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Effects of Ring Design on CMP Process Stability and Slurry Usage

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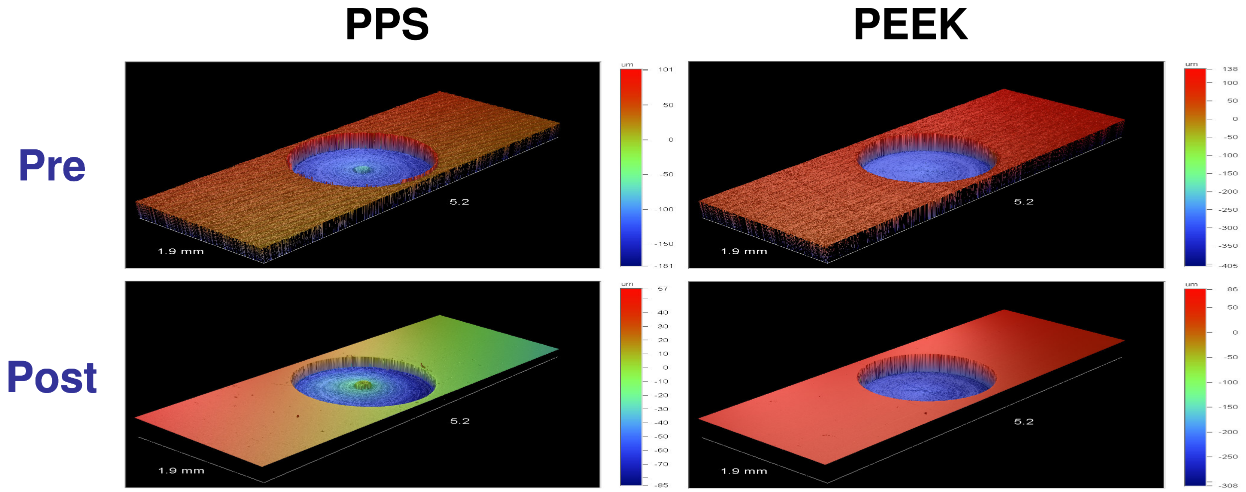
Outline and Motivation

- Ring wear rates and lifetime
- Thermal environment at Ring interface
- Ring Surface Interactions
- Optimization of slurry usage
- Wafer results with alternate polymer and geometry
  - Break-In, removal rate, defects
- Process optimization with lower process COO

