SemiQuest

Opportunities and Challenges in Development of New CMP Pad Platform

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May 06, 2009

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

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

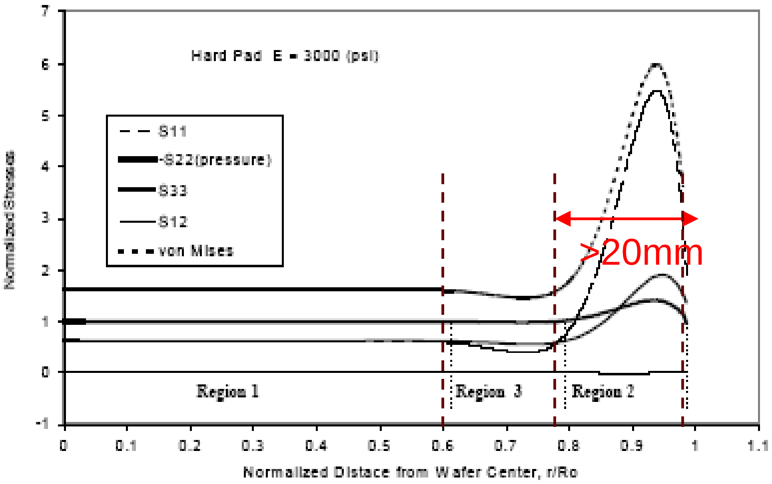
A Challenging Opportunity

- 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 ?

WAFER EDGE REMOVAL RESPONSE

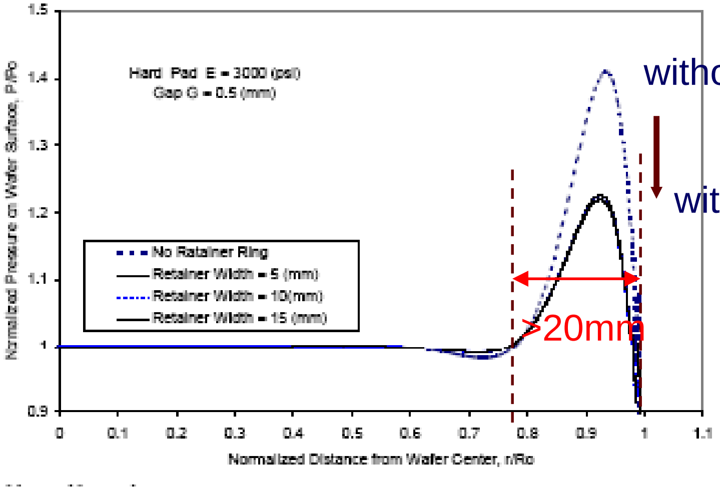
Edge Effect From CMP

Radial Pressure Distribution during CMP



>20mm

Effect of Retaining Ring on Pressure Distribution



>20mm

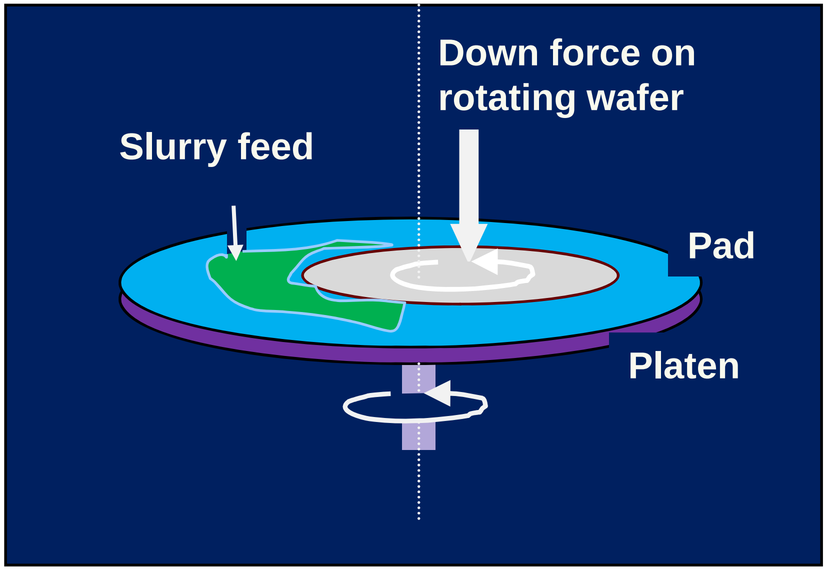
without Ret. Ring

with Ret. Ring

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

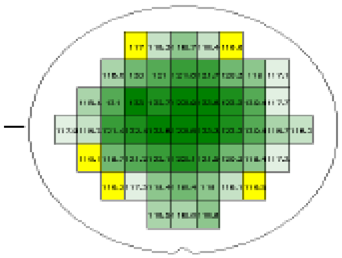
“Modeling of Pad-Wafer Contact Pressure Distribution in CMP” YunBio Xin, MEMC

Edge Effect

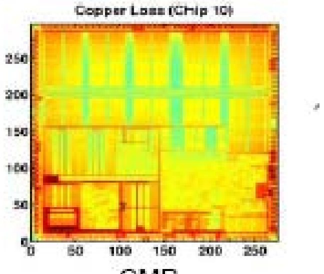


Edge Die Loss

Die-to-Die



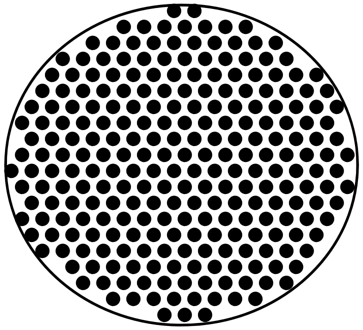
Within Die Performance Variation

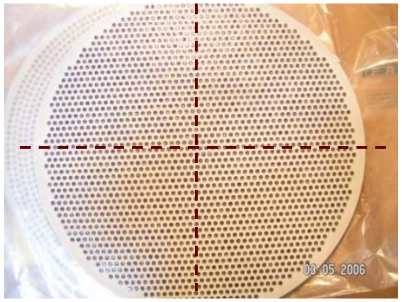


CMP

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)

