# HotSpot Extension 1.2 Test Cases

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## Computing Joint Parallel Resistivity

Let $A_{\%w/oTSVs}$ = % area of block without TSVs

$A_{\%withTSVs}$ = % area of block with TSVs

$R_{Layer}$ = Resistivity of the Layer (TIM or Silicon)

$R_{Cu}$ = Resistivity of TSVs (Copper) = $0.0025\frac{m*K}{w}$

$$R_{Joint} = \frac{1}{\left(A_{\%w/oTSVs}*\frac{1}{R_{Layer}}\right)+\left(A_{\%withTSVs}*\frac{1}{R_{CU}}\right)}$$

In order to calculate the percent area of block with TSVs you can model the TSVs with diameter 50µm[1] as square blocks, i.e. occupying a space of 50µm x 50µm. Smaller TSVs dimensions are also possible in current technologies, such as 10 µm x10 µm. You should also consider the minimum pitch requirements in between the TSVs in your design.

## Test Case Parameters

| | | |
|---|---|---|
| Sampling Interval | = | 0.0001 seconds |
| # of Row | = | 64 |
| # of Cols | = | 64 |
| Resistivity of Silicon | = | $0.01\frac{m*K}{W}$ |
| Resistivity of Interface Material | = | $0.25\frac{m*K}{W}$ |
| Length/Width of one layer | = | 2mm x 2mm |

Other parameters are listed in the HotSpot Configuration File/Layer Configuration File

[1] Mohamed M. Sabry, Ayse K. Coskun, David Atienza, Tajana Simunic Rosing, Thomas Brunschwiler. **Energy- efficient Multi-objective Thermal Control for Liquid-Cooled 3D Stacked Architectures**. In *IEEE Transactions on Computer Aided Design, vol. 30 no. 12, pp. 1883-1896*, Dec. 2011.

## Default3D

Base case with one unit in each layer and default parameters.

| Layer # | Floorplan File | Resistivity $\left(\frac{m*K}{W}\right)$ |
|---|---|---|
| 0 | layer0.flp | 0.01 |
| 1 | TIM.flp | 0.25 |
| 2 | layer2.flp | 0.01 |
| 3 | TIM.flp | 0.25 |

## 3D_10Percent

This test case consists of four layers with each containing only one unit in each layer. The 3D_10percent_TIM.flp layer has a TSV density of ten percent and the joint resistivity is calculated based on the equation in the above section.

| Layer # | Floorplan File | Resistivity $\left(\frac{m*K}{W}\right)$ |
|---|---|---|
| 0 | layer0.flp | 0.01 |
| 1 | 10percent_TIM.flp | 0.02294 |
| 2 | layer2.flp | 0.01 |
| 3 | TIM.flp | 0.25 |

## 3D_2Percent

This test case consists of four layers with each containing only one unit in each layer. The 3D_2percent_TIM.flp layer has a TSVs density of two percent.

| Layer # | Floorplan File | Resistivity $\left(\frac{m*K}{W}\right)$ |
|---|---|---|
| 0 | layer0.flp | 0.01 |
| 1 | 2percent_TIM.flp | 0.08389 |
| 2 | layer2.flp | 0.01 |
| 3 | TIM.flp | 0.25 |

## 3D_2Percent_v2

TSVs may connect the active transistor layers of each Si chip, therefore some of the Si chips may have TSVs in the bulk Si. We adjusted the resistivity in layer zero to model this case with the same two percent TSVs density.

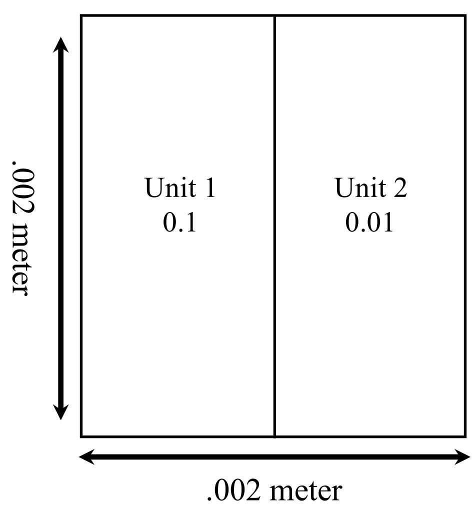
| Layer # | Floorplan File | Resistivity $\left(\frac{m*K}{W}\right)$ |
|---|---|---|
| 0 | 2percent_layer0.flp | 0.0094 |
| 1 | 2percent_TIM.flp | 0.02294 |
| 2 | layer2.flp | 0.01 |
| 3 | TIM.flp | 0.25 |

## 3D_heterogenous

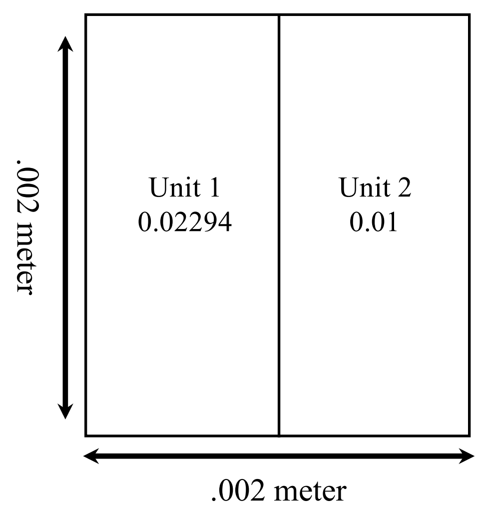
The first layer of Silicon consists of two evenly sized blocks with equal thermal resistivity values. The first layer of TIM consists of two evenly sized blocks: one with default thermal resistivity value, and the other with a modified thermal resistivity value. Other layers are unchanged.

| Layer # | Floorplan File | Resistivity $\left(\frac{m*K}{W}\right)$ |
|---|---|---|
| 0 | layer0.flp | Unit1 = 0.01 |
| | | Unit2 = 0.01 |
| 1 | heterogeneous_TIM.flp | Unit1 = 0.02294 |
| | | Unit2 = 0.01 |
| 2 | layer2.flp | 0.01 |
| 3 | TIM.flp | 0.25 |

layer0.flp




heterogeneous_TIM.flp




**Note:** We do not modify the specific heat capacity of the layer in these experiments. The change in specific heat capacity is expected to have lower impact compared to that of the thermal resistivity. Specific heat capacity values, however, can also be modified by editing the floorplan file.

## Debugging

We added a debugging flag to print out the thermal resistances in the x, y and z direction for each grid in a .csv type format. This will disable the dumping of steady state temperatures to stdout.

Usage:

```
make DEBUG3D=1
```

When running HotSpot it outputs the relevant data starting from layer zero to the last layer specified in the layer configuration file.

Output:

row #, column #, $R_x$, $R_y$, $R_z$