Copper/Low k CMP Gains Momentum™

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Agenda

- Copper/Low k CMP: Challenges
- Reduced Topography (Dishing & Erosion)
  - Topographical sensitivity to copper over-polish
- Adhesive failures and solutions
- Hydrophobic surface cleaning
- Summary

Copper/Low K CMP Challenges

Copper
Total Copper dep
Barrier
SiC
Trench Depth
Dielectric

High Defects due to exposure to aqueous CMP media
Residue
Dielectric loss
Dishing
Dielectric Erosion
$$$
Adhesive Failure

Copper/Low K CMP Challenges

Dishing

- High resistance in large structures (parametric failures)
- Cumulative topography causing shorts at upper levels (Yield loss: high kill ratio)

Erosion

- High resistance in small structures (parametric failures)
- Cumulative topography causing shorts at upper levels (Yield Loss: high kill ratio)

Oxide loss

- High resistance in lines (parametric failures)
- Higher dielectric, copper deposition needed. (higher Cost)

Defects

- De-lamination and cohesive failure (yield loss: high kill ratio, reliability?)
- Water spots (yield loss: low kill ratio)
- Micro-scratches (yield loss: low kill ratio, reliability?)
- Residue (yield loss: high kill ratio)

Cost of ownership

- Polish slurry cost (if using commercial slurry)
- Polish pad cost (especially on 300 mm)

Dishing & Erosion

- Typically topography (dishing/erosion) increases during over-polish due to many reasons.

- Low static etch rate process
- Hard pad (No soft layer underneath)
- Copper/Barrier selectivity greater than 1000

Topography (Dishing & Erosion)