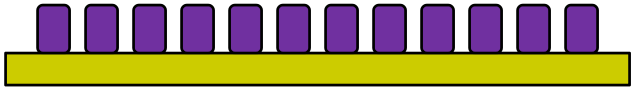
Decoupling WIWNU and WID Planarization





Uniform area density

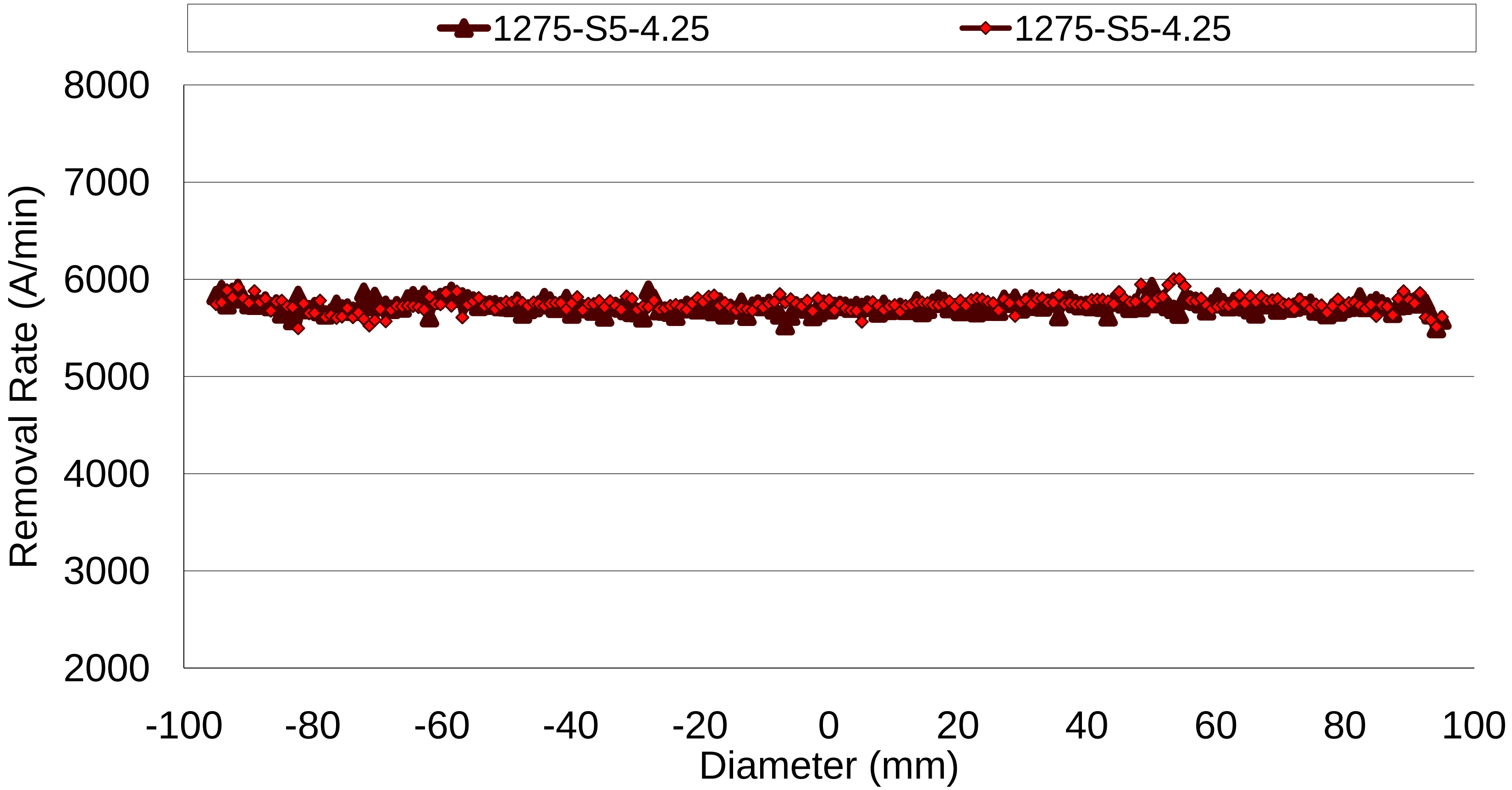
Top View



Plan View

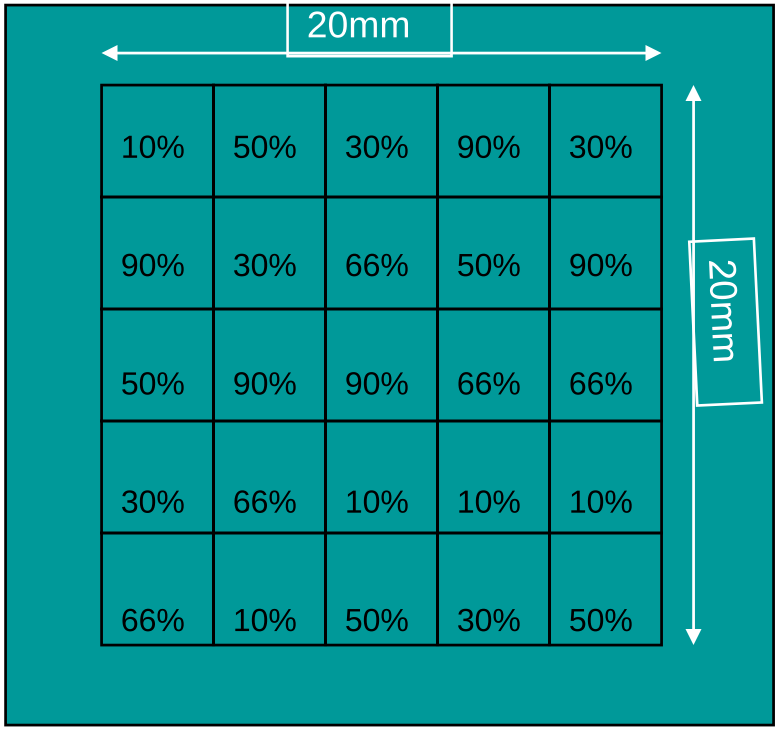
- Polish Elements
  - Multiple/Independent
- Slurry Distribution Foam
  - High porosity
- Bottom Pad
  - Compressible
- Pad Stack
  - No Edge Effect

Removal Profile: No Edge Effect



WID PLANARIZATION RESPONSE

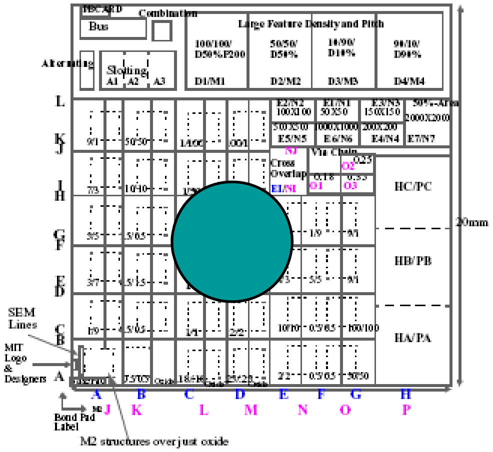
Planarizer: Element Size Modeling



10%	50%	30%	90%	30%
90%	30%	66%	50%	90%
50%	90%	90%	66%	66%
30%	66%	10%	10%	10%
66%	10%	50%	30%	50%

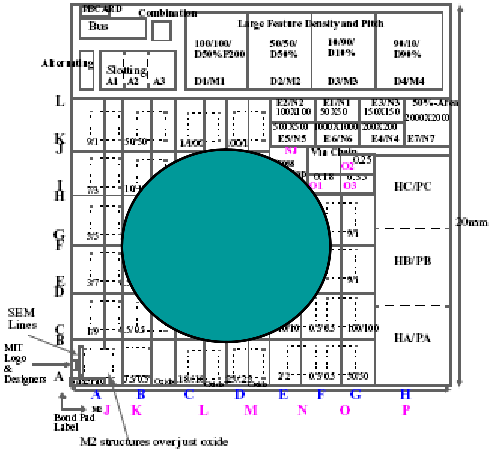
- Typical Test Die lay-out
  - 20mm x 20mm with 4mm wide street area.
  - Street: 0% metal density.
  - Array Size 4mm x 4mm
  - 10 – 90% metal density
- Metal density averaging
  - Linear method
    - Moving st line average
  - Area method
    - Moving area average