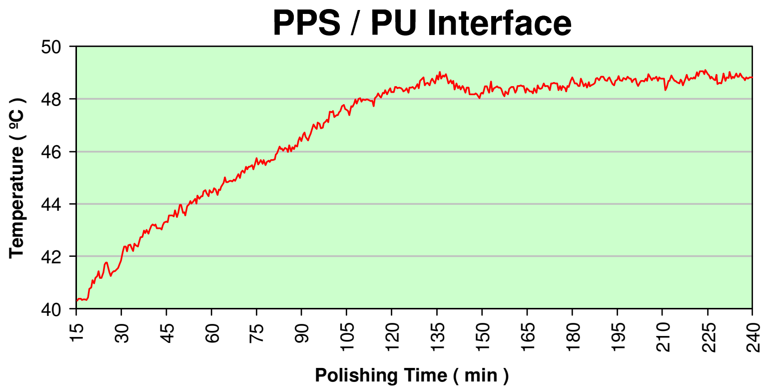
Ring Lifetime Correlates to Wear Rate

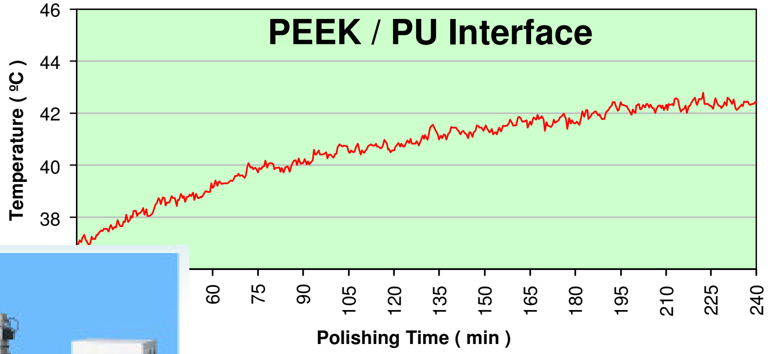


- Many studies have detailed wear rate, generally indicating lower CoF and wear rates for PEEK as compared to PPS
  - End user operating conditions have significant impact on final results
- Lower CoF results in lower energy states, as reflected in the thermal environment on the pad/ring interface
- Results indicated that there was no significant difference in the shear force associated with the two ring designs, thus removing any concerns that the optimized retaining ring could increase pad wear

Thermal Environment due to Polymer Choice

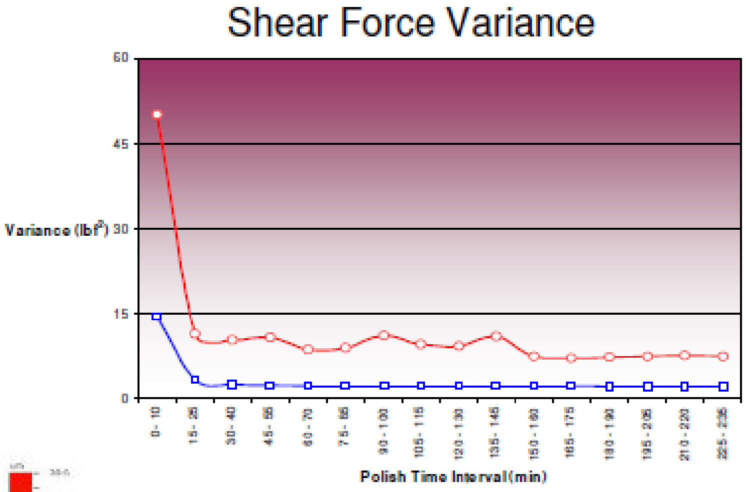
- Operating temperatures may play a role in the more chemically dominated CMP processes
- Overall, temperature effects are driven by the pad/ring/wafer interface rather than the pad/pad conditioner interface.
- Platen and head asymptote over time
- APD-800 tool for 200/300 mm processing enables real time in-situ analysis