Cu polish

End-point

Cu over-polish

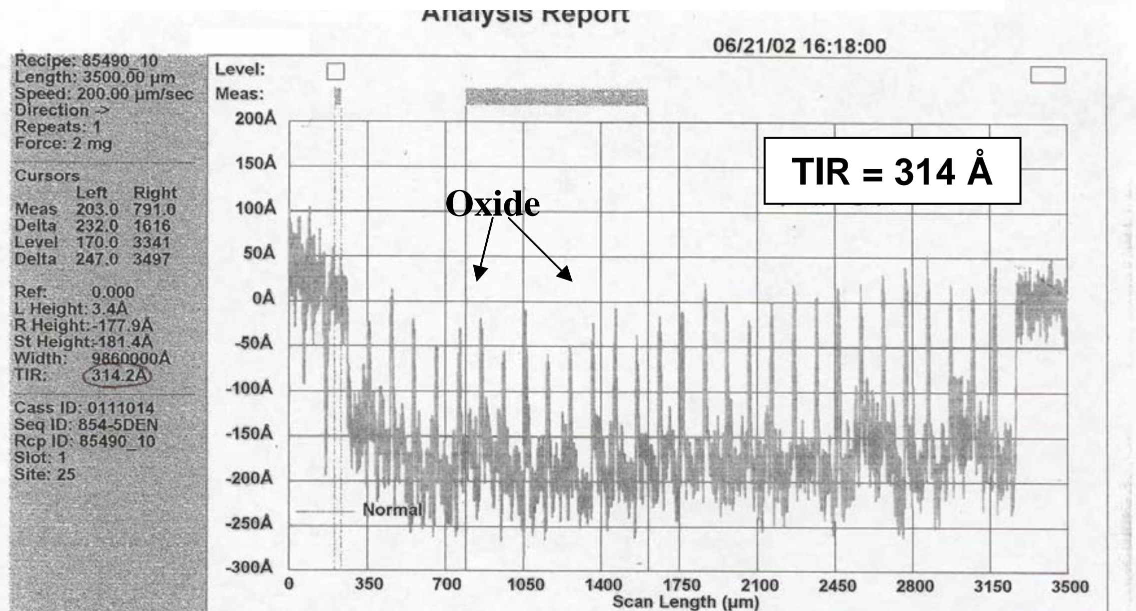
Barrier Polish

Reduced oxide loss

Time of polish

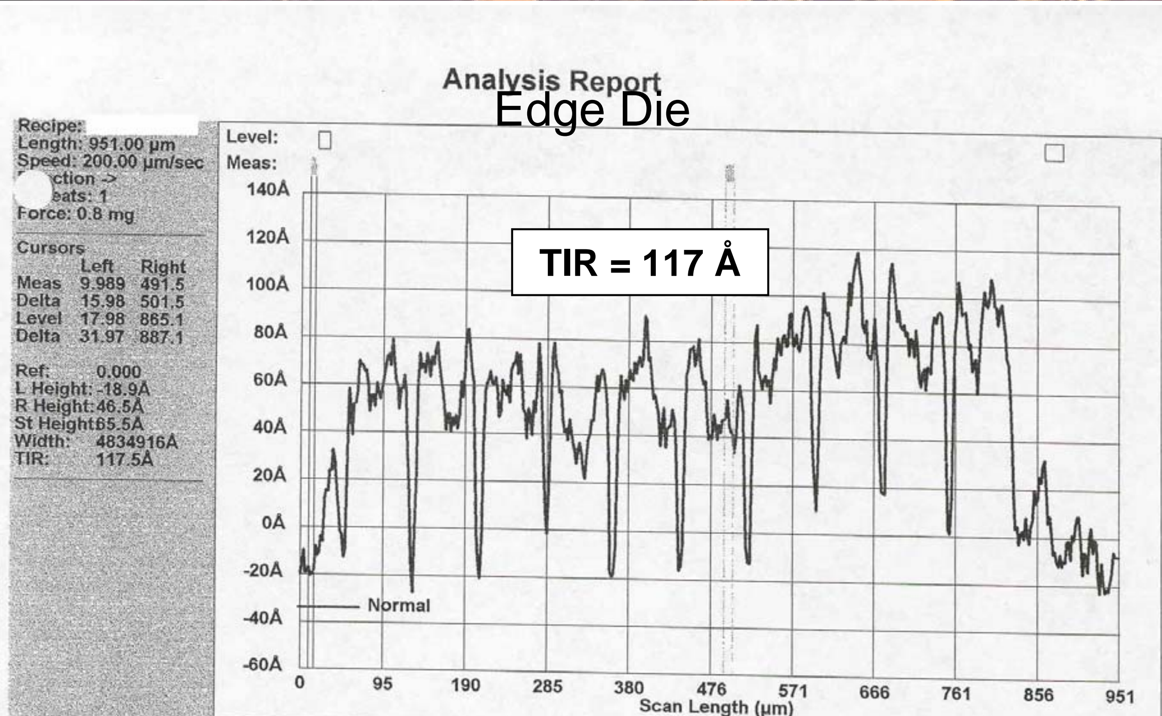
Topography after cu over-polish (30s)

After Cu Only - Pre Barrier



90% Pattern Density (90 μm lines)

Topography after barrier polish



90% Pattern Density (70 µm lines)

Dishing/Erosion (AFP + SFI barrier Slurry)

Topography after barrier polish
Copper: 430-1 on IC1000
Barrier: barrier slurry on politex or IC1000

Insensitivity to Over-polish

Dishing/Erosion(A)

0 O/P
25% O/P
50% O/P

40 um
20 um
14 um
10 um
4 um
2 um
1 um
0.4 um
0.2 um

Line width(um)

Cu-CMP Over-Polish Insensitivity

Data Source: Selete: 300 mm Sept 2002

Line/space; 1.0µm/ 1.0µm

Cumulative Probability (%)

Sheet Resistance (mΩ/sq)