854 Wafer Layout: Element Diameter Reference



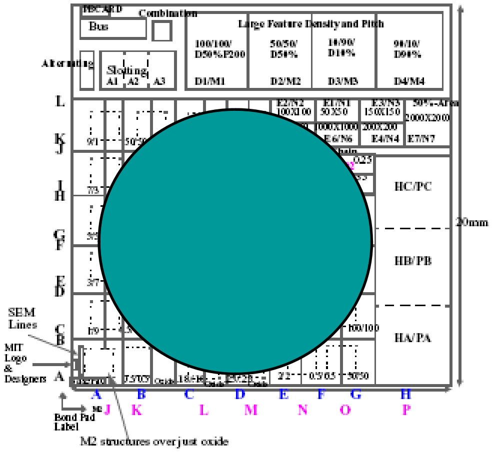
6 mm Element

Area Ratio: 9%



10 mm Element

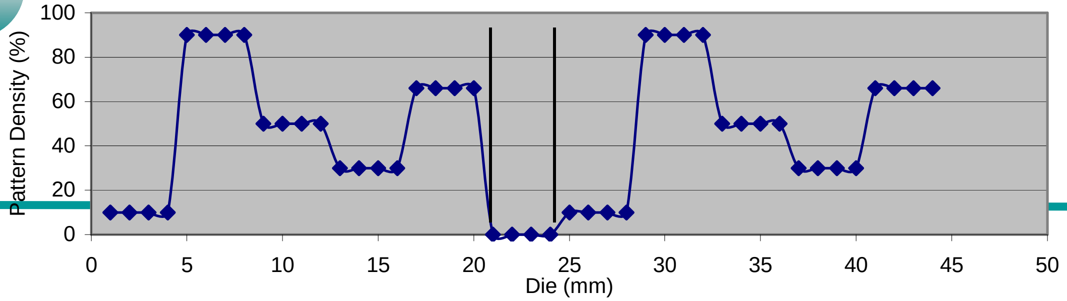
Area Ratio: 25%



15 mm Element

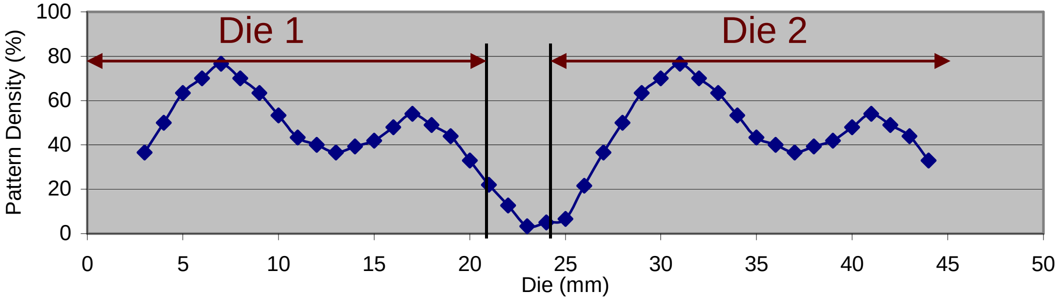
Area Ratio: 56%

Pattern Density Variation and Array Size Determine Optimum Element Size



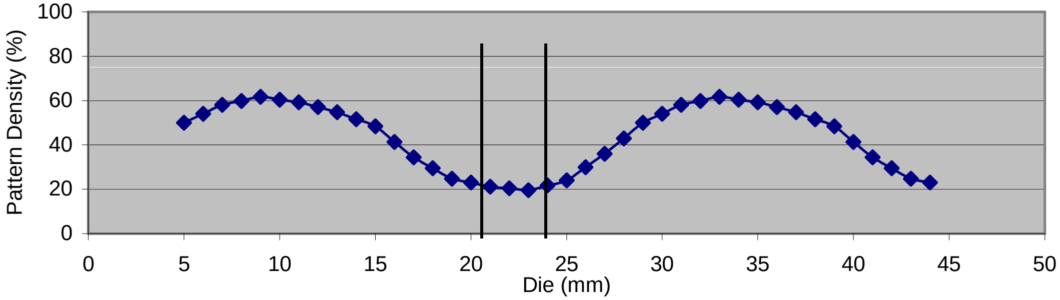
Pattern Density

WID Average:	40%
WID Range:	80%



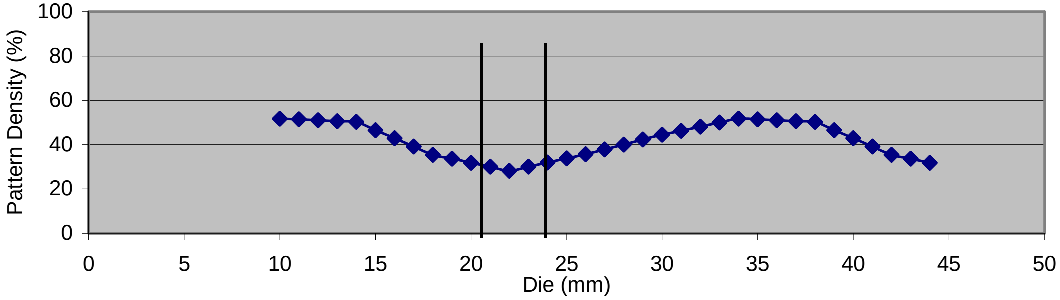
Eff. Pattern Density (6mm)

WID Average:	40%
WID Range:	70%



Eff. Pattern Density (10mm)

