Cu CMP Cleaning

Aqueous, Alkaline Chemistry

March 2002

Outline

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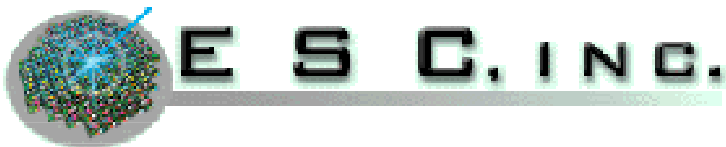
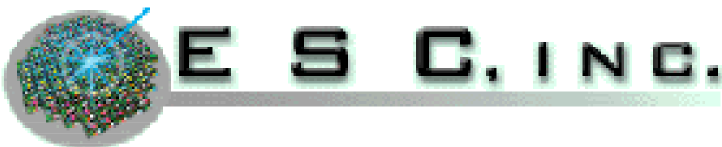
- Cleaning Requirements
- Summary



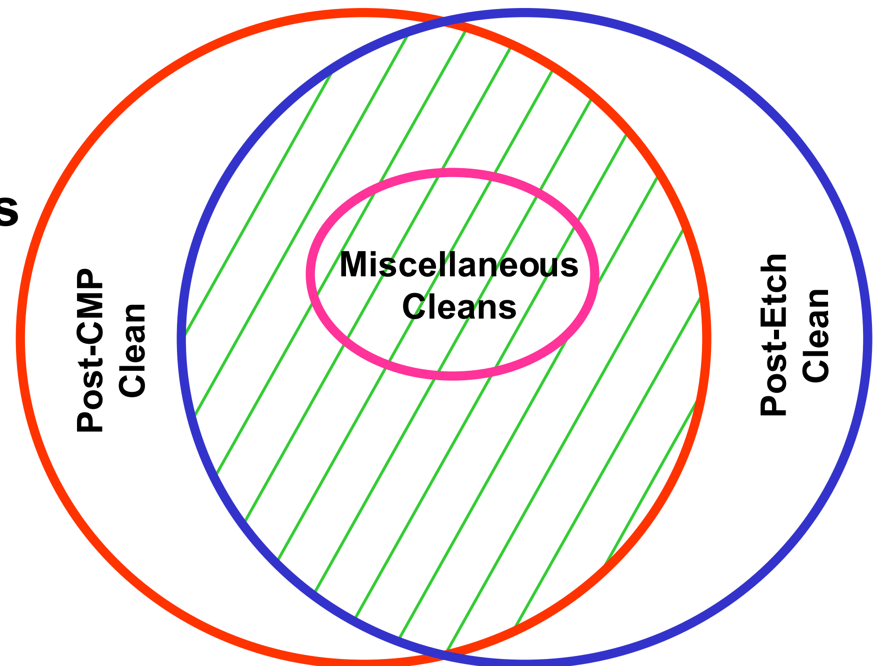
Introduction

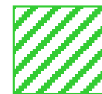
- Focus is on developing a robust Cu CMP cleaning process that achieves the cleaning objectives with a wide range of polishing processes
- A two-step cleaning process has been studied to meet these requirements.
  - Good results were observed initially
  - Since the writing of the paper issues appeared with a 2-step, high pH/low pH clean
- Single-step cleaning process is desired



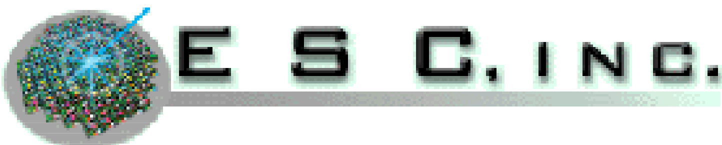
Versatility in Cu Processing

- ESC has developed alkaline chemical formulations that are versatile enough to be used for many Cu integration applications
  - Post-CMP cleaning
  - Post-Etch Cleaning
  - Miscellaneous cleans
- In Cu processing applications, the main concern is particle and residue removal without corrosion of the bulk Cu and other exposed films
- Base formula can be customized based on requirements



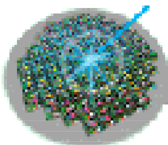


Application region that is addressed by the “base chemistry”