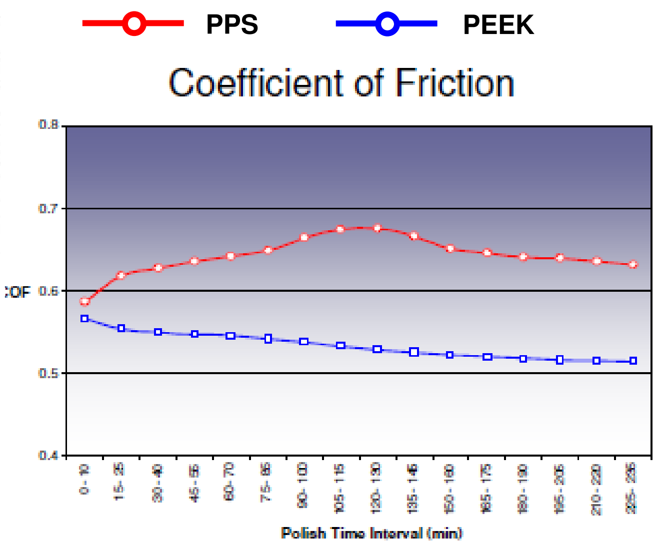


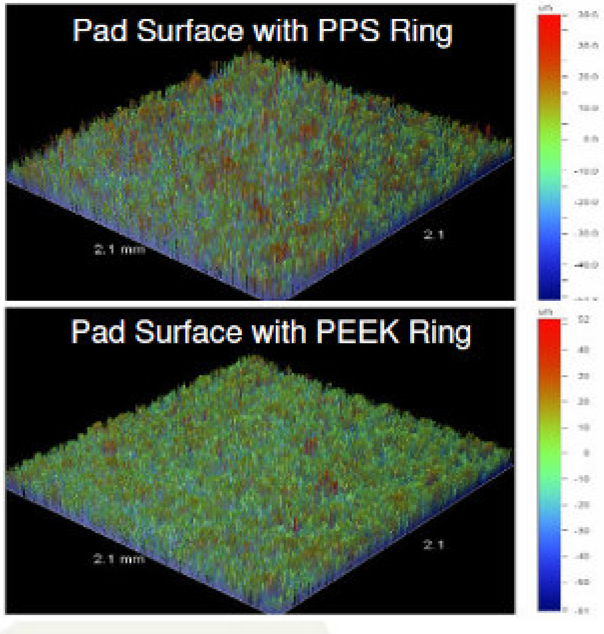


Tribology and Force Variation

- APD-800 measures shear and normal force in-situ
- *Variation* of the shear force differs greatly by polymer
  - Slip/stick phenomena
- Lower CoF for PEEK than PPS
- Agrees with earlier published work
- Interferometry of pad surface shows effect of polymer



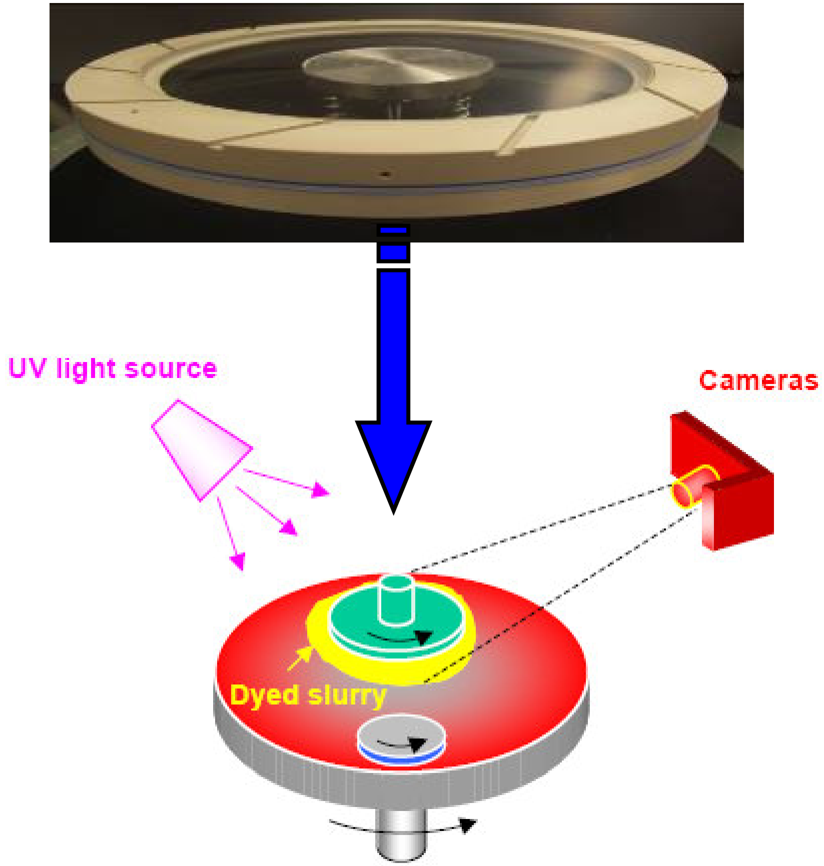




Slurry Usage Measured In-Situ

- Two retaining rings with the industry standard and optimized slot designs were attached to a 200-mm quartz wafer
- The thickness of the slurry film between the pad and wafer was measured using dual emission UV enhanced fluorescence (DEUVEF) at different slurry flow rates (150 and 220 ml/min), pad/wafer rotation rates (80 and 120 RPM) and retaining ring/wafer pressures (1.8 and 3.6 PSI)
- The next slide shows the slurry film thickness measurements associated with the two rings.