WID Average:	40%
WID Range:	39%

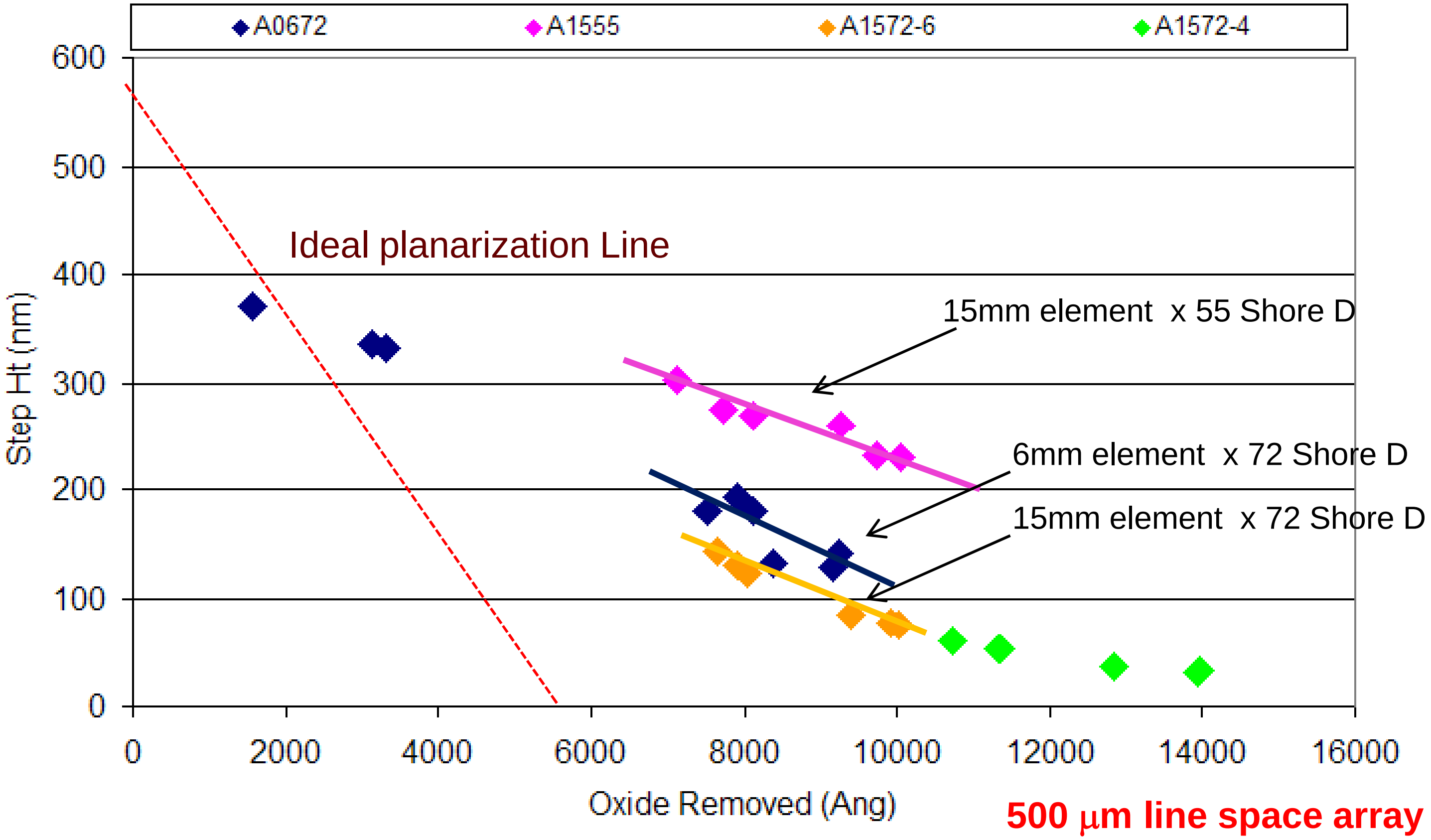


Eff. Pattern Density (15mm)

WID Average:	40%
WID Range:	20%

Oxide Planarization

(Element Size and Hardness)