ESC Chemical Formulations

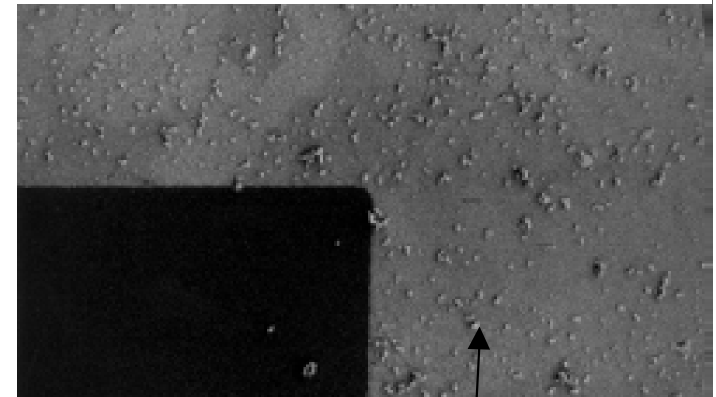
- **Base Formulation- ESC 784**
  - High pH (>10) with buffering agent
  - Oxygen scavenger
  - Provides some chelating effect
  - Aqueous solution (>80% water) that is easily diluted
- **Customization using optional additives**
  - Surfactants
  - Fluorides
  - Solvents
  - Chelating agents
  - Additional corrosion inhibitors
- **Process Flexibility**
  - Time, Temperature, Tool and Concentration



E S C, INC.

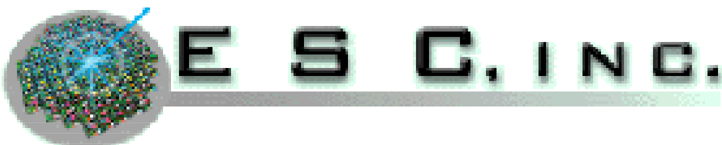
Cleaning Requirements

- Contamination Removal
  - Slurry and polish particles
  - Cu contamination in dielectric regions
- Film compatibility
  - Cu, TaN, FSG, SiOC, SiLK, MSQ
- BTA removal, if used as a quench
- Equipment performance
- Cost of Ownership