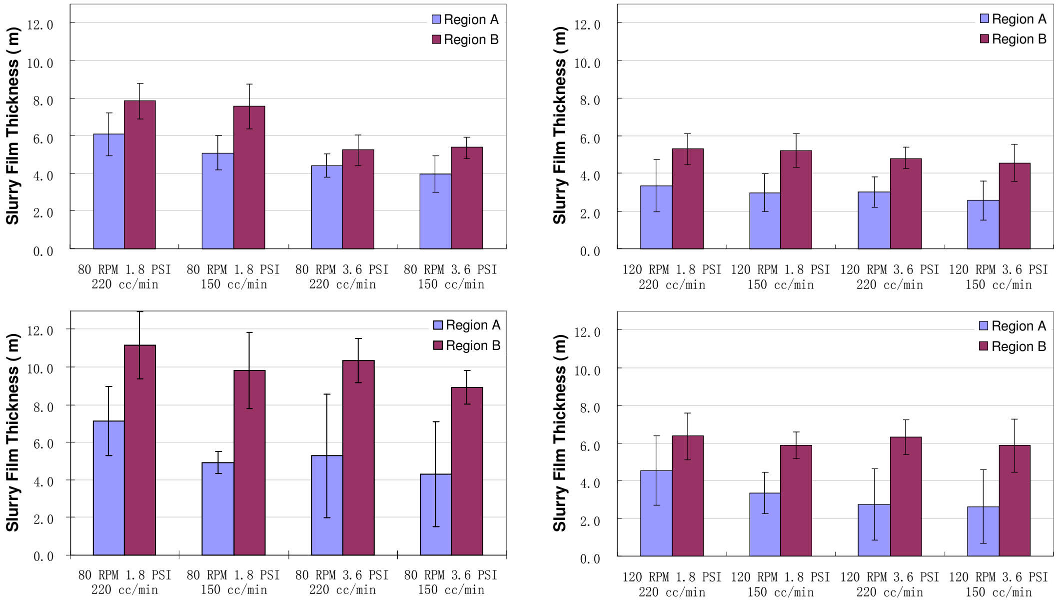
Upside down for clarity



Slurry Reduced with Optimized Ring

Standard Slot Design

Alternate Slot Design

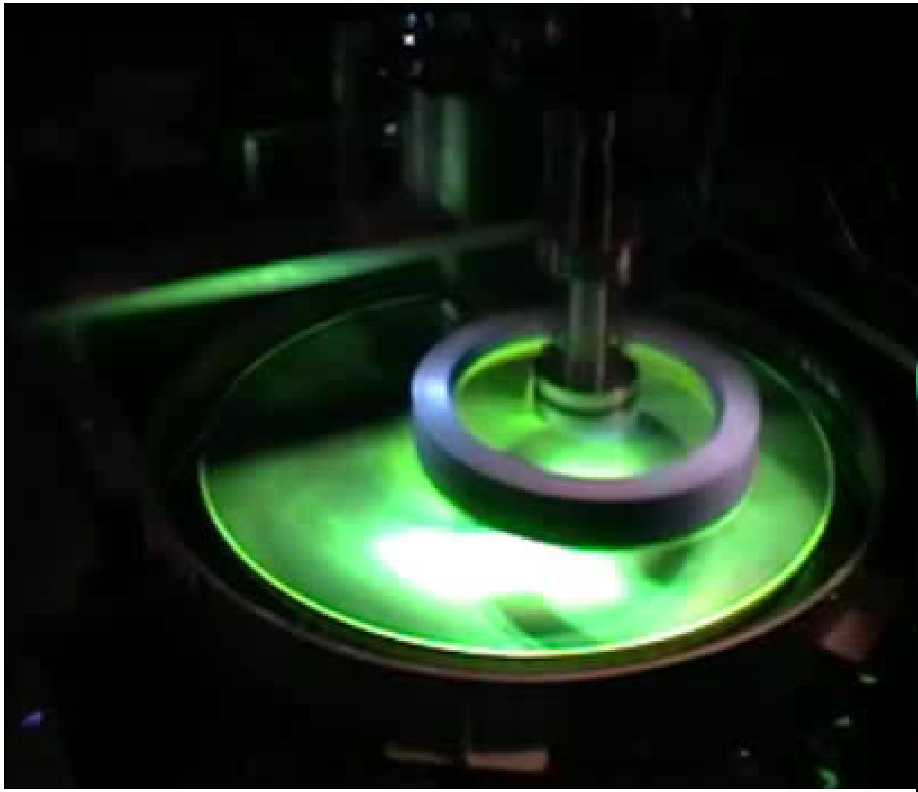


Slurry Film Thickness Varying Process Parameters

- Alternate ring design achieved **39% greater** slurry film thickness compared to an industry standard design ring
- Normalizing on slurry film thickness for both ring designs, slurry usage would be **reduced 28%** with an optimized ring slot design.
- Slurry film thickness in the pad/wafer interface region is greater as one moves away from the inner edge (Region A) of the ring

Videos of DEUVEF Study

Embedded videos will not play in pdf format. Please e-mail David Stockbower at david_stockbower@entegris.com for the relevant files and information