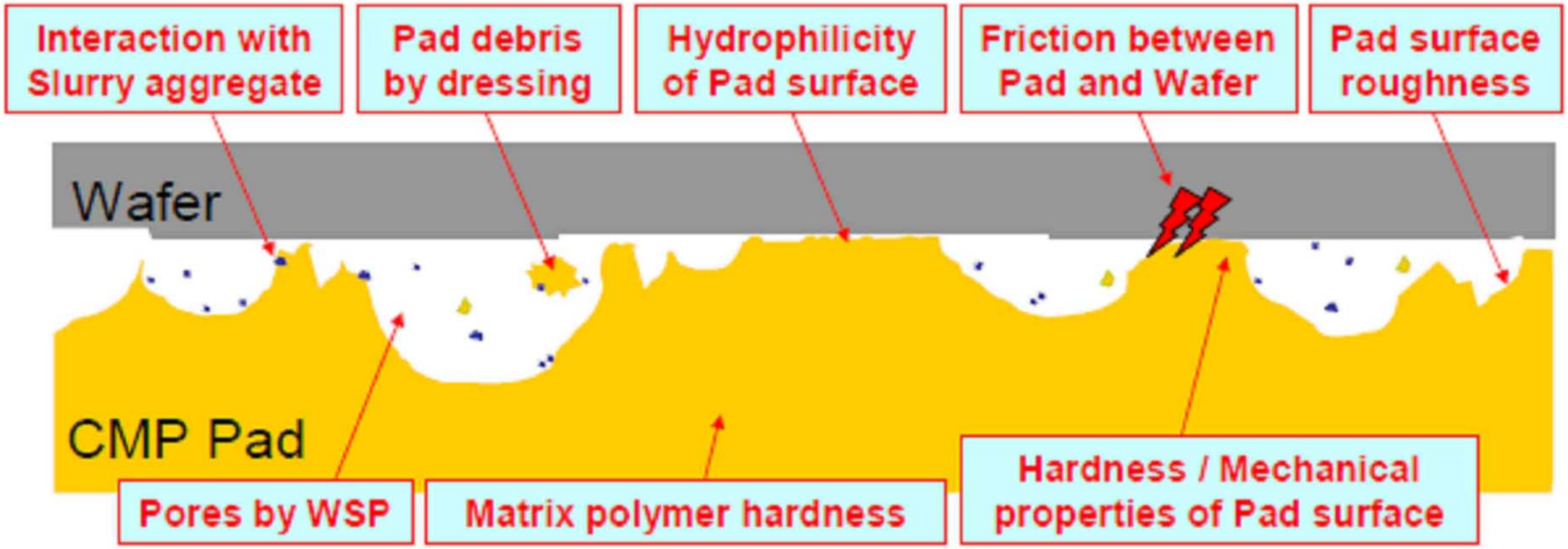


500 µm line space array

Hardness AND Size of Polish Elements Influences Planarization

DEFECTIVITY

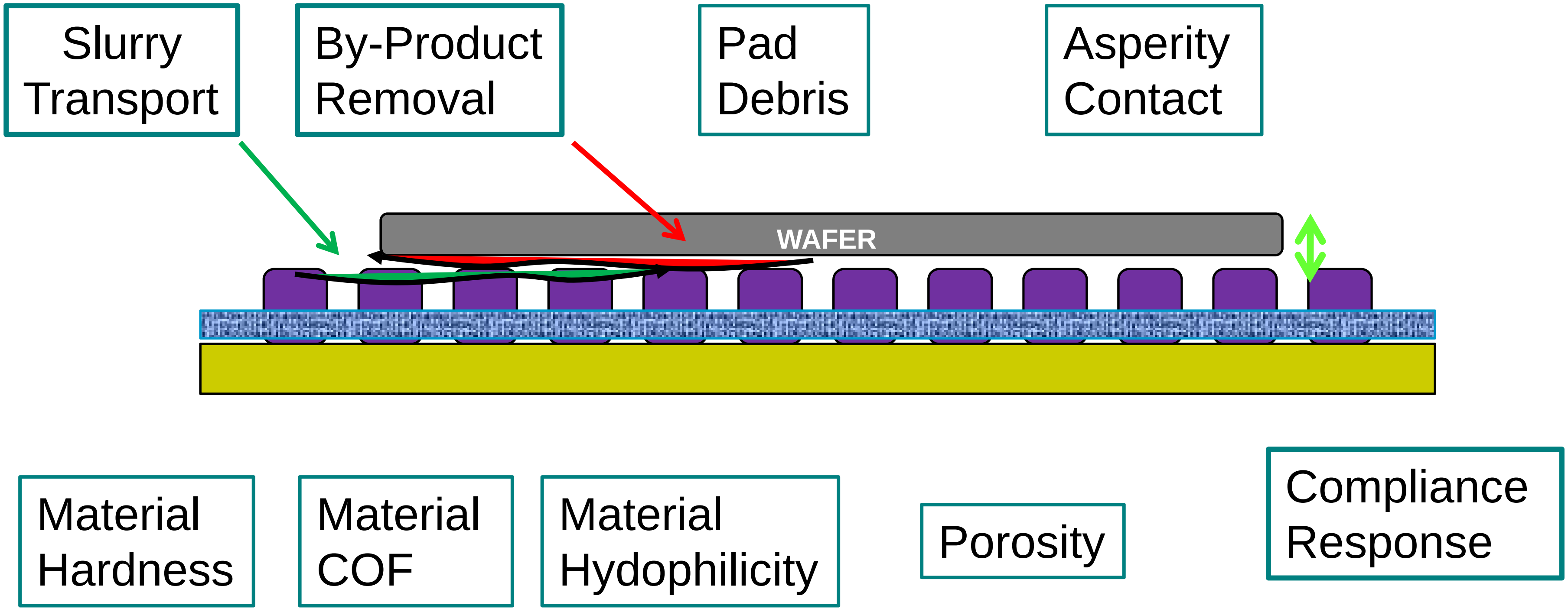
Microscratch Defectivity



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

Defect Matrix



Slurry Transport

By-Product Removal

Pad Debris

Asperity Contact

Material Hardness

Material COF

Material Hydophilicity

Porosity

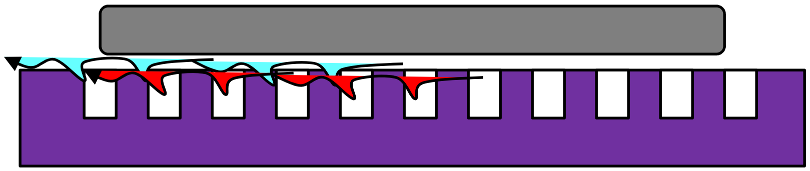
Compliance Response

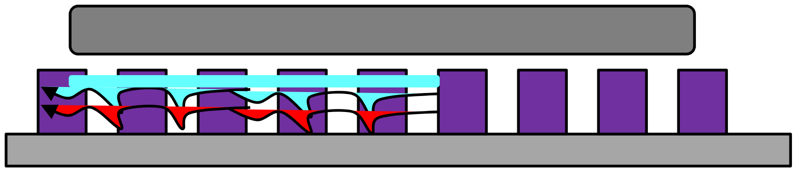
Discretized Element Design Provides a very Low Resistance Flow Path

Impact of Pad Design on Defectivity

Stacked Pads: Grooved Polish Layer

Planarizer Pads: 60% open area



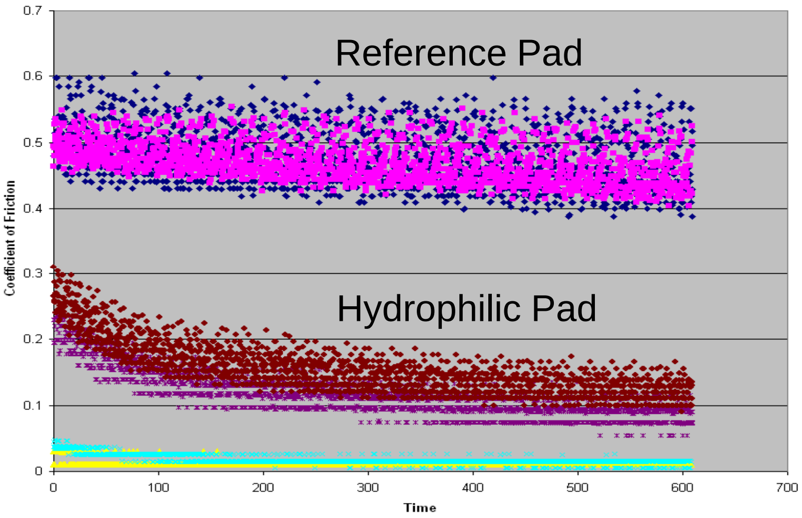


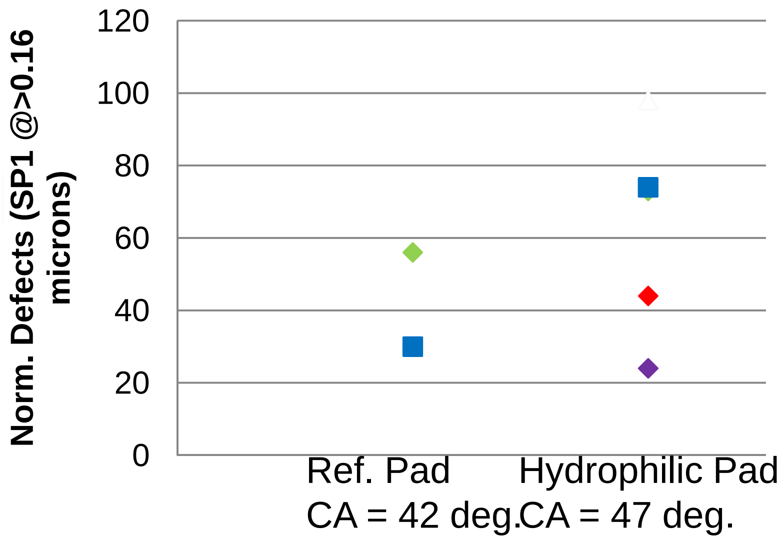
Long tortuous path for slurry and by-product transport

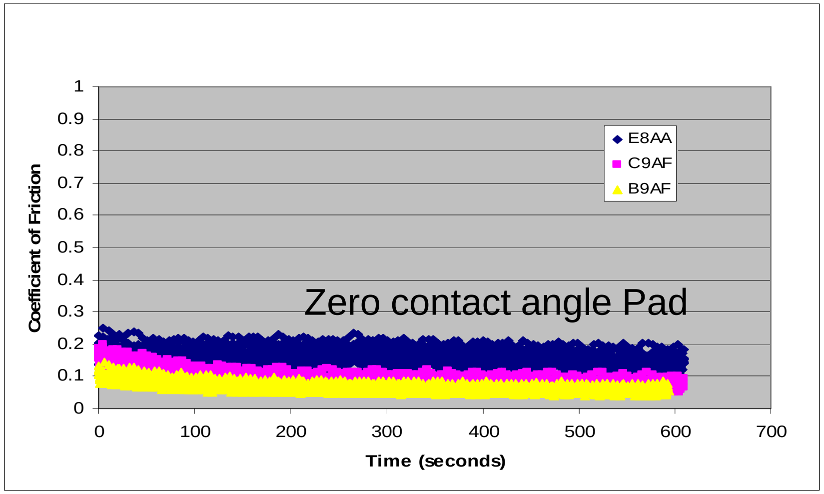
Open path for slurry and by-product transport