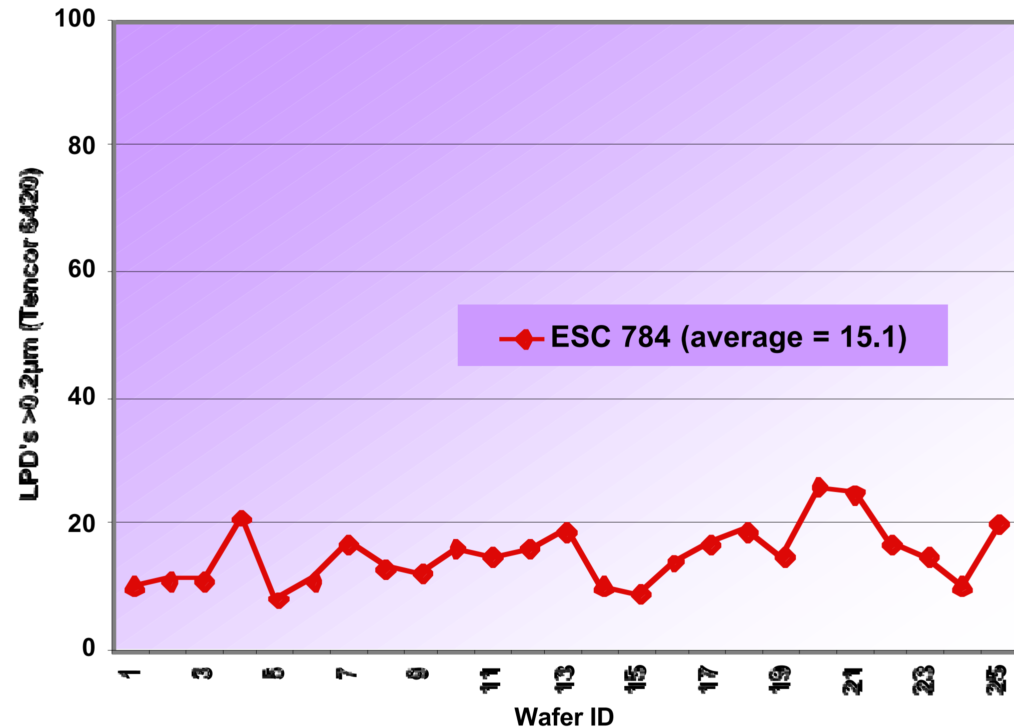
Dielectric and barrier films

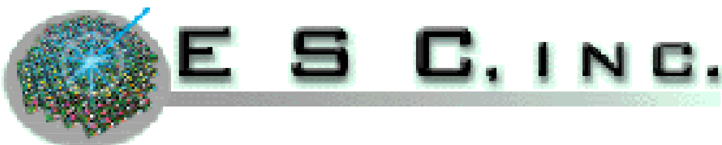
Cu areas on a polished wafer showing slurry contamination



Particle Removal

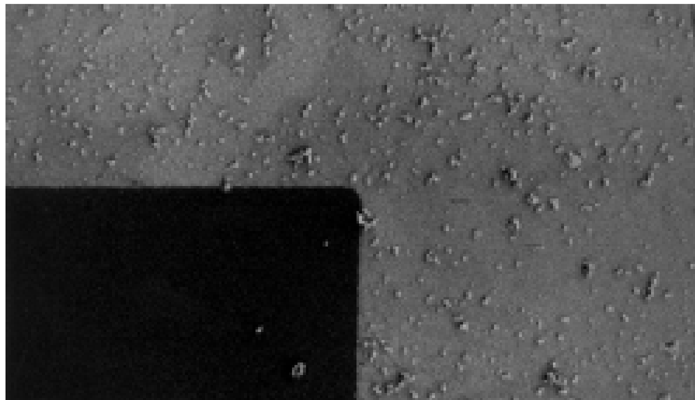
- Defect counts after blanket Cu CMP to TEOS.
- 25-wafer lot tested





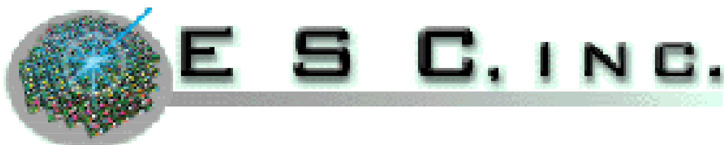
Cu Compatibility

ESC Products include proprietary Cu inhibitors that are effective in preventing Cu corrosion