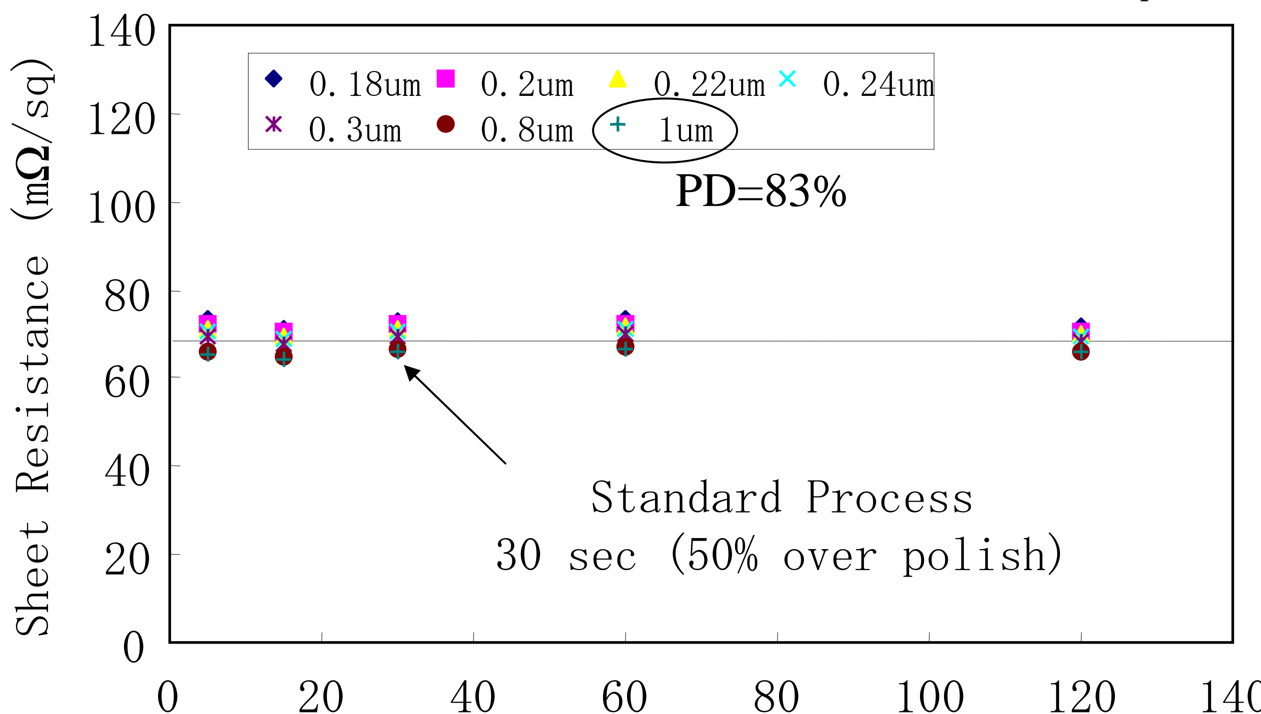
OP: 5sec
OP: 15sec
OP: 30sec
OP: 60sec
OP: 120sec

M1-CMP
'02/8/7
1.5psi

2 min over-polish (240%): No difference on line resistance

Cu-CMP Over-Polish Insensitivity

Data Source: Selete Sept 2002



EPD is detected at around 50 sec.

Adhesive failures

Occur due to poor adhesive strengths between dissimilar films.

Reduce the shear force during CMP and/or other unit processes.

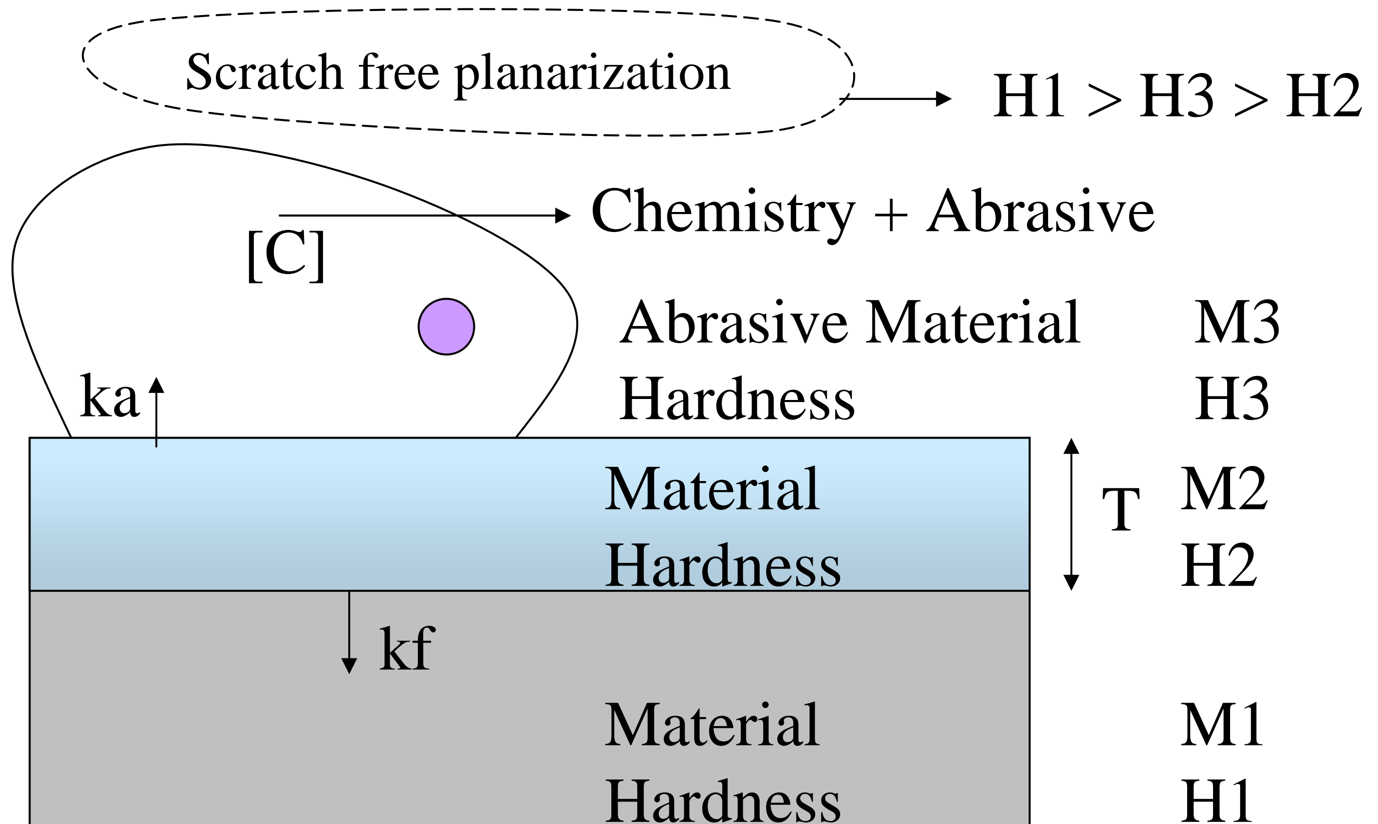
Two Shear stresses to worry about:

1. Steady state drag force = $\mathbf{F} \times \mu_{Dynamic}$
2. Shear stress associated with 'ramping up' the process.

   Rate of change of velocity from zero to the process speed.

Reducing Down Force typically reduces Removal rates.

Mechanism of copper removal



kf α [C], Diff coeff, T, Temp, ka, flow profile…..

ka α Press, velocity, H2, size of abrasive, kf etc.

High Removal Rate, Low Pressure

Jan 2001

Momentum™ AFP Copper Process

Linear velocity ~ 200 ft/min

High Removal Rate, Low Pressure

Jan 2002

Removal Rate and Polish Pressure

Linear velocity ~ 200 ft/min

High Removal Rate, Low Pressure

August 2002

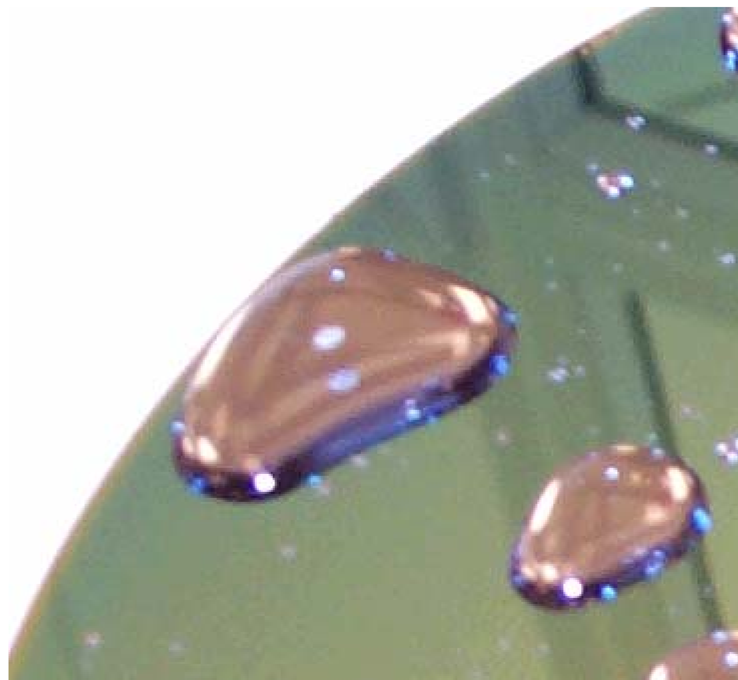
Removal Rate vs Carrier Pressure
300mm, Hitachi 430-TU, IC1000