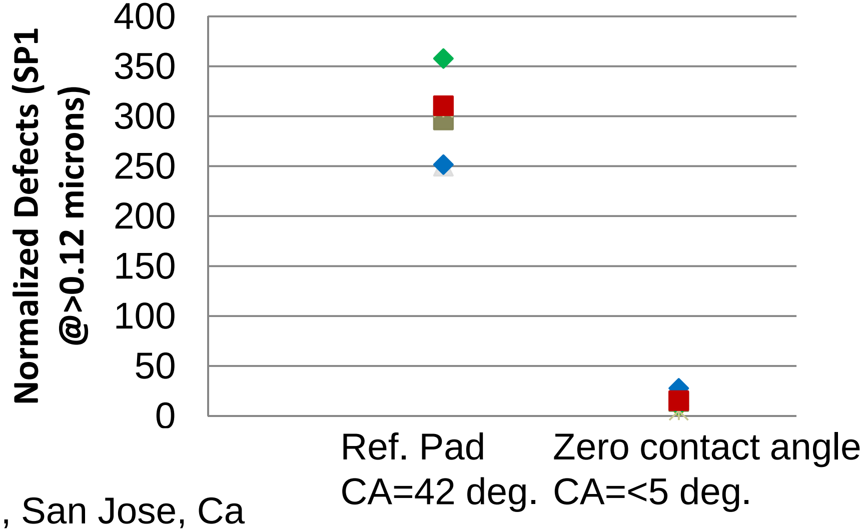
Key to Low Defectivity
- Efficient slurry transport
- Efficient removal of polish and pad wear byproducts
- Low COF polish material
- Low contact angle - Highly hydrophilic material

