New Memory Technology Migration from Lab to Fab

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Memory Technology Migration From Lab to Fab

- For a successful migration, where is the beginning and where is the end?
Underpinning of Migration from Lab to Fab

• The base technology has to solve a problem in order to start the migration

• 3 Key Questions:
  – What is the size of the problem? How bad is the pain?
  – How well does the base technology address the problems?
  – How much does it cost to take the base technology from the Lab to the Fab?
    • Does the ROI make sense?

• Constraints
  – Existing market expectations have to be respected
    • Fundamentals
    • Power / Performance / Cost
    • Reliability
    • End Use Models
Where is the Market Pull?

• **Market / End Applications for semiconductor memory:**
  – Consumer, Communication, Computing, Automotive Electronics Industry

• **3 Key Problems:**
  – Cost / Scaling
  – Performance / Power
  – Functional Integration

• **Economic Size of The Problem (just for NVM):**
  – Embedded NVM Market (2011): ~$7B

• **Base Technologies Coming to Rescue:**
  – Evolution of Existing Technologies
    • nanoFG, U-FG, etc.
  – Emerging Memory Technologies
    • RRAM (PCM, PMC, CMO, etc)
    • MRAM, FRAM
    • NEMS, MEMS, etc
Who Will Win?

- OK, now we have a significant end market facing serious problems and involving billions of dollars of economic value.

- Looking at the base technologies in the Lab, can you tell who has the best chance of addressing the problems and winning?

- It’s all about MARGINS and CONSTRAINTS.
  - How well does the base technology solve the different problems?
  - How does this technology impact all the CONSTRAINTS?
  - Example:

<table>
<thead>
<tr>
<th>Metric</th>
<th>Existing Technology</th>
<th>Technology X</th>
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<tbody>
<tr>
<td></td>
<td>Production</td>
<td>Lab</td>
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<td>Fundamentals</td>
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<td>1 X</td>
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<tr>
<td>Cost</td>
<td>1 X</td>
<td>1 X</td>
</tr>
<tr>
<td>Reliability</td>
<td>1 X</td>
<td>1 X</td>
</tr>
<tr>
<td>End Use Model</td>
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</tbody>
</table>

DEAD on ARRI
## Candidate Technologies

### Emerging Technology Options for Non-Volatile Memory

<table>
<thead>
<tr>
<th></th>
<th>Existing Non Volatile Memory Solutions</th>
<th>Phase Change Ovonics</th>
<th>MRAM</th>
<th>PMC Technology (Arizona State Univ.)</th>
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<td>OK (?)</td>
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<tr>
<td>End Use Model</td>
<td>OK</td>
<td>OK</td>
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</tr>
</tbody>
</table>

Higher is Better → Lower is Better → Higher is Better → Lower is Better → Higher is Better

*Always Bet on the Technology with the Largest MARGINS*
Requirement to Win: Withstand Trauma of Migration

- Base technology must exhibit orders of magnitude improvements and margins in key CONSTRAINTS to withstand the qualification and commercialization process

- Lab to Fab is 12 rounds of vicious punishment