Three Complementary Strategies for Micro-scratch Reduction during Chemical Mechanical Polishing (CMP)

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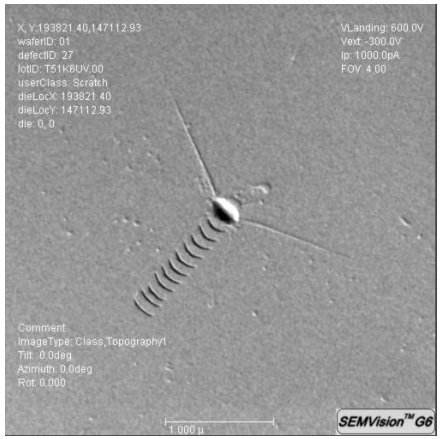
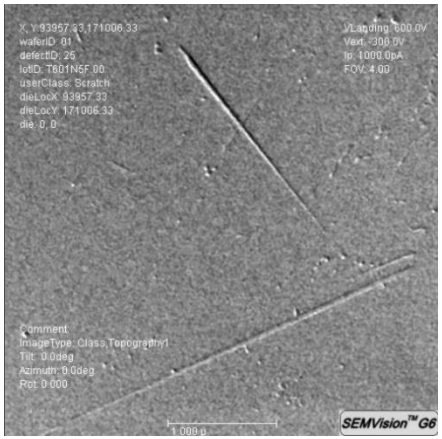
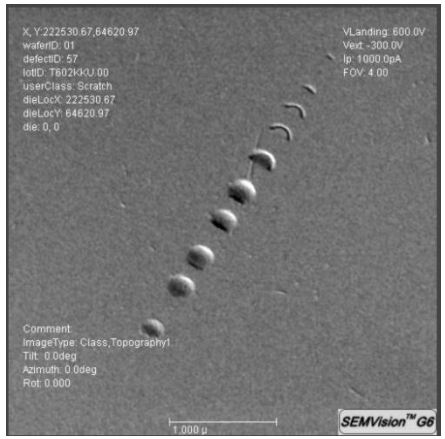
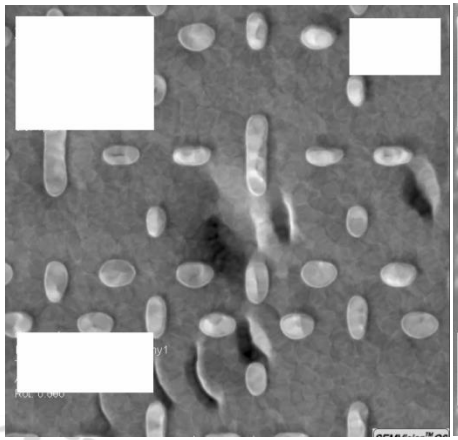
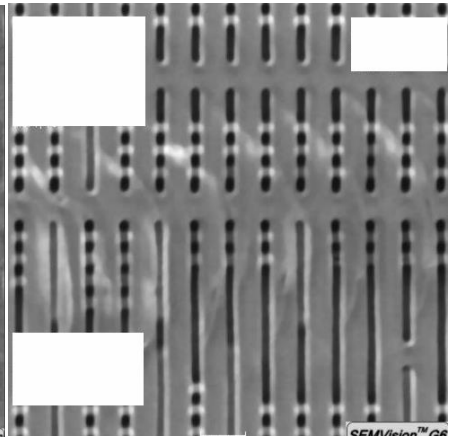
CMP-induced Microscratch: Examples