Defects: C.O.F and Hydrophilicity

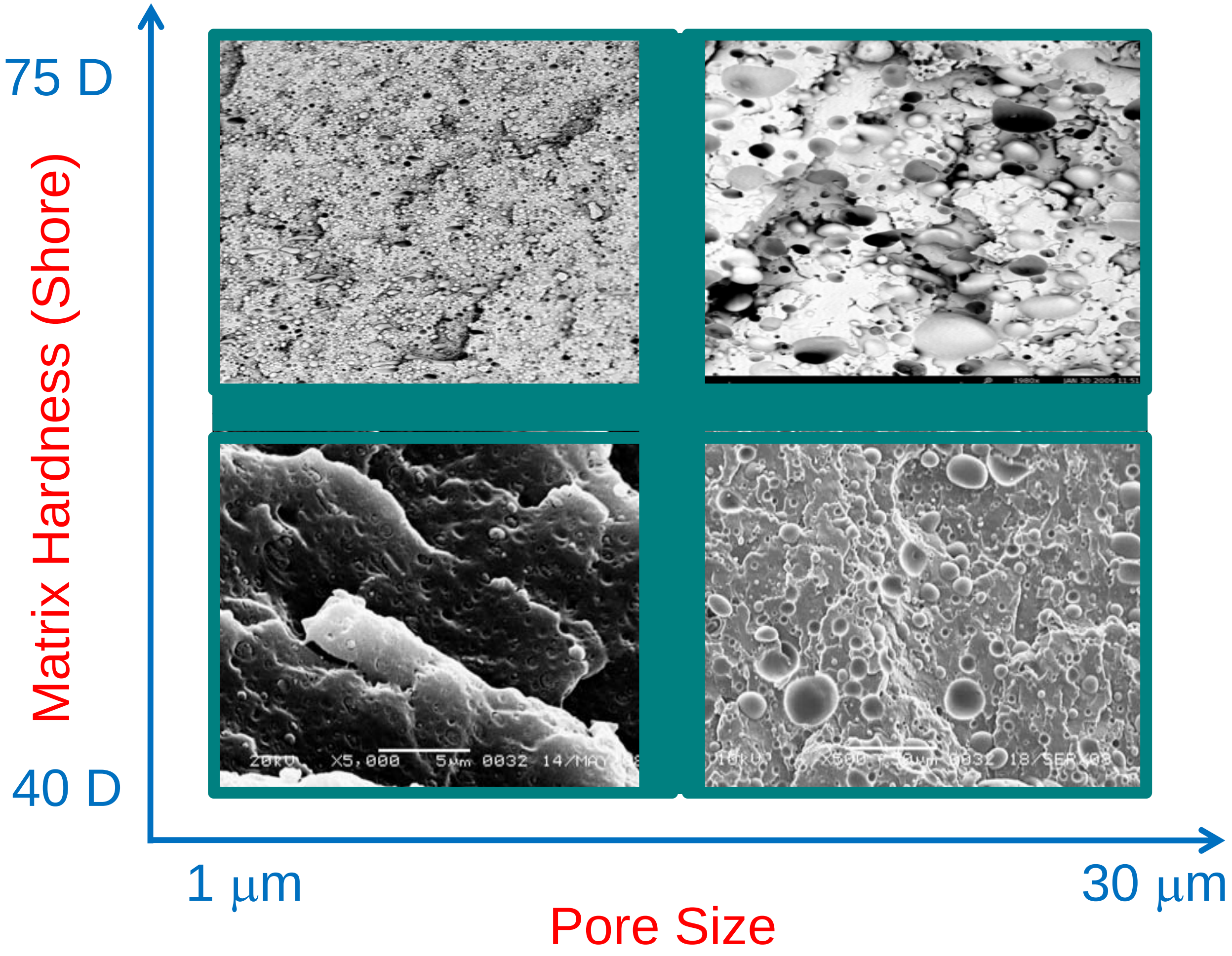




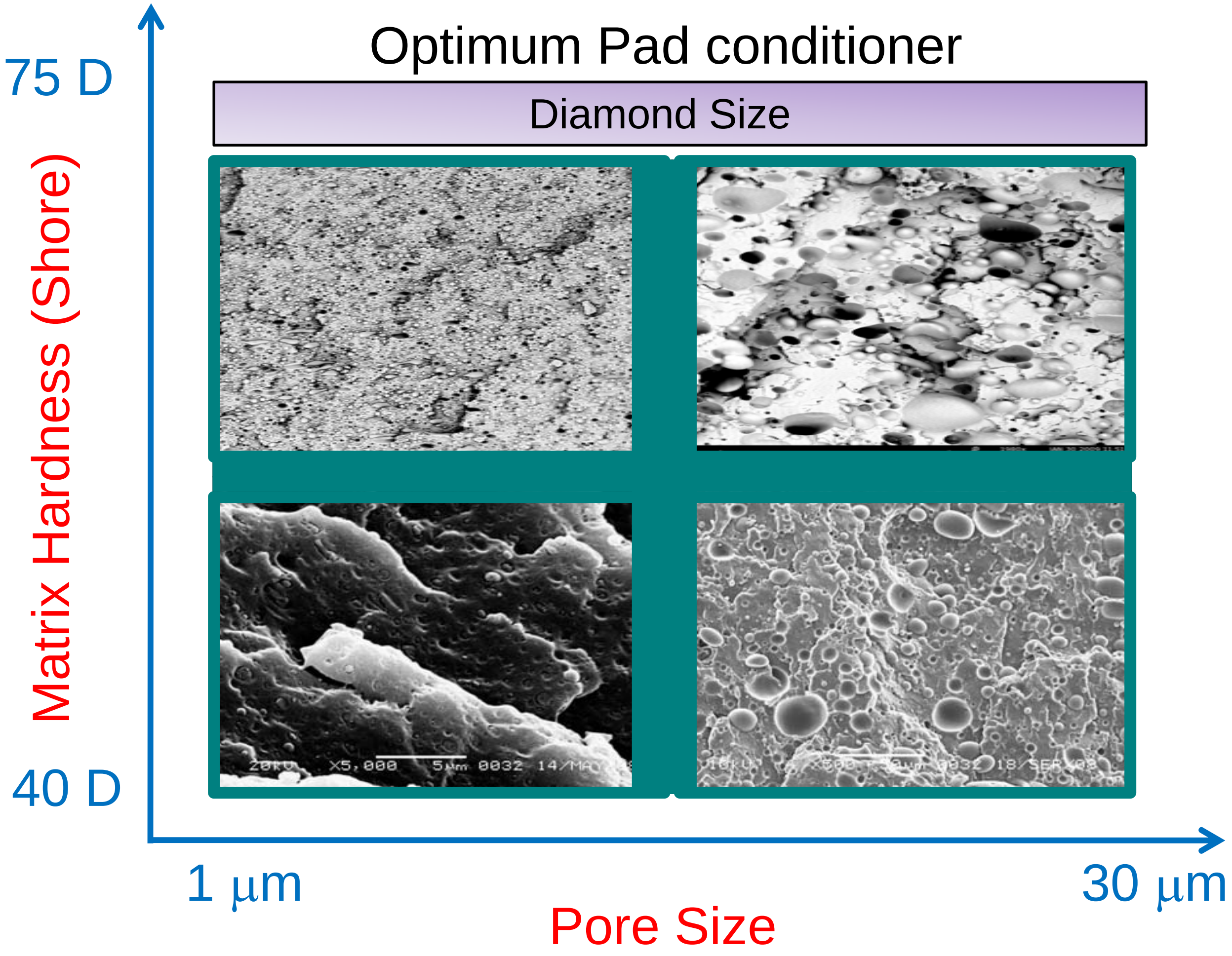




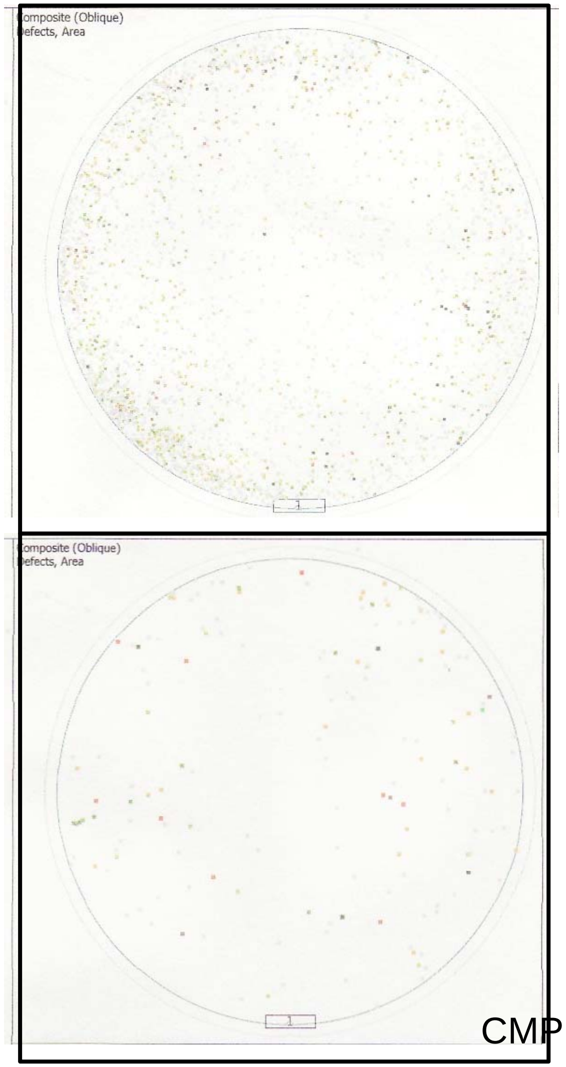
Defects: Microstructure Control

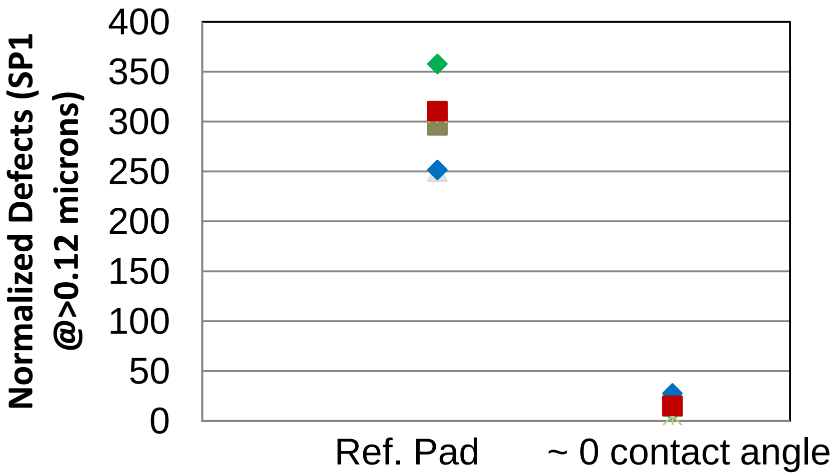


Microstructure Control



Teos Wafers: Defect Comparison





Low COF + Low Contact angle

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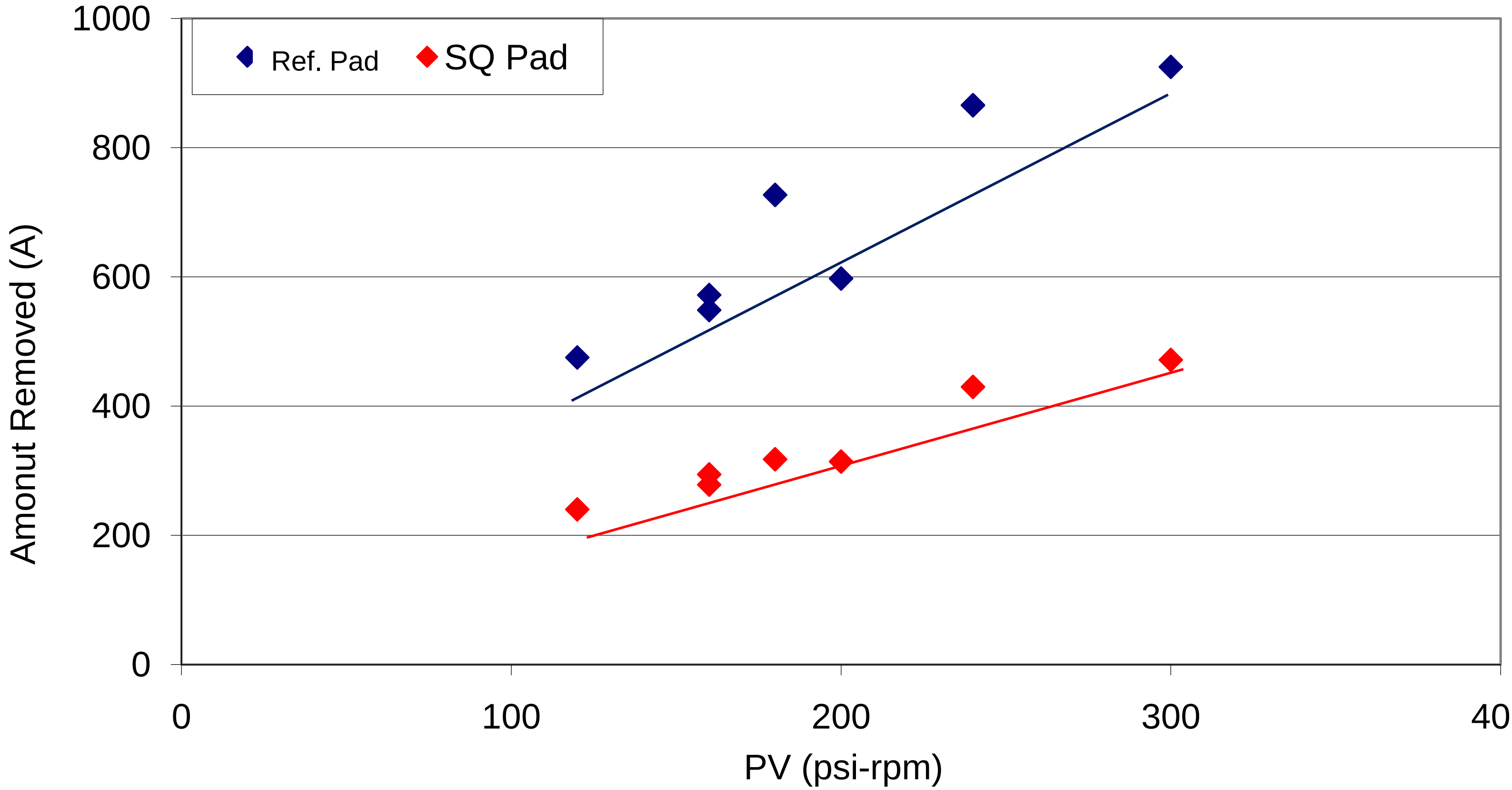