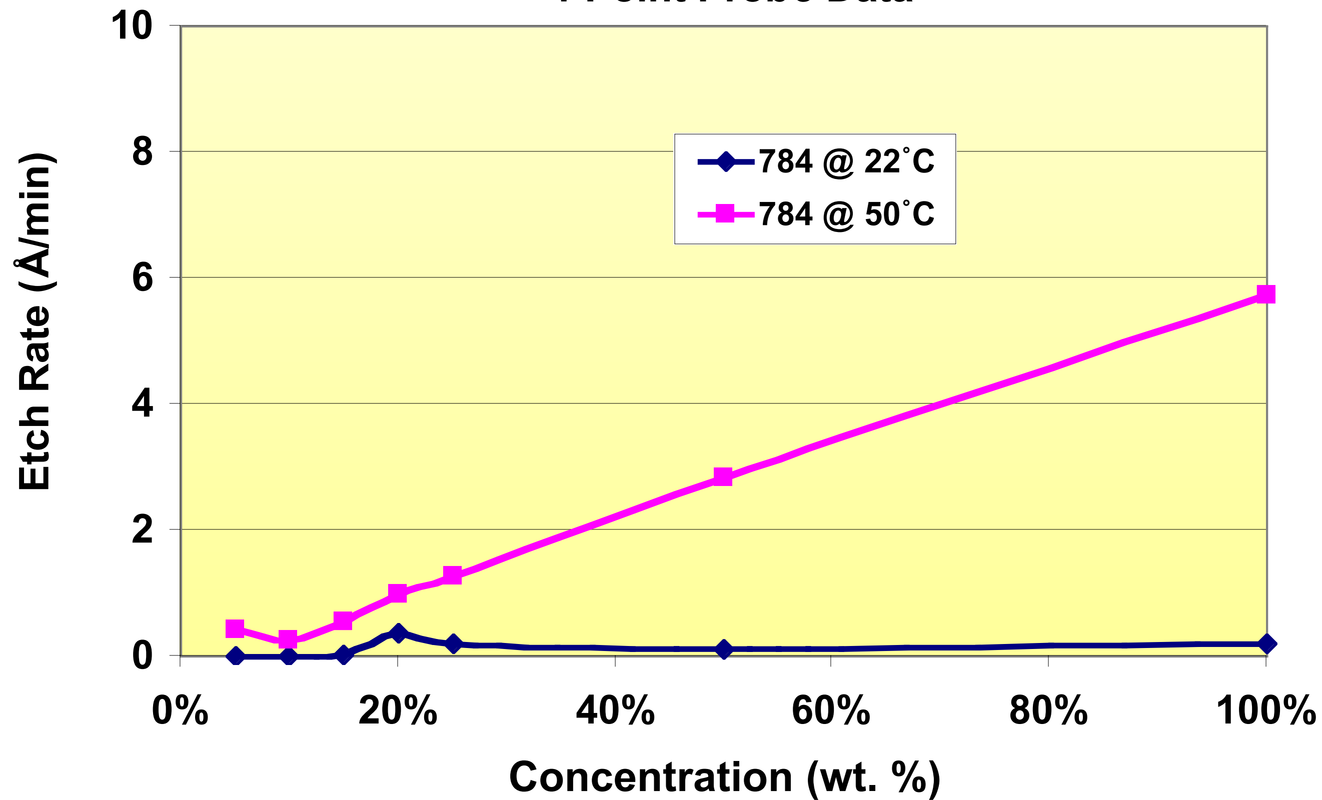


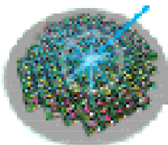
Untreated showing CMP contamination

Treated w/ ESC 784 solution (ambient, 30 sec, 20:1)



