Slurries & Particles in High Tech

- IC CMP is by far the largest in Revenues
- Si Wafer production
  - Cutting the Si Ingot into wafers uses SiC cutting fluids
  - Si Wafer polishing and final polish use high purity & excellent surface quality CMP with silicas
- Lower tech applications abound ... re-use of spent CMP slurries?
Major Slurry Trends

- For IC manufacturing, silica dominates the slurry market in amount used.
- For STI, ceria is preferred for more advanced technologies, but is much more expensive per gram.
- For Wire Cutting of the Si Ingot (IC and Solar), SiC particles are used as cutting fluid.
- For Si wafer manufacturing polish it’s silica.
Silica for CMP

Silica Comes in 3 Types

- “Fumed”: flame vapor-phase hydrolysis of SiCl₄ or the like ... 3 major suppliers
- “Colloidal”: precipitated from sodium silicate & H₂SO₄ ... >8 suppliers
- “Sol”: Stöber process condensation of silicon alkoxide (TEOS, TMOS) w/ ammonia & water, at least 2 major suppliers

Abrasives and Applications

- Oxide/ILD ≤65nm use less aggressive particles: fumed to colloidal or milled fumed
- Copper “Step 1” predominately uses Colloidal
- Copper Barrier (and Dielectric Cap) uses Colloidal or Sol
- Tungsten fumed and colloidal
IC CMP Slurry Growth?

Annual Revenue (M$USD)

- Cu Barrier
- Cu Step 1
- Tungsten
- Oxide
- S-STI

2006 2007 2008 2009 2010 2011 2012

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Abrasive and Slurry Suppliers

- Numerous Suppliers of Slurry (>21)
  - Abrasives only (>15)
  - Slurries only (>15)
  - Both Slurry and Abrasives (>6)

- Unlike CMP Pads, the Slurry and Abrasive Supplier List is Stable
IC CMP Slurry Market Size by Application Revenue

- Tungsten: 29%
- Oxide: 16%
- S-STI: 8%
- Cu Step 1: 28%
- Cu Barrier: 19%
IC CMP Slurry Suppliers

Cu Barrier
1 major >40%
4 others >10%

S-STI
1 strong supplier, >70%

Oxide
2 major suppliers, >30% each

Cu Step 1
3 suppliers split 75%
2 others >9%

Tungsten
1 strong supplier, >75%
IC CMP Slurry Suppliers

- Commodity business
- Customer pricing pressure
- Low passes per wafer start in newer nodes
- Opportunities in ≤ 45 nm

Cu Barrier
S-STI
Oxide
2 major suppliers >30% each
Cu Step 1
Tungsten
IC CMP Slurry Suppliers

- **Cu Barrier**
- **Oxide**
- **Cu Step 1**
- **Tungsten**

- 1 strong supplier, >75%
- Aggressive patent defense
- W not large growth market
- Slurry dilution & competition would erode margins
IC CMP Slurry Suppliers

- Cu Barrier: 1 strong supplier, >70%
- S-STI: Mostly ≤ 65 nm
- Oxide: Single process per wafer start
- Tungsten: Cerium is costly
Transition to Copper Interconnects

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Percent Wafer Starts w/ Cu
High growth
- Transition to Cu from Al
- Growing passes per wafer start
- Customers’ priorities differ
- New slurries for each new generation?

IC CMP Slurry Suppliers

- S-STI
- Oxide
- Tungsten
- Cu Barrier
- Cu Step 1

3 suppliers split 75%
2 others >9%

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IC CMP Slurry Suppliers

- High growth, but less volume than Cu polish
- Customers’ priorities similar
- New slurries for each new generation due to low k dielectrics?
IC CMP Slurry Challenges

- ILD/PMD/Oxide
  - Commoditization and Affect on Suppliers
  - Improved surface finish post CMP
- Selective STI
  - Lower Defects and Lower Cost (Ceria Expense)
- Tungsten
  - Lower Defects and Lower Cost (Competition)
- Copper and Barrier
  - Each Cu Node Expects a New Formulation
  - Costly for Supplier, Pricy for End User
- FEOL Polish
  - Polish of ILD thru poly gate prior to poly etchback and metal gates
Si Wafer and Slurry

- SiC for Si ingot slicing not a large market
- Solar use is >5x the volume of IC wafers
- SiC revenues will approach $40M in 2009
Slurry Disposal

- Lower tech applications abound
- Reclaim and re-use of spent CMP slurries
  - Concentrate used slurry
  - Reduce heavy metal contamination
- Road filler or ??
- Does it pay to be green?
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