CMP PRESENT AND FUTURE TECHNICAL AND ECONOMIC CHALLENGES
AVS CMPUG SEMICON WEST 2014 MEETING

Albany Nano Tech Advanced Planarization Center

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SEMATECH:
Problem Statement: CMP R&D constrained by cost/access to leading edge materials, tools, metrology and test vehicles.

Objective: Establish a Planarization Center to enable supply chain development/benchmarking and accelerate process maturity for end users

Approach:
1) Leverage the SEMATECH network to design an industry-standard mask-set
2) Establish a partnership ecosystem using CNSE’s leading edge fabrication, engineering, metrology/defect toolsets, and university network
3) Fully engage the CMP community (consumable, tool, metrology) and end-user stakeholders (IDM, foundry, fabless, EDA)
The Drivers of Change and Challenges for Manufacturing Technology

- New Memory
- Gate Architecture
- 3D Packaging
- And new channel materials
- 450mm
- EUV
Emerging Technology & New Materials driving growth. How to manage costs?
Wafer Size

Impact of 450mm - Cost of CMP ($/Wafer Basis)

Cost of CMP includes Depreciation, equipment maintenance, direct & indirect labor, facilities, test & Monitor wafers, consumables and yield loss

Must start addressing these cost challenges now!
CMP Challenges

- CoO reduction
- Defect reduction
- Increasing stringent process targets
- Supply chain access to advanced test structures
- Tightening ESH regulations
- CMP solutions for new materials
- Supply chain access to shared BKM development platform

Planarization center: Accelerate solutions to address industry challenges

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Planarization Center Beneficiaries

- IDM Suppliers
- Slurry Suppliers
- Pad Suppliers
- Pad Condition
- Clean Solutions
- Gov’t Agencies
- Fabless & EDA
- CMP Tools
- Metro and Defect Tools
- Waste Treatment
- Slurry delivery & filtration

Integrated Planarization Center

Offers benefits to entire CMP community

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Using a shared research model provides **Significant Cost Savings!**
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CNSE Team
SEMATECH Team
Planarization Test Masks: Past and Present

SEMATECH/MIT mask-set became the *de facto* CMP workhorse for the industry in the late 90’s

**Features**
- Comprehensive geometries (100 nm)
- Multi-layer topography

**Value**
- Process characterization
- Consumable benchmarking
- Standardization of results

20 years of scaling & new materials demand an updated CMP standard mask-set to meet sub-14nm challenges
Planarization Center Infrastructure

14 nm Test Structures

Leading edge materials III-V, Co....

Industry standard toolsets

Multi vendor CMP platforms

Industry Standard mask-set

State of the art defect metrology

InP  SiO₂

Si

40 nm
Planarization Center Focus / Phases

Today: CMP Process Infrastructure
- 22 nm test structure, PLY and metrology services
- 300 mm multi-platform demo services
- III-V wafer services
- COO evaluation

2015: Industry-standard test structures
- 14 nm industry standard test structure, PLY and advanced metrology services
- Standardized benchmarking
- 300 mm III-V demo services

2016: Consumable Analytics & COO
- Slurry, pad, disk, filter performance analytics & COO
- Accelerated consumable lifetime evaluations
- Adaptive/tunable consumable development
- Extension to 450 mm, EUV, “Beyond-5nm” technologies
Planarization Center Unique Capabilities

- 14 nm industry standard mask-sets
- Maintained baseline w/ quantified in-line metrology targets and e-test
- Proven consortium model to drive consensus and increase ROI for CMP supply chain.
- Synergy between centers of excellence: EUV, III-V, 3DI, G450C, CNSE derivatives

SP3 Output
W contact

ILD dep
- SiN dep
- HDP dep

Contact Litho/Etch
- CD 42 nm, pitch 84 nm
- Contact RIE

Contact liner/fill
- Ti/TiN liner dep
- W dep

Contact CMP

Metro, PLY, E-test

- W consumable performance and CoO evaluation
POP/W RMG flop down

- **Dummy gate**
  - Poly/HM dep
  - Litho
    - Current CD 65 nm, Pitch 200 nm
    - Future CD 42, Pitch 84 nm
- **Spacer dep/etch**
- **ILD**
- **POP CMP**
- **Metro, PLY**
- **PRL gate**
  - Dummy gate removal
  - TiN/W gate dep
- **RPL MG W CMP**
- **Metro, PLY, E-test**
  - Consumable performance, CoO & defectivity evaluations
M1/Cu Damascene

ILD dep
- SION dep
- Low-k dep
- TEOS/TiN HM dep

M1 Litho/Etch
- CD 42 nm, pitch 84 nm
- M1 RIE

M1 liner/fill
- Ta/Co/Ru based liner/seed dep
- Cu plate/anneal

M1 CMP
Metro, PLY, E-test

Next generation liner and interconnect materials
STI and replacement fin

**HM dep and litho**
- Current - CD 18 nm, pitch 200 nm
- Future - CD 18 nm, pitch 80
- SIT– CD - <10, pitch 40 nm

**Fin/Active Etch**
- Fin etch

**Shallow Trench Isolation**
- Oxide dep (HARP, flowable Ox, HDP) and anneal
- **CMP**
  - Metro, PLY

**Fin Release**

**Replacement fin**
- Dummy fin etch/clean
- III-V and Ge selective epi
- **CMP**
  - Metro, PLY

**Applications:** non-planar STI consumables optimization, high-mobility replacement fin consumable development
Planarization Center Focus Areas

Industry Standard Mask-set
- Characterization of new consumables at relevant critical dimensions
- Updated dummy-fill / cheesing rules enabled by new consumables

ESH
- III-V outgassing and waste water treatment
- Nano-particle toxicity

Cost of Ownership Improvement
- Slurry volume reduction, pad-life improvement, Break-in improvements
- Waste-handling improvement, Recycled DIW
- Scale up to 450 mm

Defect Reduction and Metrology
- Advanced process control using hybrid metrology techniques
- Multi-spectral defect characterization
Partner / Center Interaction Areas

Consumables Vendors
- Consumable lifetime studies – defectivity, performance
- Characterization of consumable degradation, mechanism studies
- Break-in/CoO improvements
- Pad/Slurry/low-k dielectric interactions
- New materials defectivity characterization
- Advanced particle size analyses
- Post-CMP clean chemistry for novel materials

Equipment Vendors
- New material ESH
- Slurry delivery systems
- Improved filtration
- Killer particle identification
- Improved in-situ metrology
- New defect characterization techniques
- Novel post-CMP metrology techniques
- Novel post-CMP clean technologies

IDM / Design Tools
- Characterization of CMP of new materials and necessary design rules
- Updates to existing design rules enabled by new processes
- Node-relevant ‘BKM’ processes developed at the Center by vendor-groups
- Industry-standard mask-set for easier performance comparison
CMP Ecosystem Survey

• SEMATECH will conduct a survey to determine:
  – Prioritized industry challenges
  – Mask-set design requirements

• Please contact richard.hill@sematech.org to participate
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