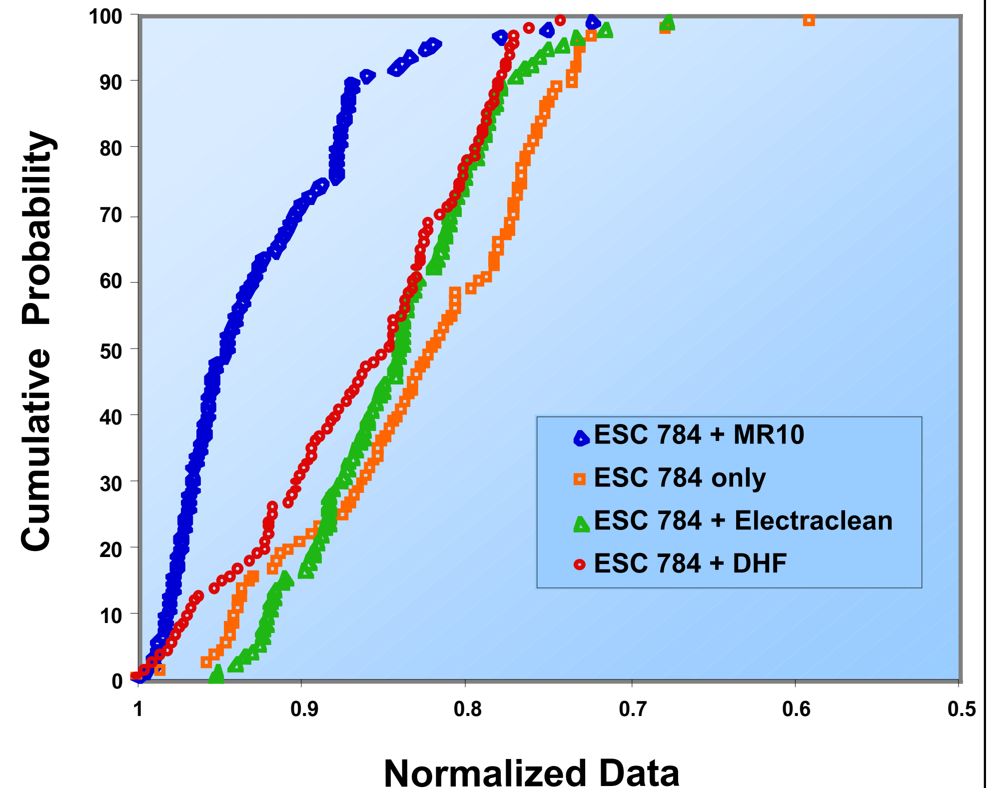
Cu Etch Rate for Post-CMP

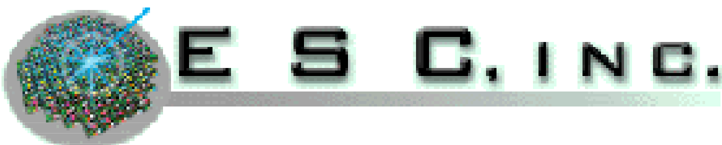




2-Step Clean

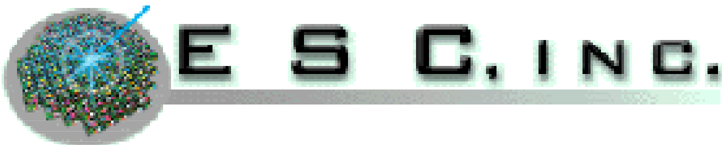
- A 2-step clean, high pH followed by low pH, shows good Cu contamination removal
- Evidence from leakage current data
- However, damage to front-end devices reported compared to one-step, high pH clean
- Also, unique corrosion defect observed





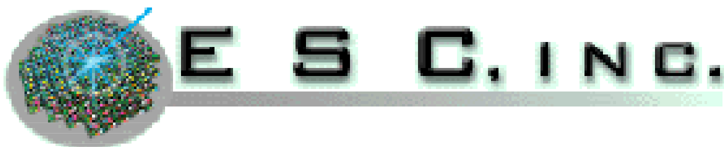
Corrosion Defect

- Cu corrosion defect seen with 2-step cleaning process
- Observed at several customers with different chemistries
- High pH, followed by low pH in each case
- High pH-only and low pH-only do not create this defect

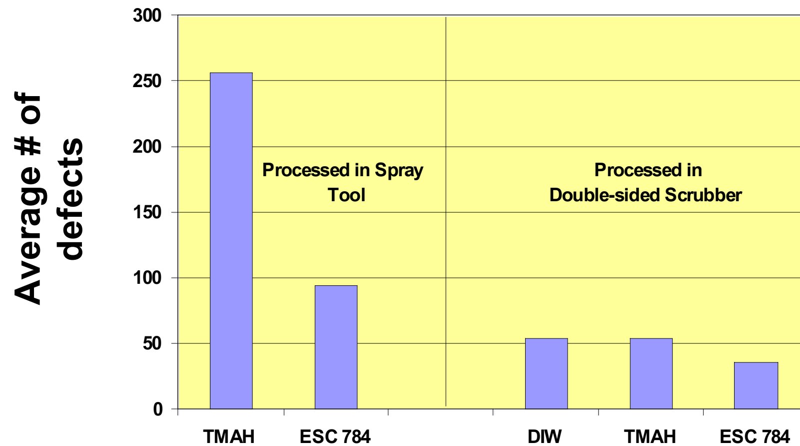


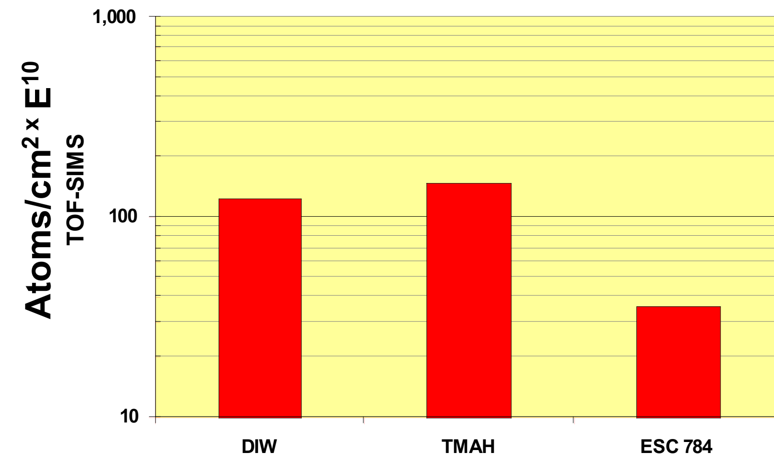
1-Step, High pH Clean

- **Several customers have qualified ESC 784 as a single-chemistry clean**
- **Cu contamination level has been demonstrated to be within spec without additional cleaning steps**
- **Development of improved chelating efficacy to address future needs for Cu contamination levels and to increase the CMP process window**