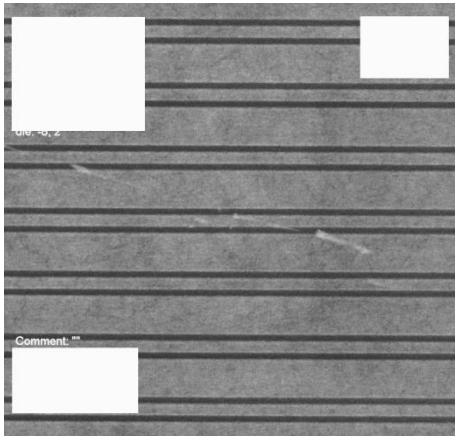


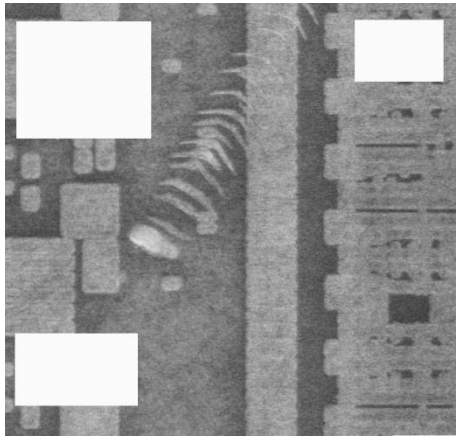






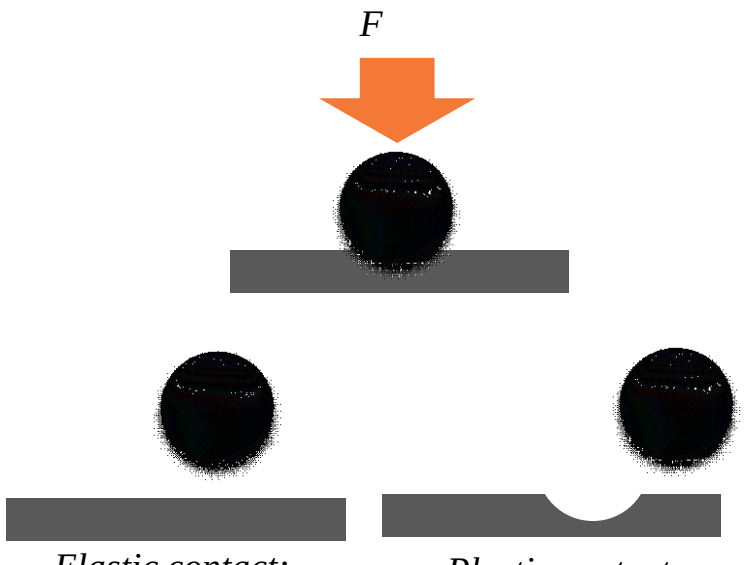




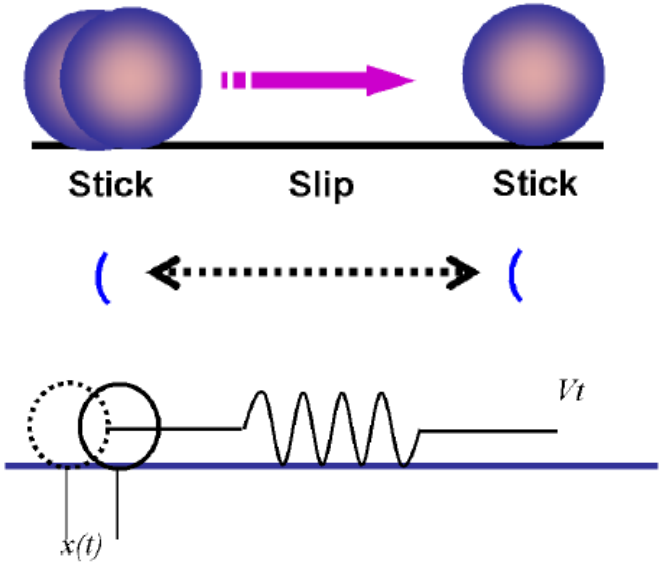


Mechanism and Origin of Scratch Formation I

Traditional Approach: Contact mechanics and particle-wafer interaction



Scratch Formation



