450mm: A Wafer Manufacturer Perspective

Dr. Bruce Kellerman
Senior Director Semiconductor Product Marketing

11 July 2012
Agenda

- 450mm Rationale from the Device Maker Perspective
- Wafer Supplier Industry Status
- 450mm Wafer Supplier Perspective
450mm Rationale from the Device Maker Perspective

**Cost Aspects**

- Increased Number of Devices per Wafer
- Lower Manufacturing Costs
- Lower Labor Cost per Wafer
- Lithography availability debate: influences timing but not the necessity for diameter move

The transition to 450mm is supported by arguments similar to the 300mm transition
450mm Rationale from the Device Maker Perspective

Competitive Aspects

- Displace Competition ... only the largest, profitable ones can afford

- After Tier 1 adoption of 450mm, what strategy for Tier 2?

- Concentration in the Semi Industry, more large scale M&A

- Some Tier 3 move to Fabless

The transition to 450mm may substantially reshape the Semi landscape and lead to disruptive scenario

<table>
<thead>
<tr>
<th>Potential 450mm Fab Owners</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Definite and Early Adopters</strong></td>
</tr>
<tr>
<td>Intel</td>
</tr>
<tr>
<td>Samsung</td>
</tr>
<tr>
<td>TSMC</td>
</tr>
<tr>
<td>GlobalFoundries</td>
</tr>
</tbody>
</table>

Source: IC Insights
450mm Rationale from the Device Maker Perspective

Key Challenges

- Unclear timing for 450mm transition
- At what node?
- Which transistor Architecture?
- Advanced Lithography Availability?
- Tool Availability?
- Starting Material?

• Although volume driven, the transition to 450mm includes many economic and technical challenges
• Strong necessity for cooperative approach - G450C
The Silicon industry is adapting to the market evolution and will cautiously invest in capacity and capability.
Wafer Supplier Industry Status

Competitive Landscape - Consolidation

How many (profitable) wafer suppliers will be left and are needed for 450mm?

- ≤150mm: < 1990 - 20+ producers
- 200mm: 1993 - 10 producers
- 300mm: > 2007 - 6 producers
- 450mm: > 2015 - ? producers
Wafer Supplier Industry Status

- Previous diameter generations have all reached pricing maturity
- Rapid pricing decline
- No extra pricing available to fund 450mm development
- 450mm will represent a very minor fraction of silicon demand by 2015-2016 (about 1-2%)

In order to be profitable, wafer suppliers need to enter 450mm wafer production at the right time with the right mindset.

Source: IC Knowledge
Wafer Supplier Industry Status

Cost Considerations

- Increased cost (Sie equiv.) for 450mm?
  - Increased thickness (increased cost per Si volume)
  - Increased equipment cost with lower throughput (crystal pullers, epi reactors…)
  - In proportion vs 300mm:
    - more epi vs polished
    - more usage of complex structures (SOI, III-V…)?

The cost per unit surface does not necessarily decrease when moving to 450mm.

Source: White Paper ITRS 450mm
Wafer Supplier Industry Status

Assumptions:
- CAGR (kSie) ~5%
- Cross-over with 300mm volumes in 2022
- Degressive ASP from >12$/Sie in 2012 to 1$/Sie in 2022
- Decreasing margin and spending as % of revenue per year

Simulations show wafer maker losing money until 450mm is close to reach maturity

Source: MEMC estimates
450mm Wafer Supplier Perspective

- SEMI helps define standards
  - SEMI M1-1111 - Polished Single Crystal Silicon Wafers
  - SEMI M74-1108 - Mechanical
  - SEMI M76-0710 - Developmental
  - SEMI M80-1111 - FOSBs

- ... but the previous diameters (including 300mm) teach that nearly every user wants his own specificities:
  - Lasermak
  - Edge Profile

- Lack of flexibility

- Extra costs for the silicon suppliers

Use the 450mm diameter as a new platform to achieve actual Standards
450mm Wafer Supplier Perspective

Timing

- No significant technical hurdles foreseen to achieve 450mm prime wafer quality
- Mechanical wafers readily available
- Test wafers being made available however facing metrology limitations

- The timing is defined by
  - Cost and ROI considerations
  - Equipments availability (edge grinder, polisher, cleaning bench, epi reactor…)
  - Metrology availability (particle, flatness…)

Need close cooperation among consortium, final users and the material suppliers to optimize cost and availability
MEMC is in a position to support the 450mm transition in a timely manner.