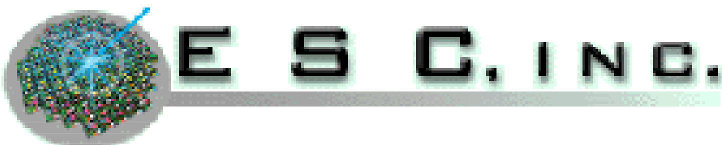


ESC 784 vs. TMAH



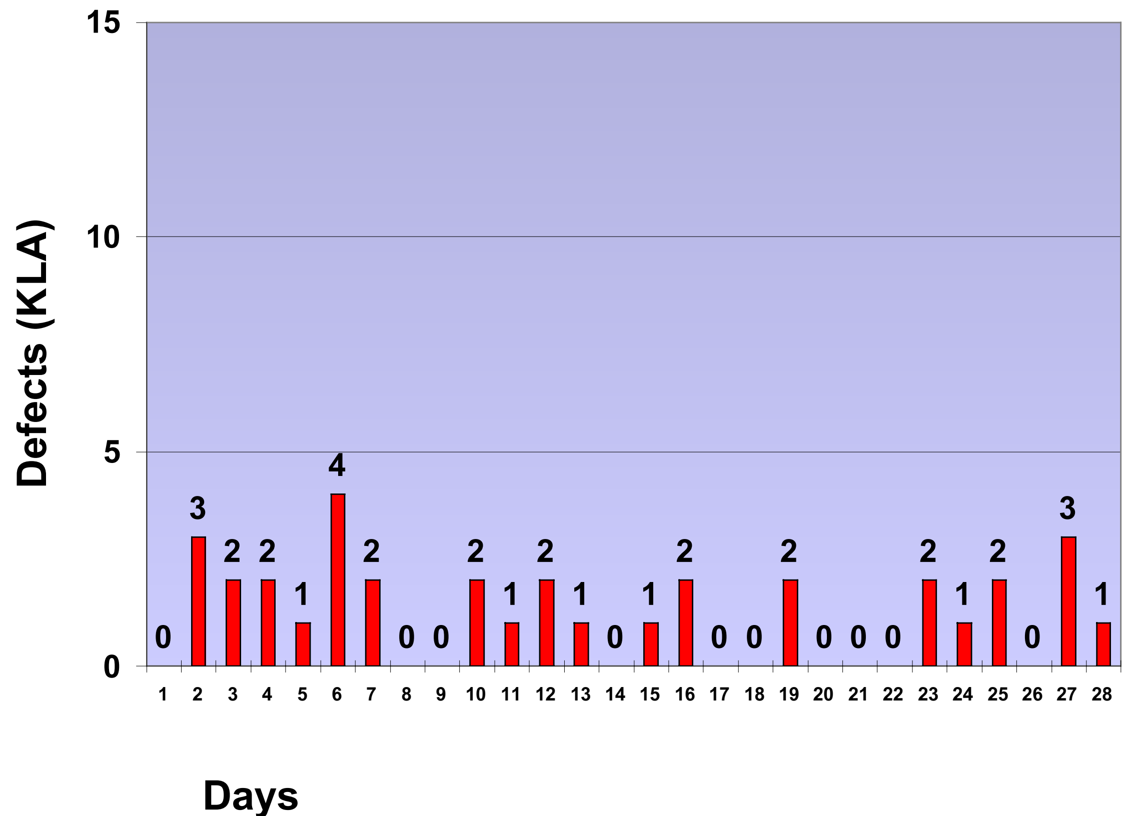


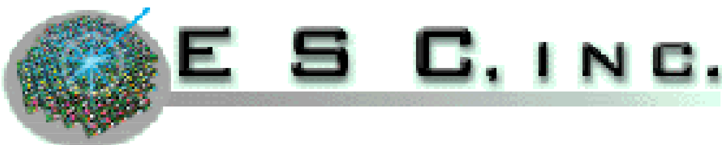
- ESC 784 shows better particle removal performance without mechanical assistance
- ESC 784 shows slightly better particle removal performance in scrubber process
- ESC 784 shows significantly better Cu contamination removal performance