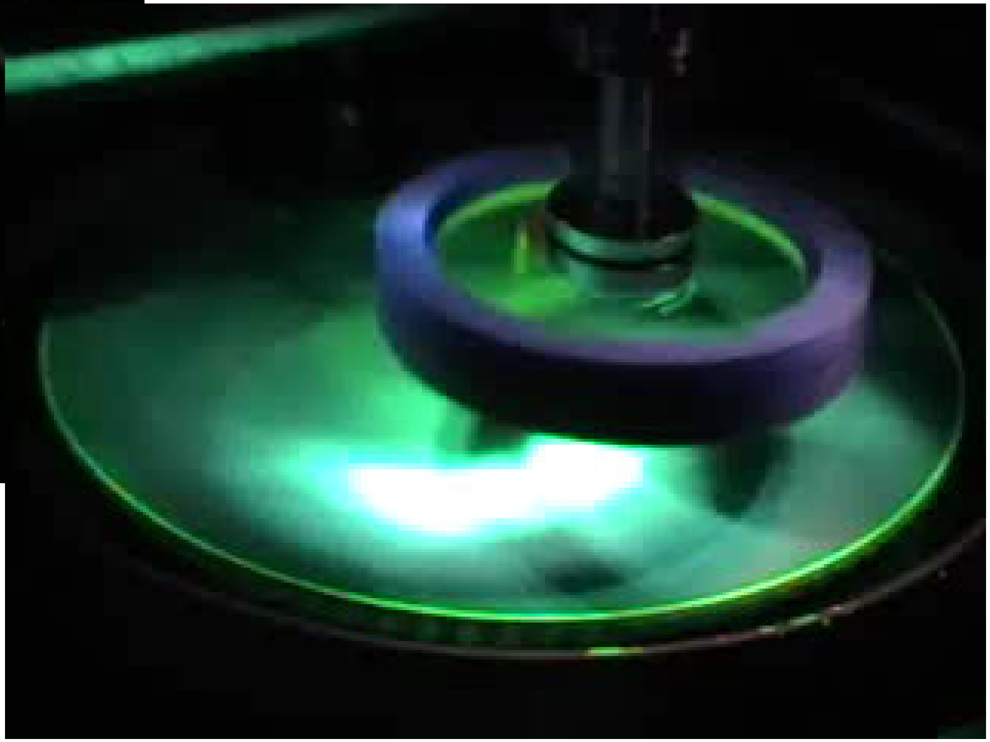


Novel Slot Design

Suppression of Bow Wave
Reduced Slurry Usage

Standard Slot Design

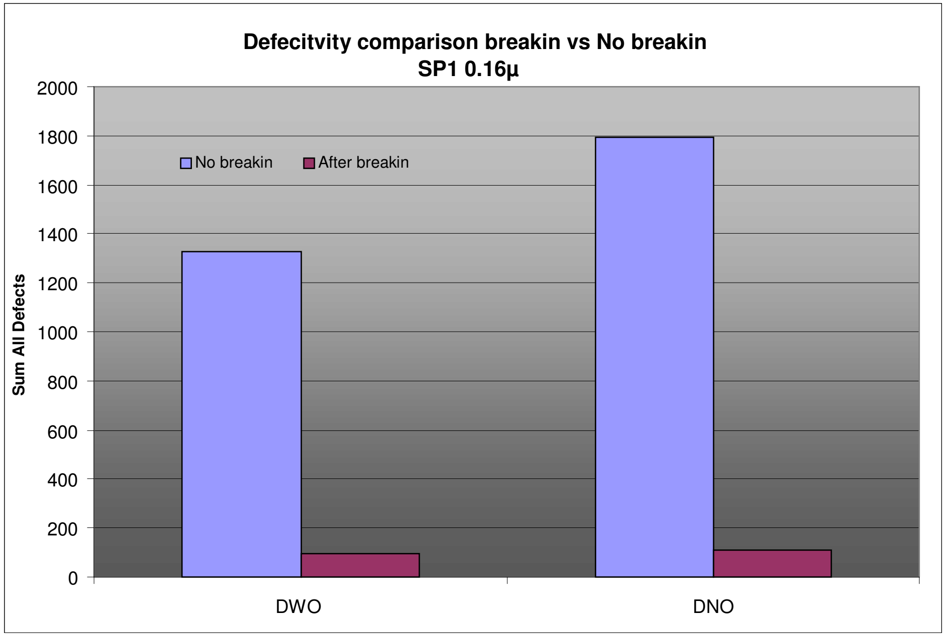
Generation of Bow Wave
Excess Slurry Usage

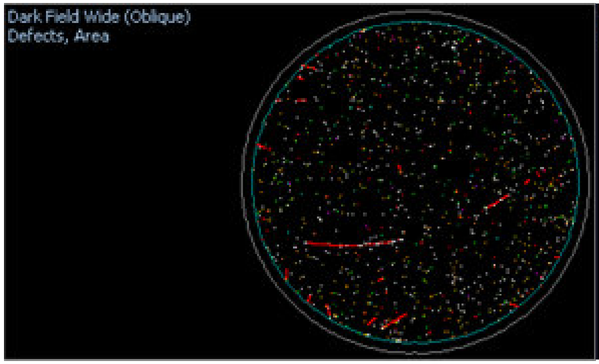


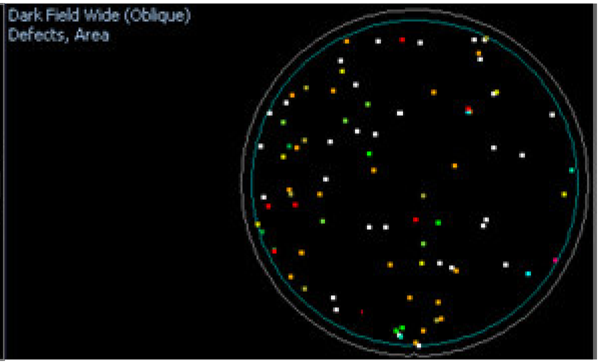
Method proprietary to Araca, Inc

A Costly Step - Ring Break-In

- Rings break-in varies at end users
  - Defects, wafer count, time driven, PM cycle
  - Highly dependant on speed, pressure, fluid
  - Usually concurrent with pad change and break-in
- Absolutely necessary, but costly
- Working to correlate ring condition to ring break-in
  - Edge effects
  - Polymer type & quality
  - Surface finish







