Opportunities and Challenges in Development of New CMP Pad Platform

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Opportunities and Challenges in Development of New CMP Pad Platform

- Background
- New Pad Design
- Impact of Design and Materials
- Summary
Opportunities

- Edge Die: Impact of removal at wafer edge
  - response of stacked pad system
- Planarization
  - WIW and WID is necessary to improve overall performance
- Defectivity
  - Fluid transport and materials challenge

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Challenges

- Work with existing consumables
  - Need to demonstrate significant advantage in key areas with no performance parameter worse
- Work with existing equipment
  - No significant hardware modifications
  - No significant changes to Process recipes

Pads must fit into an existing Tool-Slurry-Conditioner eco-system

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A Challenging Opportunity

- Design: Fluid Transport
  - To groove or not to groove is not the question. How much and How !!!
  - Can we move away from stacked pads ?
- Materials
  - Are Urethanes enough !
- Microstructure
  - Non-porous vs porous. size of pores
  - Copolymers ? Blends ?

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WAFER EDGE REMOVAL RESPONSE
Edge Effect From CMP

Radial Pressure Distribution during CMP

Effect of Retaining Ring on Pressure Distribution

Removal Rate discontinuity at the wafer edge is inherent in Conventional Pad Design

“Modeling of Pad-Wafer Contact Pressure Distribution in CMP” YunBio Xin, MEMC

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Edge Effect

1. Rotation of wafer and polish table create an “Edge Effect” as pad compresses under the wafer
2. Mech. Properties of pad act in opposite ways wrt WID (Chip performance) and WIW (Edge die yield)

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Decoupling WIWNU and WID Planarization

- Polish Elements
  - Multiple/Independent

- Slurry Distribution Foam
  - High porosity

- Bottom Pad
  - Compressible

- Pad Stack
  - No Edge Effect

Top View

Plan View

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Removal Profile: No Edge Effect

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WID PLANARIZATION RESPONSE
Planarizer: Element Size Modeling

- Typical Test Die lay-out
  - 20mm x 20mm with 4mm wide street area.
  - Street: 0% metal density.
  - Array Size 4mm x 4mm
  - 10 – 90% metal density

- Metal density averaging
  - Linear method
    - Moving st line average
  - Area method
    - Moving area average

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854 Wafer Layout: Element Diameter Reference

6 mm Element
Area Ratio: 9%

10 mm Element
Area Ratio: 25%

15 mm Element
Area Ratio: 56%

Pattern Density Variation and Array Size Determine Optimum Element Size

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Pattern Density
WID Average: 40%
WID Range: 80%

Eff. Pattern Density (6mm)
WID Average: 40%
WID Range: 70%

Eff. Pattern Density (10mm)
WID Average: 40%
WID Range: 39%

Eff. Pattern Density (15mm)
WID Average: 40%
WID Range: 20%
Oxide Planarization
(Element Size and Hardness)

Hardness AND Size of Polish Elements Influences Planarization

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DEFECTIVITY
Microscratch Defectivity

Ref.: CMP Pad Surface Characterization for CMP Mechanism Investigation, CAMP, Aug 2008, JSR Corp

Fluid Transport in Conventional Pads Remains a challenge beyond Pad Material
Discretized Element Design Provides a very Low Resistance Flow Path
Impact of Pad Design on Defectivity

Stacked Pads: Grooved Polish Layer

Planarizer Pads: 60% open area

Key to Low Defectivity
- Efficient slurry transport
- Efficient removal of polish and pad wear byproducts
- Low COF polish material
- Low contact angle - Highly hydrophilic material
Defects: C.O.F and Hydrophilicity

Reference Pad

Hydrophilic Pad

Zero contact angle Pad

Normalized Defects (SP1 @>0.12 microns)

Coefficient of Friction

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Defects: Microstructure Control

Matrix Hardness (Shore)

Pore Size

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Microstructure Control

Optimum Pad conditioner

- Diamond Size

Matrix Hardness (Shore)

- 75 D
- 40 D

Pore Size

- 1 µm
- 30 µm

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Teos Wafers: Defect Comparison

Low COF + Low Contact angle

= Low Defectivity

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Removal Rate Performance

Low COF and Low contact angle pads show low Rem. Rate

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Polymer Tuning enables Rate while Maintaining Defect Advantage
Opportunities and Challenges in Development of New CMP Pad Platform

- A discretized polishing element based pad platform has been presented.
- New pad platform can be implemented with in the existing tool-slurry-conditioner eco-system.
- Planarizer enables new knobs for tuning process performance.
  - Edge Removal Profile
  - WID Planarization
  - Defectivity
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