Process Definition File Documentation 2/16/06

General Format:
The process definition file (PD) is used to control the Sandia 2D Process Visualizer and the Sandia 3D MEMS Modeler. A process definition file can contain multiple processes, each with a unique *ProcessName.* A given process definition file can contain up to 256 process definitions. Each definition has the following format:

Begin_Process_Definition *ProcessName*

Begin_Color_Table
Color list
End_Color_Table

Begin_Step_Definition
Step Definition list
End_Step_Definition

Repeat steps as needed

End_Process_Definition

If a PD file contains multiple definitions of the same *ProcessName*, the last definition will be used.

Color Definitions:
Colors are defined with a name, an RGB value, and an AutoCAD color index:

NAME = (r.rr, g.gg, b.bb) a

Where *r.rr* is the red, *g.gg* is the green and *b.bb* is the blue indes, as numbers between 0.00 and 1.00, and *a* is the AutoCAD color indes from 0 to 255. RGB will be used for 2D visualization and for SAT files, AutoCAD indexes will be used when 3D models are opened in AutoCAD. The color table size is limited to 256 colors. Black and white are predefined and are the logical inverse of each other. A set of commonly used colors is included below.

RED=(1.00, 0.00, 0.00) 1
ORANGE=(1.00, 0.50, 0.00) 30
PEACH=(0.90, 0.30, 0.30) 21
X4_PURPLE=(0.80, 0.40, 1.00) 205
SILVER=(0.75, 0.75, 0.75) 9
DARK_RED=(1.00, 0.00, 0.60) 6
LT_BLUE=(0.50, 1.00, 1.00) 4
BLUE=(0.00, 0.00, 1.00) 5
YELLOW=(1.00, 1.00, 0.00) 2

PURPLE=(0.50, 0.00, 0.50) 205
GREEN=(0.00, 0.80, 0.00) 100
BLUE_GREEN=(0.00, 0.50, 0.50) 123
DK_BLUE_GREEN=(0.00, 0.45, 0.45) 124
YELLOW_GREEN=(0.80, 0.80, 0.10) 70
LIME_GREEN=(0.80, 0.80, 0.20) 60
LT_GREEN=(0.00, 1.00, 0.00) 3
TAN=(0.80, 0.80, 0.30) 42
DARK_BROWN=(0.50, 0.50, 0.10) 54
OLIVE=(0.50, 0.50, 0.10) 66
LT_GREY=(0.50, 0.50, 0.50) 254
LIGHTER_GREY=(0.75, 0.75, 0.75) 253
DARK_GREY=(0.15, 0.15, 0.15) 252
DARKER_GREY=(0.10, 0.10, 0.10) 251
BLACK=(0.00, 0.00, 0.00) 7
WHITE=(1.00, 1.00, 1.00) 250

Process Step Definitions:

There are several types of process steps, each will be outlined below. A process may have up to 256 process steps. All process steps have the first four lines in common. The numbering should be integral and sequential but can be out of order (it may be renumbered). It is only used in displaying the progress during a modeling process.

Begin_Step_Definition
Number = *StepNumber*
Name = *StepName*
Type = *ProcessType*

Depositions:

Used to apply material, one layer at a time. Note: The 3D Modeler treats uniform, conformal and CVD depositions the same. Up to 10 Material types per file are allowed.

Uniform Deposition:

The uniform deposition model is a constant material thickness. The example below shows several layers deposited with the uniform deposition model.

It is intended to be used on a flat surface, typically the first deposition performed, or perhaps after a planar deposition.

Uniform Deposition Example

Type = UNIFORM_DEP
Thickness = x.xx
Material = *MaterialName*
Color = *MaterialColor*
End_Step_Definition

Conformal Deposition:
The conformal deposition model has a constant material thickness on top surfaces but a different thickness on vertical walls.

Valid only for depositions without undercuts. It has a constant top thickness and a different side thickness. The model used is a swept dual ellipsoid (e.g. an egg shape). Egg values are given as a factor of thickness, from 0 to 1.0, and define the film thickness on the top surface and sidewalls.

Conformal Deposition Example

Type = CONFORMAL_DEP
Thickness = x.xx
Top_egg_x = x.xx
Top_egg_y = x.xx
Bottom_egg_x = x.xx
Bottom_egg_y = x.xx
Material = *MaterialName*
Color = *MaterialColor*
End_Step_Definition

CVD Deposition: A fully conformal deposition that will work with under cuts. It uses the same Egg values as the conformal deposition.

The CVD deposition model has a constant material thickness on top surfaces. Different thicknesses are used on vertical walls and overhanging surfaces. The example below shows the deposition of SacOx2 for a hub.