Linear velocity ~ 200 ft/min

Carbon doped film dry OSG/CDO no cap

DI Dispensed on CDO/OSG

Un-polished CDO is very Hydro-phobic



Un-polished CDO/OSG Post SRD

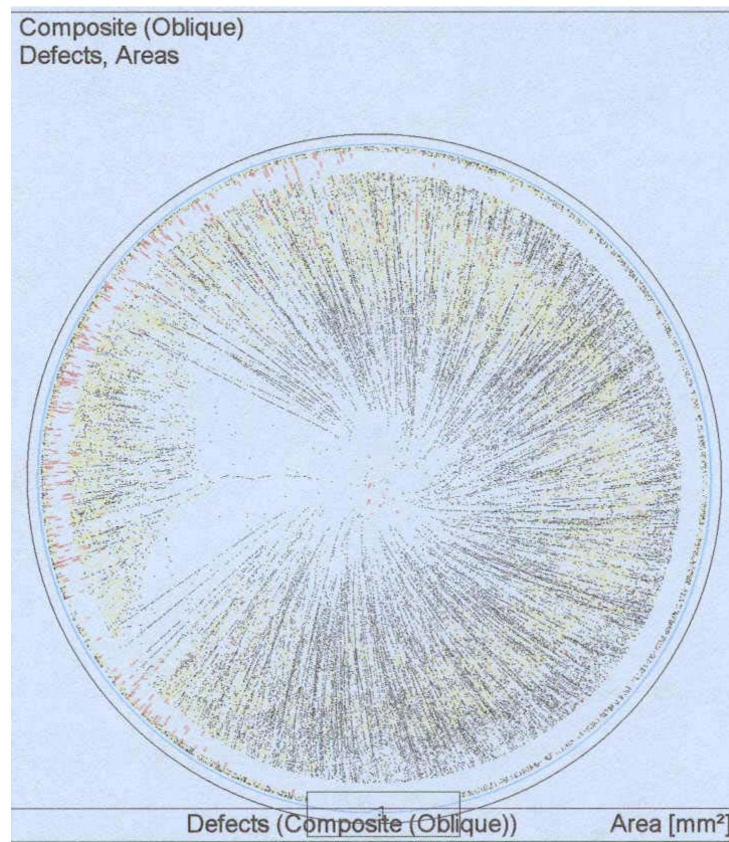
1. Standard POR (Kanto CMP MO2, 10:1)

Step	Duration	Chuck RPM	Sweeps	Upper DI	Lower DI
1	5	500	0	ON	ON
2	20	1500	6	OFF	OFF
3	20	3000	0	OFF	OFF

Wafer ID	01
Pre Defect Count	261
Post Defect Count	70359*

**SP1 overloaded*

Shows Heavy Water Streaking
Marks on a Hydrophobic Surface

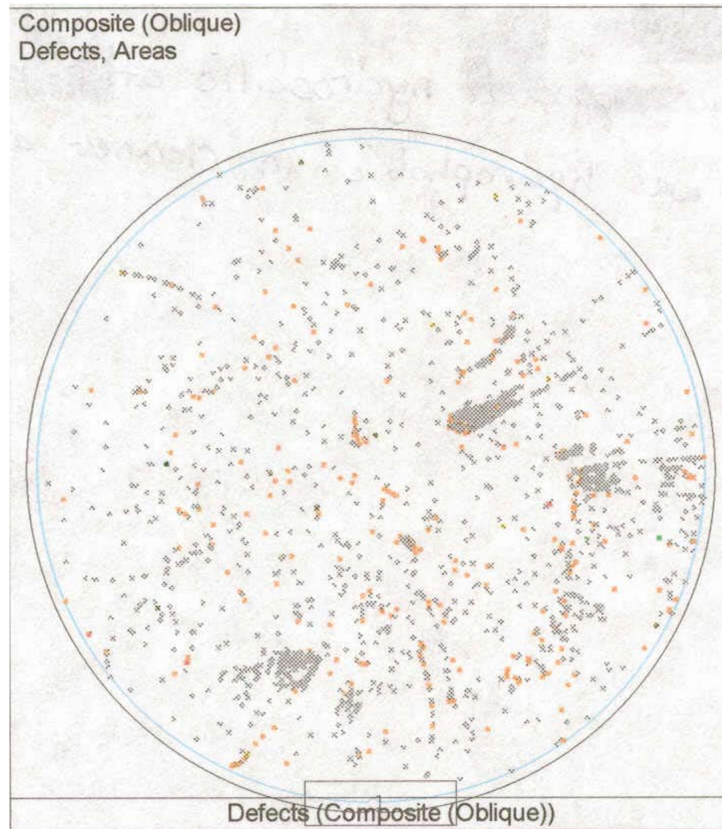


Post CMP CDO/OSG Post SRD

Buff Polish (1 psi for 30s) & Std POR clean (10:1 Kanto MO2)

