CLEAN-RENEWABLE-GREEN

# *Nano Green Technology, Inc.*

## Critical Cleaning Systems

## Disruptive Cleaning Technology For Silicon Wafers, Devices & Masks

An Ultra-Dilute to Near-Zero Ammonia Process for Particle Removal

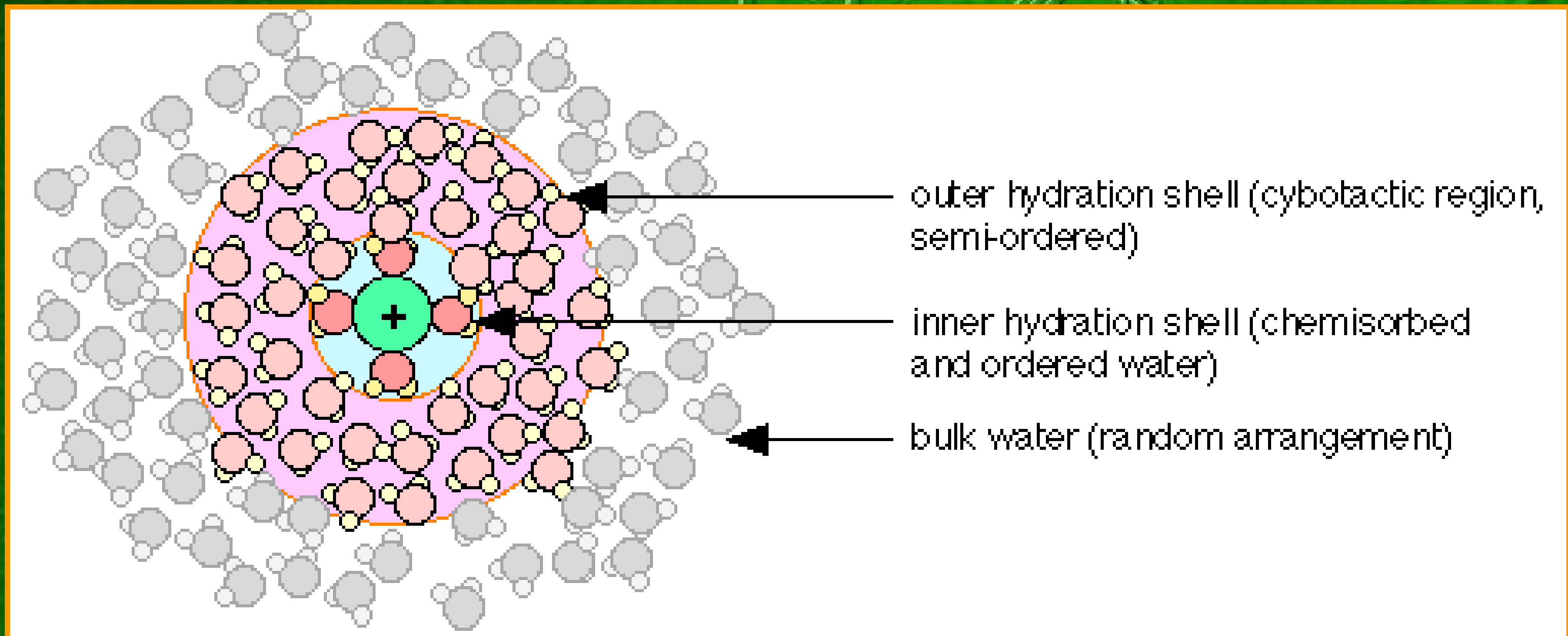
# Agenda

- The Problem:
  - Damage to devices due to megasonic energy.
  - Damage to devices due to etching.
  - Ineffective removal of particles below 45nm.
- The Solution:
  - No Megasonic required due to highly energized clusters.
  - No loss of topography because there is no reaction with native oxide.
  - No physical limitation in removable particles sizes 45nm and below.
- Technology Highlight
- Production Evaluation Results

