G450C Status
Supply Chain Collaboration on 450mm Transition

SEMICON Europa
October 9, 2013
G450C Background

- Building 450mm wafer / equipment development environment
- Consists of 5 member companies (Intel, TSMC, GLOBALFOUNDRIES, IBM, Samsung) and New York State partnering with CNSE
- New York based consortium
- Built on the base program started under ISMI’s 450 Program
- Collaboratively work with suppliers to develop 450mm equipments
- Using wafers, equipments, people and cleanroom to develop and test equipment and build up infrastructure to meet industry needs
Key Messages

• Suppliers are developing the 450mm tool set with ~ more than 25 tools being delivered to G450C in 2013
• Significant progress in wafer quality
• Automation and carriers are working
• Notchless wafer and 1.5mm Edge exclusion
• Collaboration between IC makers, Tool suppliers, Material suppliers, and Facility group is key to the future 450mm success.
Supply Chain Collaboration

- Supply chain collaboration enables efficient and effective 450mm transition
Test Wafer Center for Tool Development

- Collaboration among IC makers and equipment suppliers
- Focused resources + share the cost + share the risk

IC Makers Interaction

- Carrier and AMHS
- Film Deposition & Growth
- Wafer Clean and Strip
- CMP, IMP,..
- Lithography
- Etch and Plasma Strip
- Inspection & Metrology

G450C
- EPM
- Test Wafer
- DTM

EPM - Equipment Performance Matrix
DTM - Demonstration Test Methodology
# Development and Technology Intercept Targets

<table>
<thead>
<tr>
<th>Year</th>
<th>Description</th>
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<tbody>
<tr>
<td>2010</td>
<td>Early Development of Silicon and Infrastructure</td>
</tr>
<tr>
<td>2011</td>
<td>ISMI 32/22nm Equipment Performance Metrics</td>
</tr>
<tr>
<td>2012</td>
<td>Test Wafers to support development and demo</td>
</tr>
<tr>
<td>2013</td>
<td>Tools for Consortium Demonstrations (unit process)</td>
</tr>
<tr>
<td>2014</td>
<td>14nm G450C Demonstrations</td>
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<tr>
<td>2015</td>
<td>450mm and 300mm tools progress synchronously through technology generations</td>
</tr>
<tr>
<td>2016</td>
<td>Ready for IC Makers</td>
</tr>
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</table>

Nominal “nm” = ITRS M1 Half Pitch

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**G450C Program**
G450C Equipment Delivery Plan

Accumulated Tool Numbers

- Total (current projection)
- on-site
- off-site

Quarter: Q4 12, Q1 13, Q2 13, Q3 13, Q4 13, Q1 14, Q2 14, Q3 14, Q4 14, Q1 15
### G450C Lithography Tool Roadmap

<table>
<thead>
<tr>
<th>Year</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
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**300mm Coupon**

**450mm Directed Self-assembly (DSA)**

**450mm Imprint**

**Coupon + DSA + minimal Imprint**

- **193i patterning service at Nikon site**
- **Nikon 193i Move-in**
Consortium’s DSA Development Status

- Developed DSA Process on 300mm in CNSE

  14nm L/S fingerprints

- Developing STI Module Process Using DSA
# Wafer Quality Roadmap & Reclaim Capability

## Wafer quality roadmap

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</table>

### Mechanical Wafer
- M74 Spec
- Q3, 2013

### Test / Mon Wafer
- SFQR meet (~95% → 98% area)
- Particle (~90% → 100% pass rate)
- M76 Spec
- Q2, 2014

### Prime Wafer
- M1 Spec
- Q1, 2015

### Epi Wafer
- M62 Spec

## G450C Monitor Wafer reclaim capability

**G450C On-site ready ★**

<table>
<thead>
<tr>
<th>Process</th>
<th>Film</th>
<th>2013 1Q</th>
<th>2013 2Q</th>
<th>2013 3Q</th>
<th>2013 4Q</th>
<th>2014 1Q</th>
<th>2014 2Q</th>
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<td>1 2 3 4 5 6 7 8 9</td>
<td>1 2 3 4</td>
<td>5 6 7 8</td>
<td>9 10 11</td>
<td>12 1 2</td>
<td>3 4 5 6</td>
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<tr>
<td>FEOL</td>
<td>Oxide / Poly / SiN</td>
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<td>★</td>
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<tr>
<td></td>
<td>Photo Resist</td>
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<td></td>
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<td>★</td>
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<tr>
<td>BEOL</td>
<td>Metal (Ni/TiN/W/TaN/Cu)</td>
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<tr>
<td></td>
<td>Lk film</td>
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</table>
Wafer Quality Continues to Improve

Year-to-year defect improvement on both defect size and defect density

<table>
<thead>
<tr>
<th>Year</th>
<th>Defects/Wafer</th>
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<tr>
<td>2010</td>
<td>&gt; 3000 @ 90nm</td>
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<tr>
<td></td>
<td>defects/ wafer</td>
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<tr>
<td>2011</td>
<td>~ 175 @ 90nm</td>
</tr>
<tr>
<td></td>
<td>defects/ wafer</td>
</tr>
<tr>
<td>2012</td>
<td>~ 66 @ 38nm</td>
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<tr>
<td></td>
<td>defects/ wafer</td>
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<tr>
<td>Q3-2013</td>
<td>~30 @ 35nm</td>
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<tr>
<td></td>
<td>defects/ wafer</td>
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Thermal/CMP Module Data