Step	Duration	Chuck RPM	Sweeps	Upper DI	Lower DI
1	5	500	0	ON	ON
2	20	1500	6	OFF	OFF
3	20	3000	0	OFF	OFF

Wafer ID	01
Pre Defect Count	57268
Post Defect Count	2121

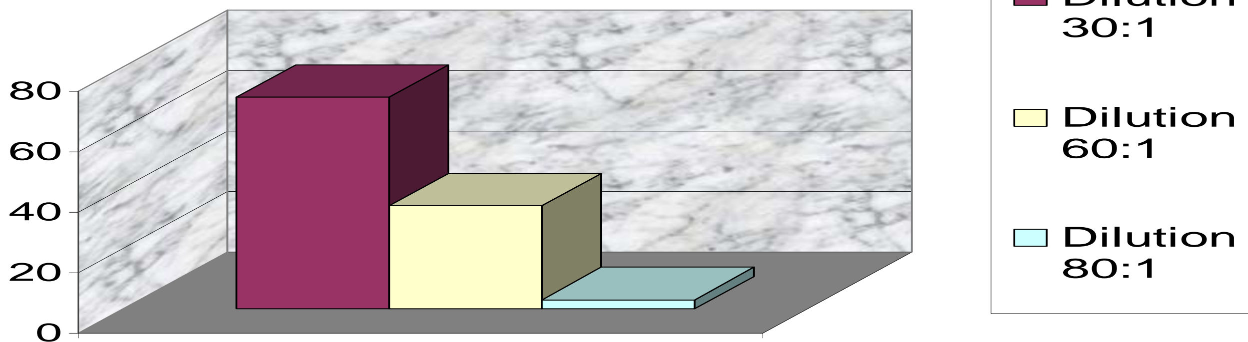


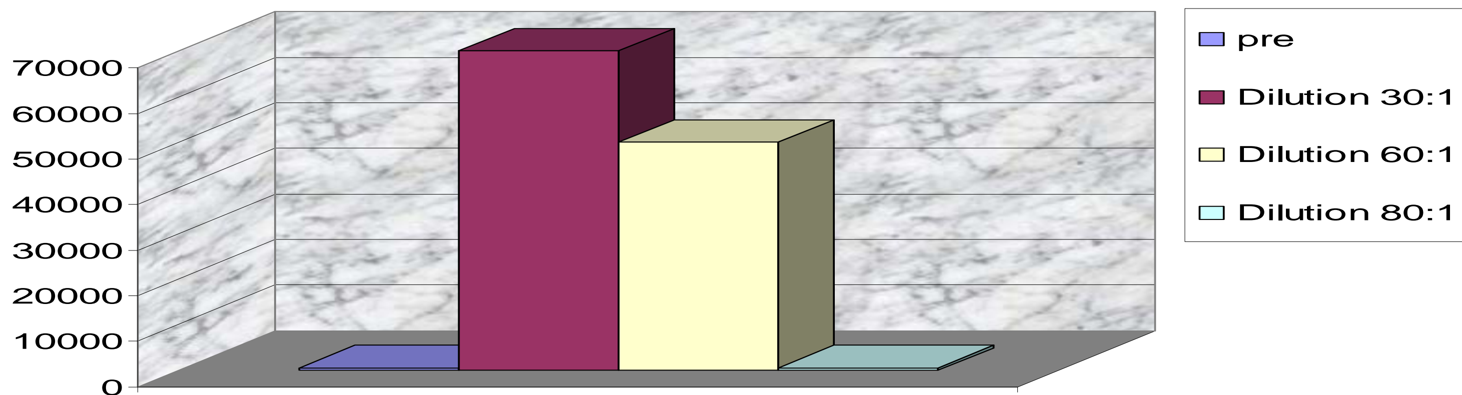
Indicates Polishing Improves Water Streaking on a Hydrophobic Surface

Drying CDO without Streaks

Post Defects on Coral (SP1 @>0.16um) using Chemistry "A"

Drying CDO without Streaks





Drying CDO without Streaks

New Drying technique vs regular SRD

New Drying Technique
Std Drying Technique

Added Defects; SP1 >0.16um

8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
-2000

0 1 2 3 4 5 6

Wafer #

Summary

- Momentum Cu/Low k process provides :
  - Low dishing
  - Low Erosion
  - Total Topography of 90% dense structures of 150A
  - In-sensitivity to copper over-polish
  - High removal rates at low press: 5900 A/min @ 2 psi
  - Streak (dry spots) free drying of hydrophobic wafers