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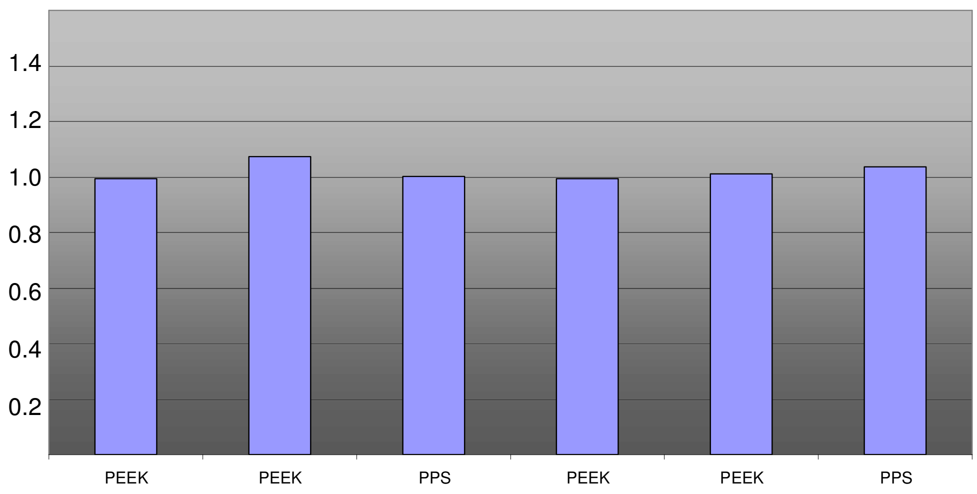
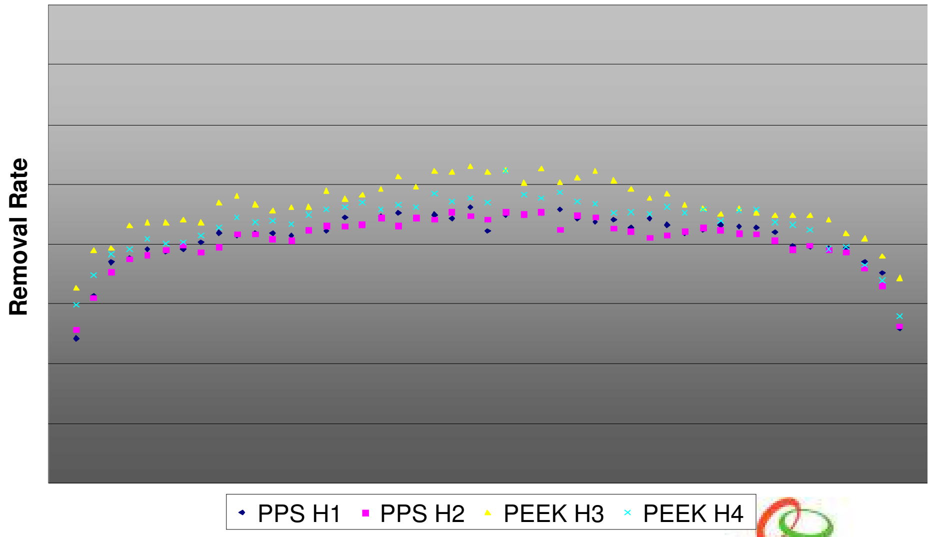
No RR Variation with Different Polymers

- Industry standard conditions at end user
  - Looking for drop in replacement
  - Exact same geometry, only polymer changed
- Post break-in, geometry dominates RR results
  - No obvious polymer effect
- Differing polymer rings with the same preparation deliver similar wafer removal