CVD Deposition Example

Type = CVD_DEP
Thickness = x.xx
Top_egg_x = x.xx
Top_egg_y = x.xx
Bottom_egg_x = x.xx
Bottom_egg_y = x.xx
Material = *MaterialName*
Color = *MaterialColor*
End_Step_Definition

<u>Planar Deposition</u>: This is used to simulate a deposition followed by a CMP step. It deposits material up to a planar level, where the thickness of the deposition is defined as an absolute thickness above zero.

The example below simulates the result after the SaxOx3 layer was deposited and the CMP process applied.

Planar Deposition Example

Type = PLANAR_DEP
Thickness = x.xx
Material = *MaterialName*
Color = *MaterialColor*
End_Step_Definition

Mask Definitions:

Masks are defined using AutoCAD layers, and are then used as the pattern in an etch step. The MASK type is used in conjunction with the CUT_MASK to create a single definition for an etch. All MASK geometry with the same Name property is ORed together, all CUT_MASK geometry with the same Name property is ORed together, then the MASK and CUT_MASK geometry with the same Name property is XORed for the final definition. Just to clarify, all the MASK and CUT_MASK process steps that are used to create a single hard mask should have the same Name property so that the code knows to XOR them together. Each of the two types are defined independently and can be light or dark field, although all steps used to create a mask are typically the same Field. The Acad_name field is for specifying the layer name from the MEM geometry file – which is derived from the AutoCAD layout. The Field property defines the mask field as either light (0) or dark (1) field. In a light field mask, the defined geometry will correspond to locations with chrome, and the "open field" will be clear. The color is typically defined to match the mask color of the step being etched, and only affects the mask color shown at the top of the 2D visualizer.

Type = MASK/CUT_MASK
Acad_name = *LayerName*
Field = 1/0
Color = *ColorName*
End_Step_Definition

Etches:

Etch steps are used to remove material. The Edge entry defines the Name of process step that contains the mask to be used. For the Material tag, list all the materials that the etch should operate on, with each material on its own line. Up to 10 different Material types per file are allowed. For Etch_Type, indicate *Pos* or *Neg* to specify positive or negative photo resist. Positive resist will duplicate the mask chrome pattern into the film, negative will invert the pattern. Overetch is always specified as a percentage of the thickness. Etch color should always be BLACK.

Dry Etch: This etch is a anisotropic etch that can be used to produce straight or angled sidewalls. Angle is defined from 0 to 90 degrees, with 90 the default. Note, the 3D Modeler does not currently support angled

side walls, if an angle is specified it will be ignored. The example below shows the result of a dry etch cut on the SacOx1 layer.

Dry Etch Example

Type = DRY_ETCH
Edges = *MaskName*
Etch_type = POS/NEG
Thickness = x.xx
Overetch = 0.xx
Angle = x.xx
Material = *MaterialName*
Color = BLACK
End_Step_Definition

<u>Wet Etch:</u> This is an isotropic etch. The 3D modeler will not represent curved edges, but will perform the wet etch with straight sidewalls. In the 2D Process Visualizer, the wet etch step removes material based on a ray casting model. It will create curved undercuts. The example below shows a wet etch used to create a pin joint cavity in the SacOx1 layer.

Wet Etch Example

Type = WET_ETCH
Edges = *MaskName*
Edge_type = Pos/Neg
Thickness = x.xx
Overetch = 0.xx
Material = *MaterialName*
Color = BLACK
End_Step_Definition

Bosch Etch: This etch step is used to simulate a dry etch up from the bottom of the model.

Type = BOSCH_ETCH
Edges = *MaskName*
Edge_type = Pos/Neg
Thickness = x.xx
Overetch = 0.xx
Material = *MaterialName*
Color = BLACK
End_Step_Definition

Planar Etch: This etch is used to simulate a CMP step. Etches all materials down to a planar level, where the resultant thickness is defined as an absolute thickness above zero. Note: This step along with a preceding deposition step can be used to replace the PLANAR_DEP step.

Type = PLANAR_ETCH
Thickness = x.xx
Color =
End_Step_Definition

The example below simulates the result after the SaxOx3 layer was deposited and the planar etch step
applied.

Planar Etch Example

Release Etch: Used to remove all of a sacrificial material. In the 3D Modeler, all top surface accessible material will be removed. In 2D Process Visualizer, trapped oxide will remove all material specified. This includes any trapped material. The example below shows the result of the release etch removing all of the sacrificial oxide. Note that the trapped SacOx2 in the center post was removed also.

Planar Etch Example

Type = RELEASE_ETCH
Material = *MaterialName*
Color = BLACK
End_Step_Definition

Setting up AutoCAD to use a custom definition:
To configure AutoCAD to use your custom process definition, open the drawing file to be used and go to “File/Drawing Properties.” On the “Custom” tab you specify AutoCAD environment variables that direct the modeling tools to the proper file.

snl_process	The *ProcessName* you want to use
snl_process_file	The location and name of the definition file