• Demonstrate Thermal OX capability $\Rightarrow U\%(3s)1.97\%$ (EPM<2%)

• Demonstrate OX CMP capability $\Rightarrow U\%(3s)3.8\%$ (EPM<4%)

1000A Thermal OX

OX CMP

3sigma (3.8%)
<table>
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<tr>
<th>Material</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Q1, 14</th>
<th>Q2, 14</th>
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<td>Photo Resist</td>
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: on-site : off-site availability
## Metrology Readiness

<table>
<thead>
<tr>
<th>Tool Type</th>
<th>On-Site Tool Status</th>
<th>Applications</th>
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<tbody>
<tr>
<td>Bare Wafer Particle</td>
<td>1&lt;sup&gt;st&lt;/sup&gt; Tool Operational 2&lt;sup&gt;nd&lt;/sup&gt; Tool Ready</td>
<td>bare Si or films particle</td>
</tr>
<tr>
<td>SE/OCD</td>
<td>Thickness - Operational OCD – Ready to Measure</td>
<td>dielectric or thin metal film thickness</td>
</tr>
<tr>
<td>4P Probe</td>
<td>Ready</td>
<td>sheet resistance</td>
</tr>
<tr>
<td>3DAFM</td>
<td>Operational</td>
<td>surface roughness, pattern CD and depth</td>
</tr>
<tr>
<td>TXRF</td>
<td>Operational</td>
<td>metal ion concentration</td>
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<tr>
<td>XRR/XRF Opaque Film Thickness</td>
<td>Operational</td>
<td>metal thickness</td>
</tr>
<tr>
<td>Macro Inspection</td>
<td>Operational</td>
<td>macro defect inspection, EBR distance</td>
</tr>
<tr>
<td>Defect Review SEM</td>
<td>Ready</td>
<td>defect review, pattern CD</td>
</tr>
</tbody>
</table>

- All basic metrologies for demonstrations are ready now
- Advanced wafer geometry working on supplier’s site
- Overlay Tool Q1, 2014
50% wafer increases Q1-> Q4 (onsite + offsite)
Wafer moves are also increase rapidly
G450C Operations - NFN Cleanroom

15 tools installed in NFN cleanroom

3 Process
8 Measurement
4 Ops Support
G450C Operations - NFX Cleanroom

- 450mm OHT is ready for inter-fab transfer
- 15 tools in-fab (2 metro, 7 process, 6 stocker/sorter)
- +3 tools ODD 3Q2013, +10 tools ODD 4Q2013
### Notchless Wafer Standardization

#### Key dates:
- **June** – Start tests to select the design of laser fiducial marks
- **July** – TF submit SNARF to Si committee (North America)
- **Sep** – MC review to start supplier engagement
- **Oct ~ Jan ’14** – Submit ballot at SEMI
- **~ Mar ’14** – Ballot adjudication by Si Committee

#### Timeline:

<table>
<thead>
<tr>
<th>March</th>
<th>April</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>Aug.</th>
<th>Sep.</th>
<th>Oct</th>
</tr>
</thead>
<tbody>
<tr>
<td>Set up framework to collaborate</td>
<td>Prepare 300mm wafers; Define, setup, evaluate alternative laser marks</td>
<td>Submit SNARF (SEMICON WEST)</td>
<td>First tests on alternative laser mark</td>
<td>IC process at CNSE and fiducial marks selection</td>
<td>Prepare ballot for standards</td>
<td></td>
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</tr>
</tbody>
</table>

**Cost / benefit analysis**
- Collect proposals for alternative laser marks (T7 code & others)
- Supplier solution development

**Member company representatives:**
- GLOBALFOUNDRIES    Dave Gross
- Intel              John Williams
- IBM               Gerd Pfeiffer
- Samsung          Samjong Choi
- tsmc               Vincent YH Chou
- G450C staff

**Participating companies:**
- Applied Materials, ASML, KLA-Tencor, Lam Research, Nikon, Tokyo Electron, Sumco, GSI Group, Cognex, Sinfonia, Keyance, Brooks, etc.
Other Standardization activities

- **1.5mm Edge Exclusion**
  - M1 FQA Radius from 223mm to 223.5mm
  - Collaborating with SEMI Si committee and AWG TF

- **Industry Alignment on Component Lifting**
  - Productivity
  - Safety
  - Discussing industry guidelines- development of reference designs and/or relevant standard
Precompetitive Cooperation for Cost Reduction

SEMI

Sub-component Suppliers

Equipment Suppliers

Standards

Prototypes

Facilities Systems, Component, Service Suppliers

F450C

Reference designs for non-differentiating components

Standard connections

Streamlined installation

EHS improvements

Optimized sizing

Effective base build/fit-up

Standardization WG

Device Makers

Facilities Council

Test Bed Guidelines

- Identify focus areas / concepts
- Define pilot work
- Demo feasibility of approaches
- Drive timely adoption
Summary

- G450C has launched with full industry momentum
- Significant progress is continuing in all areas of the supply chain
- Suppliers are developing the 450mm tool set with >25 new tools being delivered in 2013
- Significant progress in wafer quality
- Automation and carriers are working
- Global collaboration is picking up steam
Questions and Discussion