Combatting Overheating in 3D Memory

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1 Introduction

3D memory is a recent technology which provides inherently fast access. However, every technology has it's limitations and there is a need to combat overheating of this system as well as to save energy. However, all this needs to be done while ensuring there is no noticeable loss in performance of the system.

Analysis of temperature patterns and efficient shutdown sequence for prevention of overheating in 3D memory has been looked upon in this report.

The analysis has been done for shut down of half of the memory ranks in the base layer. This has been done in accordance with the fact that shutting down the system partly, although reduces performance but allows components to cool down, saving power and prevents any damage due to heat to the components.

2 Set Up

Working with the starter files, a brute-force script was added, which went across all possibilities of shutdown sequences. This script takes a couple of hours to run.

Another script was also added which then took the optimal results, obtained for access_pattern_flag = 0 by the brute-force script, and then returned their access and temperature for access_pattern_flag values from 0 to 4.

3 Results

12	13	14	15
8	9	10	11
4	5	6	7
0	1	2	3

Table 1: Base Layer Floorplan

These values provide minimum value of the maximum steady state temperature of ranks of the base layer.

1	0	1	0
0	0	1	1
1	1	0	0
0	1	0	1

Table 2: $T_{SS,max} = 72.96$

0	1	0	1
1	1	0	0
0	0	1	1
1	0	1	0

Table 3: $T_{SS,max} = 72.96$

The symmetric case, where all central ranks are shutdown, and the corners are also shutdown, also gives great results.

0	1	1	0
1	0	0	1
1	0	0	1
0	1	1	0

Table 4: Another optimum leakage_flag values for base layer
$T_{SS,max} = 73.37$

A similar result was observed for other values of access_pattern_flag. For a value of 1, the leakage_flag values of Table 4 dominate the other optima, however, for the rest of the values, values of Table 2 & 3 stay slightly ahead.

4 Analysis

When a contiguous segment of base layer ranks are on, the neighbouring ranks also contribute the the temperature of such a block, and hence this causes large values of steady state temperatures.

Central ranks are are heated from all the sides, which results in their higher temperature. Thus shutting them down tends to produce a significant drop in temperature. Also shutting off the corners then results in only the edge ranks to be on, which share only one cell boundary with another "on" rank. This produces low standard state temperatures and prevents overheating, while maintaining a workable efficiency.

Another, result which produces a great result is the pattern shown in Tables 2 & 3. This also presents a symmetric shutdown sequence, and results in lower temperatures.

Minor errors may be caused to the parameters of the simulation, but overall, table 4 provides a great ranks shutdown sequence for the base layer, intuitively, as well as on the basis of the simulation.

5 Conclusion

Symmetry in the heating allows the intuitive examination process to become much simpler.

The analysis also presents a new model which provides essential insights in the design of 3D memory systems, which can help in reducing power consumption while maintaining the required performance and efficiency of the system.