Applied MIRRA MESA Data

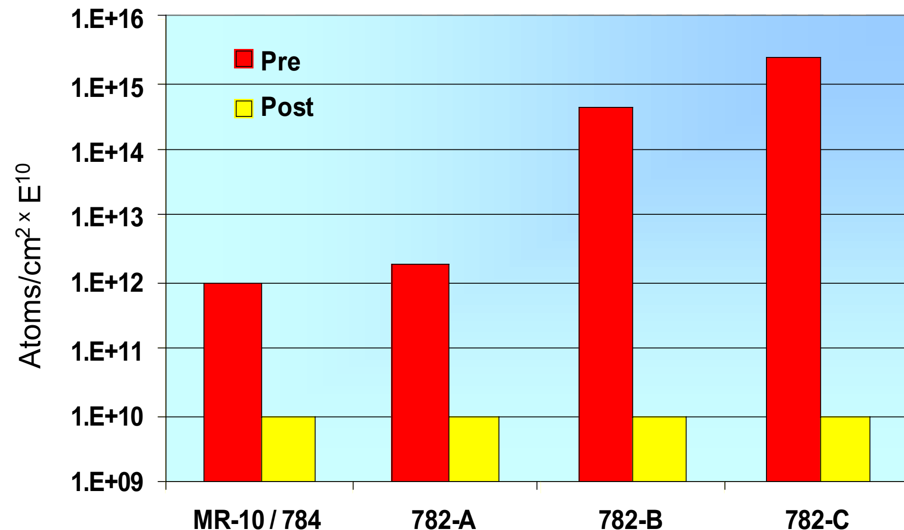
- Customer SPC data
- Patterned wafer tested daily for particle defects
- One-chemical clean with 784 only on brushes in Mesa cleaner

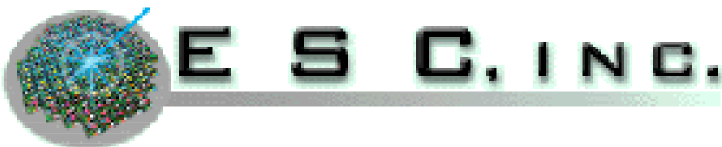




Preliminary Data on Modified Formulation

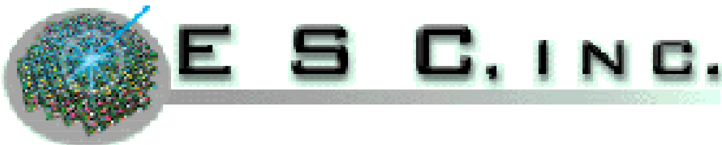
- TEOS wafer contaminated with CuCl solution
- 782 is 784 with chelating agent added
- Encouraging preliminary results
- Further testing of product wafers scheduled





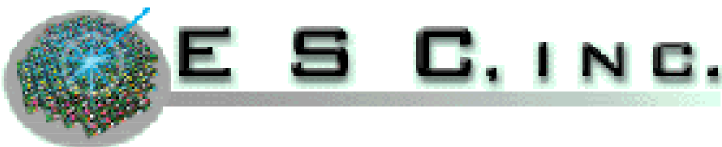
BTA Removal

- **BTA is typically used between the polish process and the cleaning step.**
- **Removal is desired to prevent defects and increase electrical resistance.**
- **High pH cleaning chemistries can remove BTA more readily than low pH chemistries**
- **XPS data demonstrates this**



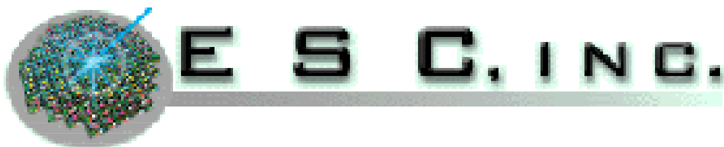
CMP Equipment Performance

- Contact Cleaning
  - Double-sided scrubbers
  - “Disk-type” scrubbers
- Non-Contact Cleaning
  - Single wafer megasonics
  - Batch megasonics
- Single-pass chemistry is typical
- Ambient temperature operation
- No particle brush loading in scrubbers
- Megasonic performance enhancement for particle removal