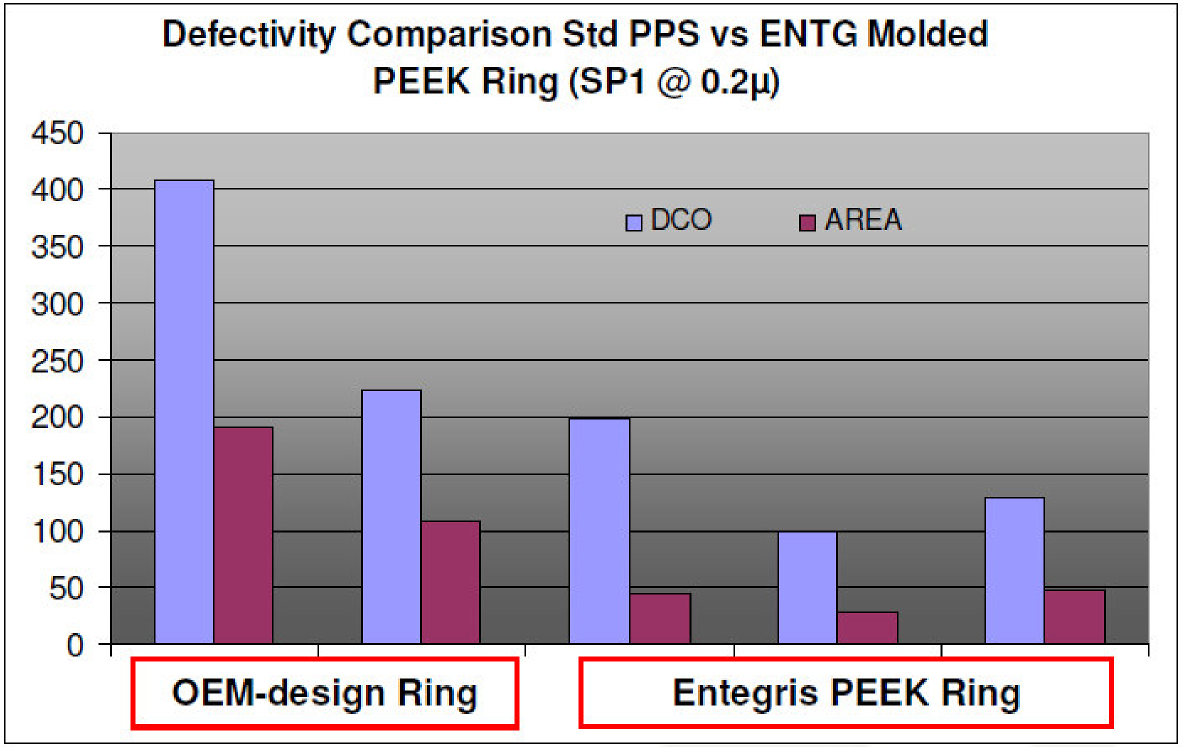
Normalized Oxide Removal Rate Comparison



Removal Profile

End user conditions proprietary

Same Geometry, Different Polymer, Lower Defect



- Same ring geometry, different polymer to isolate effect
- Results are TEOS monitor wafers, SP1 0.2 µm
  - Cu results are similar
- Molding methods, injection vs compression, could impact
  - Ring or pad particulation an area of investigation

Understanding Retaining Ring Effects

- Ring material choice impacts process conditions and results
  - Polymers generate varying thermal environments
  - Rings mass alters down force on pad, wafer edge
  - Defect rates may be impacted by polymer or pad particulation
  - Ring preparation is critical for optimal performance
- Ring wear rates / lifetime correlated to polymer
  - Generally “harder” polymers last longer
- Ring and slot design can modulate slurry usage
  - Novel slot design suppresses bow wave, maintains slurry film thickness under wafer
  - Initial studies indicate 28% slurry saving
  - Ring geometry dictates removal rate and profile
- Process optimization with static tool settings is difficult
  - Optimized ring designs can greatly reduce process COO

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