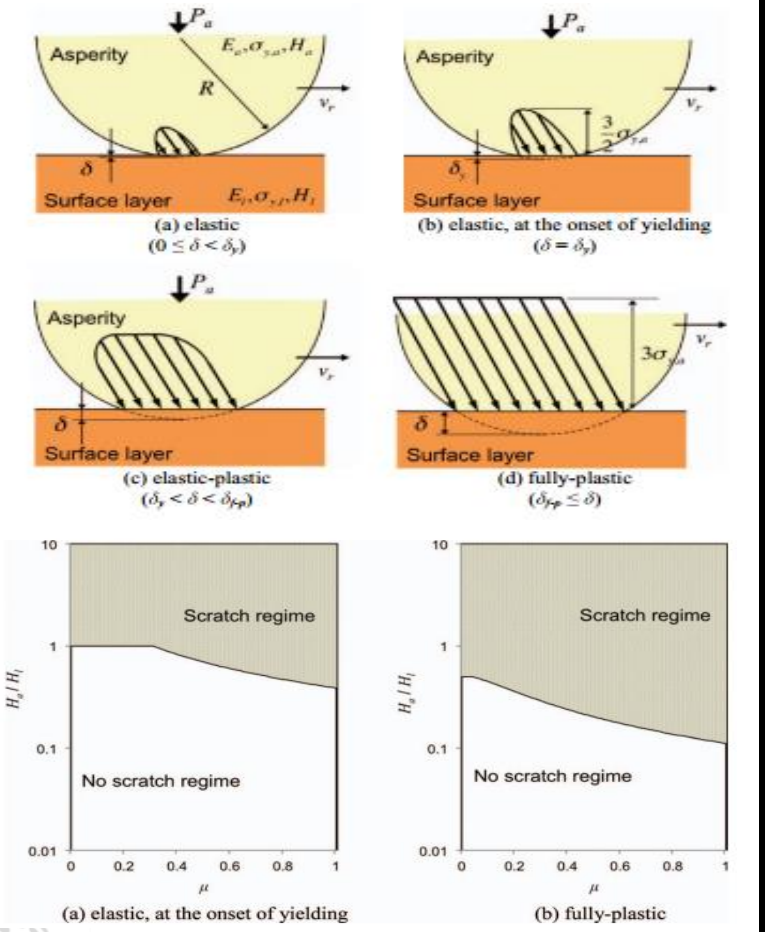
Force balance: $M\frac{d^2x}{dt^2} + B\frac{dx}{dt} = K\Delta x$

$K\Delta x = K(V \cdot t - x(t))$

Stick-slip for Chatter Mark

Mechanism and Origin of Scratch Formation II

New Findings: Polishing pad itself → Scratch on hard silicon by softer polyurethane