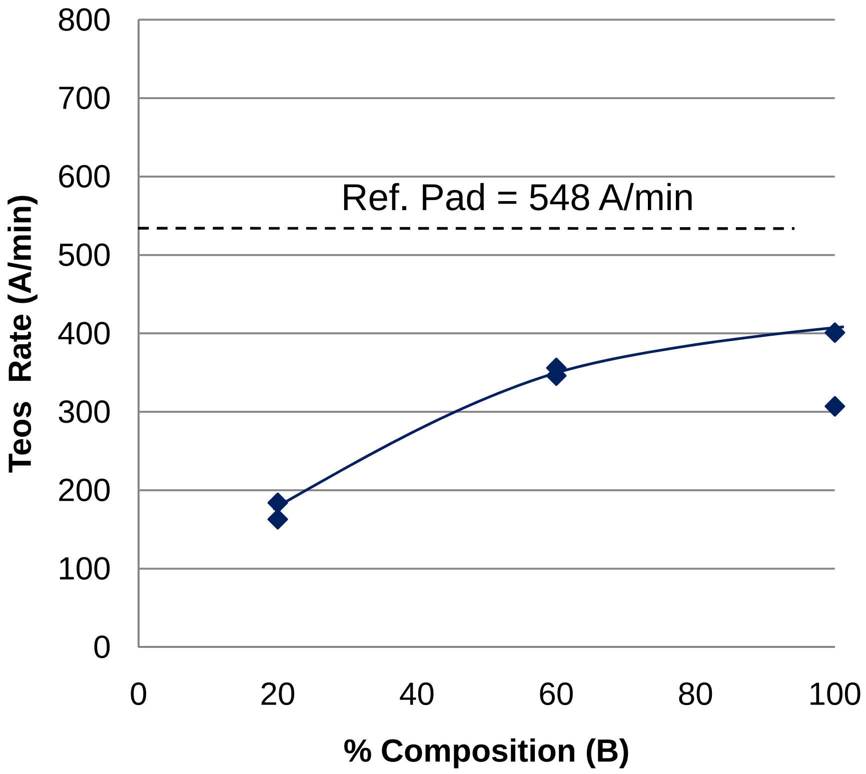
Low Defectivity

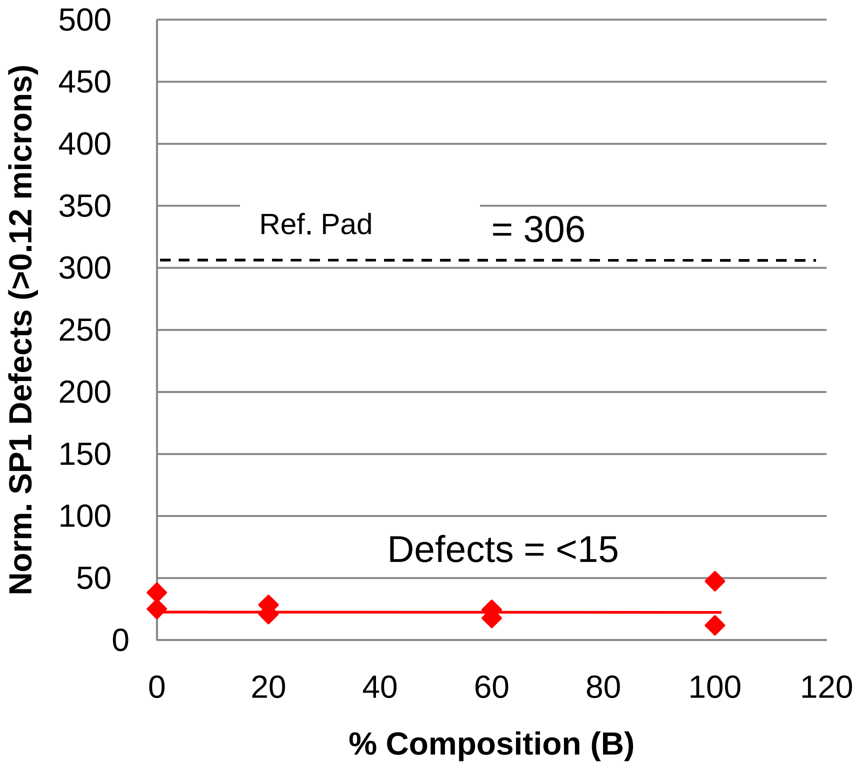
Removal Rate Performance



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

SQ9000: Summary Results (B)





Polymer Tuning enables Rate while Mantaining 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

Acknowledgements

- Bill Joseph, 3M Company
- Araca Inc.