Since process depths are measured in technology units, the displayed thicknesses of layers in cross-section scale with the current layout magnification. At very large or very small magnifications, it may be impossible to display cross-section views effectively at a 1:1 horizontal-to-vertical aspect ratio. The two fields (numerator and denominator) specify the ratio by which to compress or expand the vertical axis of the cross-section.

Auto-fit in window

Sets magnification along the *z*-axis for maximum visibility.

Display

L-Edit displays the cross-section view in the lower portion of the application interface.



Where the active cell displays a cross-section view:

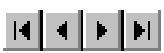
- You cannot pan, zoom, or edit in the cross-section window.
- You cannot perform an editing operation in other windows associated with the file.
- You cannot resize the layout window.

The split line separating layout from the generated cross-section can be dragged into another location. Double-clicking on this line removes the cross-section view.

To continue normal layout editing, close the cross-section window.

Single-Step Display

You can step through the cross-section view one process step at a time. To do click the appropriate button in the cross-section window:



First process step

Previous process step

Next process step

Final process step

A tooltip identifying the associated process step appears over these buttons when you point at them. The current step is displayed in the status bar.

Single-step mode is useful for learning the steps involved in fabrication. For instruction in real fabrication processing, a much more detailed process definition could be used.

Single-stepping through a fabrication cross-section that includes all the photoresist and other intermediate processing steps would better communicate the full complexity of today's fabrication processes. For designers who only want to view final cross-sections, simpler process definitions (such as the example in this chapter) are sufficient and easier to maintain.

Process Definition Files

Syntax

The cross-section process definition file (XST) contains a list of comment statements and process statements. Comment statements begin with a pound sign (**#**) and continue to the end of the line.

Process statements have the following format:

```
step layer depth label [angle [offset]] [comment]
```

Each process statement begins with a ***step*** type, one of the following:

- **gd** or **grow/deposit**
- **e** or **etch**
- **id** or **implant/diffuse**

Layer is the name of the involved layer. The name of the layer must match the layer name used in the L-Edit TDB file. If the layer name begins with a digit or contains spaces, then the entire name must be enclosed in double-quotes ("…"). The layer name describes something different for each type of step:

- For grow/deposit steps: the layer to be grown/deposited

- For etch steps: the layer to be etched away
- For implant/diffuse steps: the layer to be diffused

A dash (**-**) in place of a layer name indicates that the process step has no associated rendering information.

Depth is a (non-negative) value indicating the depth, measured in technology units. The depth also means different things for different steps:

- For grow/deposit steps: the number of units to grow upward
- For etch and implant/diffuse steps: the number of units downward to apply the step

Label is optional. The label may be any string. If it contains spaces, the entire label must be enclosed in double-quotes ("…"). A dash (**-**) may be used in place of a label.

If desired, two parameters that apply only to etch and implant/diffuse steps are inserted next:

- Etch-implant **angle** (integer)
- Undercut **offset** (non-negative floating-point or integer)

Angles are measured in degrees and must be between 0 and 180; offsets are measured in technology units. The default values are **angle = 80** and **offset = 0**.

Last is an optional **comment**. The comment begins with a pound sign (**#**) and continues to the end of the line.

Example

A sample definition for an *n*-well, double-poly, double-metal CMOS process is shown below. Each line (after the header) corresponds to one process step.

```
# File: mORBn20.xst
# For: Cross-section process definition file
# Vendor: MOSIS:Orbit Semiconductor
# Technology: 2.0U N-Well (Lambda = 1.0um, Technology = SCNA)
# Technology Setup File: mORBn20.tdb
# Copyright (c)  1991-93
# Tanner Research, Inc.  All rights reserved
# ************************************************************************
#     L-Edit
# Step                  Layer NameDepthLabel   [Angle[offset]]               Comment
# ------------------------------------------------------------------------------
gd                      -       10      p-                      #  1. Substrate
id                      "Well X"3       n-                      #  2. n-Well
id                      ActPSelNotPoly0.9p+    75      0        #  3. p-Implant
id                      ActNSelNotPoly0.9n+    75      0        #  4. n-Implant
id                      CCD&Act 0.4     -                       #  5. CCD Implant
id                      "P Base"2       -                       #  6. NPN Base Implant
gd                      -       0.6     -                       #  7. Field Oxide
e                       Active  0.6     -       45              #  8.
gd                      -       0.04    -                       #  9. Gate Oxide
gd                      Poly    0.4     -                       # 10. Polysilicon
e                       NotPoly 0.44    -       45              # 11.
```

```
gd                  -       0.07    -       45          # 12. 2nd Gate Oxide
gd                  Poly2   0.4     -                   # 13. 2nd Polysilicon
e                   NotPoly20.47    -       60          # 14.
gd                  -       0.9     -                   # 15.
e                   "P/P2/Act Contact"0.9- 60           # 16.
gd                  Metal1  0.6     -                   # 17. Metal 1
e                   "Not Metal1"0.6 -       45          # 18.
gd                  -       1       -                   # 19.
e                   Via     1       -       60          # 20.
gd                  Metal2  1.15    -                   # 21. Metal 2
e                   "Not Metal2"1.15-       45          # 22.
gd                  -       2       -                   # 23. Overglass
e                   Overglass2      -                   # 24.
```