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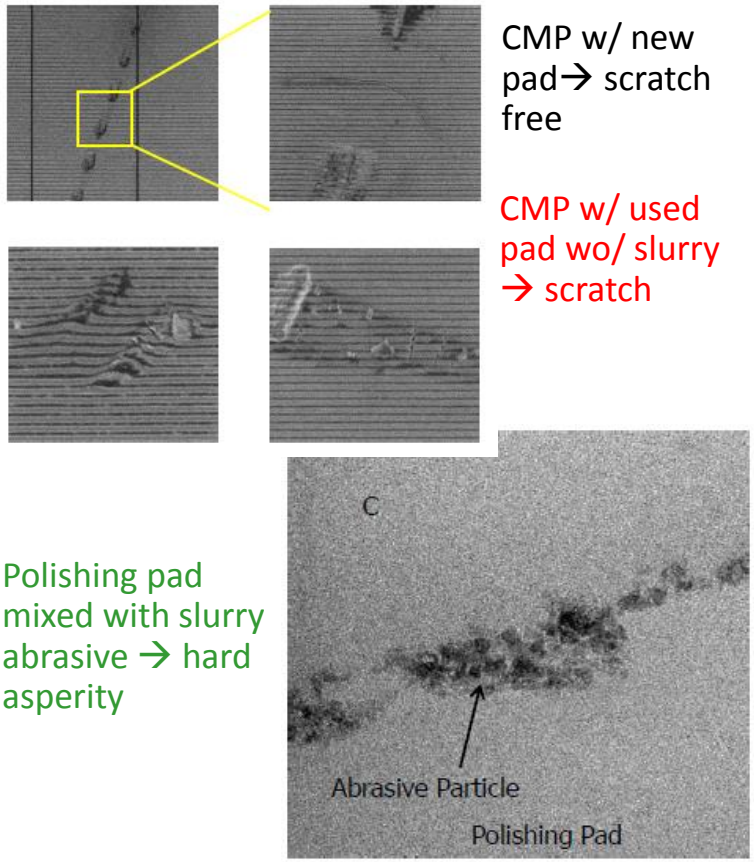
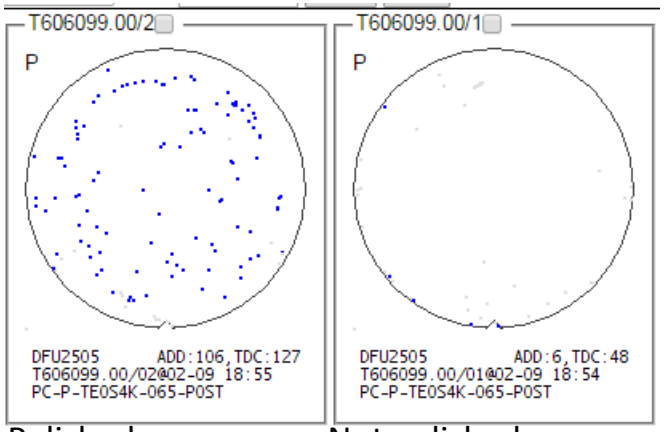


In-Ha Sung, Hong Jin Kim, Chang Dong Yeo, Applied Surface Science 258(20) pp. 8298-8306 (2012)

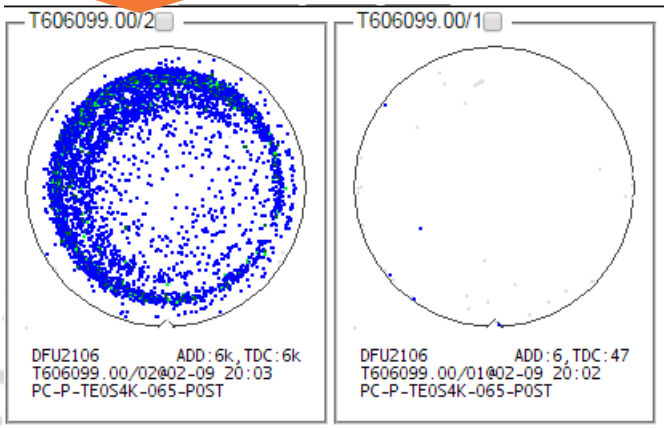
Mechanism and Origin of Scratch Formation III

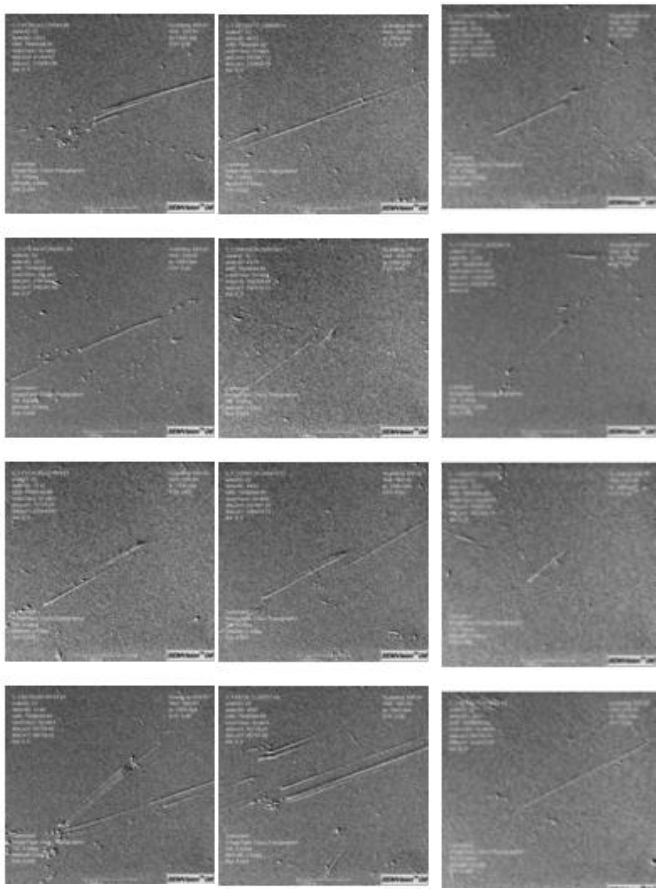
CMP-induced micrscratch → enlarged by HF etch