CMP Equipment Supplier Experience

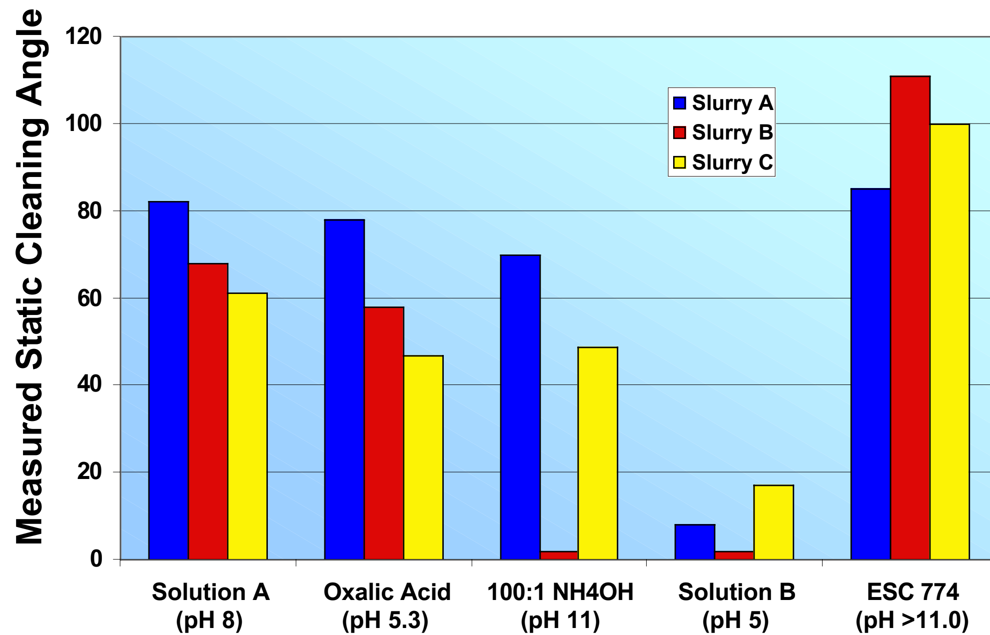
- **AMAT Mirra Mesa**
- **Lam TERES**
- **IPEC/Speed-Fam 776**
- **Ebara**
- **Verteq Goldfinger**
- **Verteq Cobra VcS**
- **DNS AS2000**
- **Ontrak DSS/Synergy**
- **FSI Mercury**
- **SSEC Scrubber**



Megasonic Cleaning Enhancement

Static Cleaning Angle Test

Verteq Goldfinger Megasonic System



Contaminated Wafer

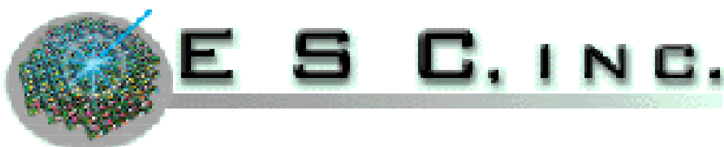
Goldfinger Megasonic Transducer

Wafer is cleaned with megasonics and chemistry without wafer rotation

Area not cleaned by chemical and megasonic energy

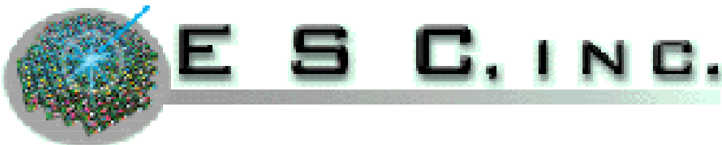
Area cleaned by chemical and megasonic energy

Static Angle



Cost of Ownership

- 20:1 to 40:1 dilution
  - 10 - 30 ml of concentrate per wafer
- No particle loading in brushes
- Easily rinsed with DI water
- 30-45 sec chemical process time can be performed in a single station with excellent results
- Reduced waste treatment cost compared to fluorinated chemistries



CMP Cleaning Summary

- Cleaning performance and cleaning process dependent on polish process and cleaning tool
- Excellent particle removal performance
- Good Cu contamination removal with excellent Cu compatibility
- 1-step process is possible to replace 2-step process and its defect and yield issues
- Successfully used with variety of process equipment
- Low cost of ownership