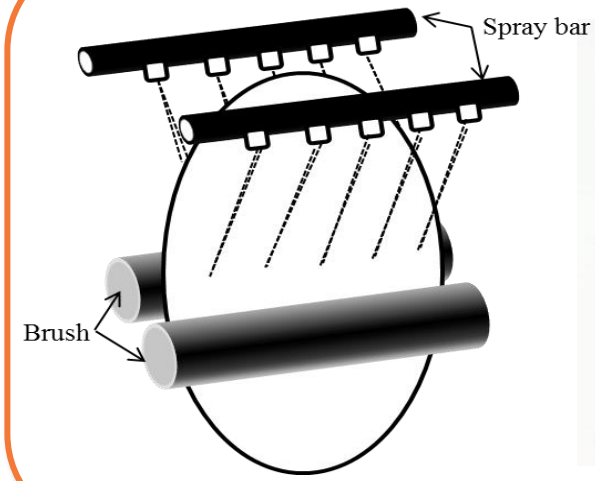
Polished Not polished

HF exposed at post CMP





Particles from Cleaner (Brush) Module

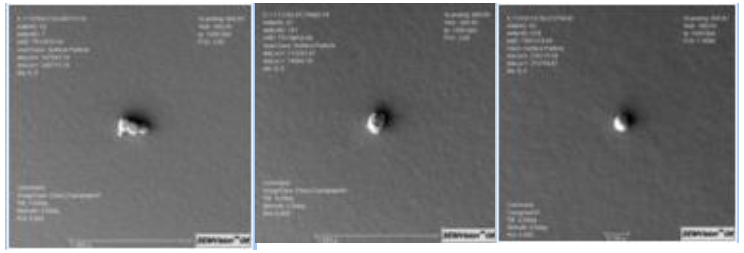


- Wafer is located between two brushes vertically.
- Both wafer and brushes rotate each other .
- Spray bars are installed to flow clean chemical.
- DIW flows through brush core.

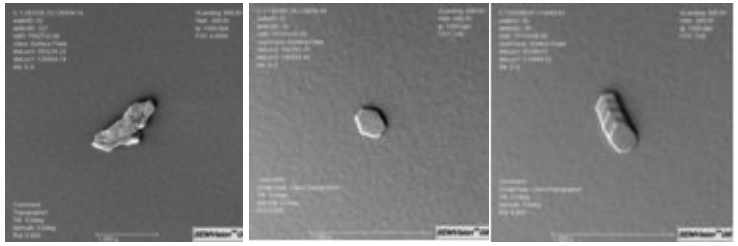
Particles from the brush (cross contaminated defects) can cause nano-scale scratches → clean chemical from spray bar enlarge them

Particles inside brush nodule

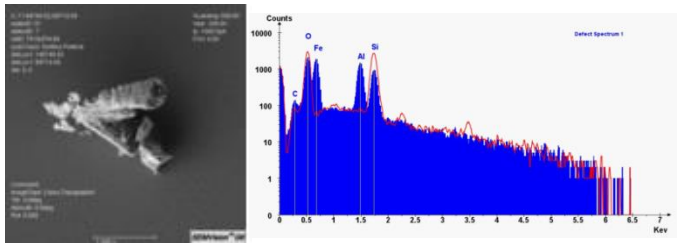
1. Slurry Abrasive



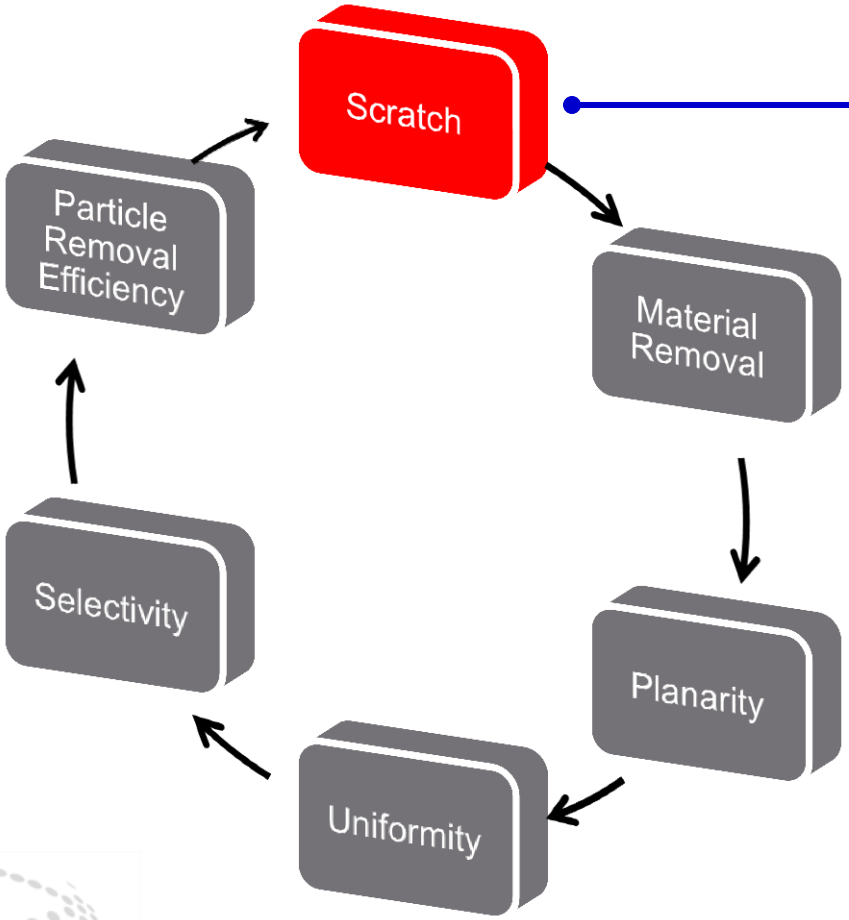
2. Flakes



3. Tool Particle



Strategies for Scratch Mitigation



- Soft Pad w/ Proper Conditioning
- Ultrafine Abrasive Particle
- Recipe Optimize (Low Down Force, Slurry Flow)
- Cleaner Brush Treatment
- CMP Friendly Process

Scratch SOLELY can be minimized?

Summary

Microscratch is the most critical defects by CMP process and its yield detracting ratio becomes higher at advanced node logic device. In addition to abrasive particle contact mechanism, *polishing pad surface itself and cleaner brush are revealed as source of microscratches.* In order to mitigate microscratches during CMP, several approaches have been tried. *Nano-scale abrasive particle slurry is the most effective way to microscratch reduction*, however basic mechanism of polishing is not fully understood. Therefore, selectivity and planarity controls are challenges for nano-scale abrasive particle application. Brush cleaner module is not developed much, and *a lot of optimization challenges in cleaner module are addressed for defect reduction including microscratches.*