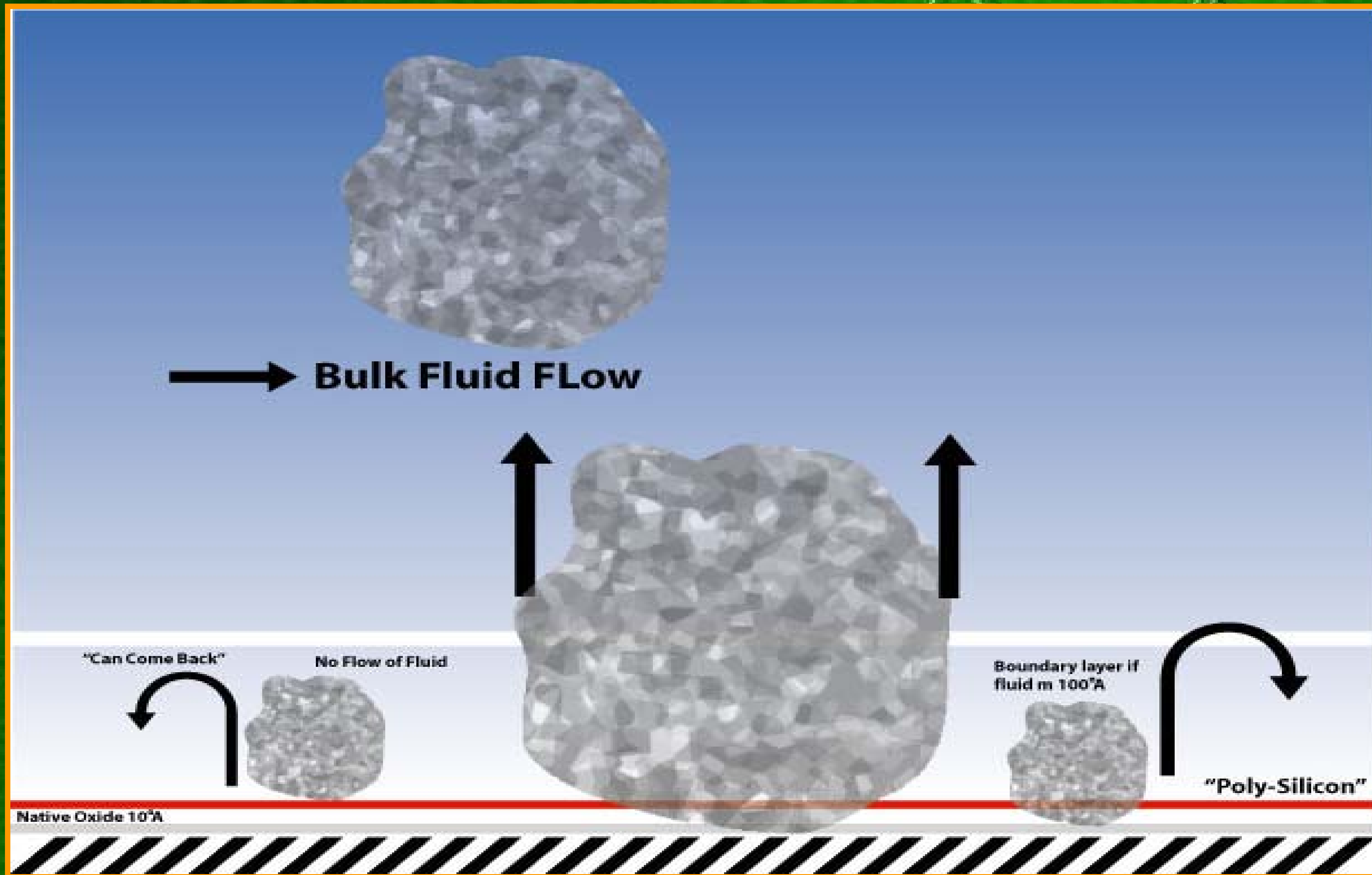
# Clustered Water Formation – iMACS

**(ionized Molecular Activated Coherent Solution)**

- **Well established fact in the research community**

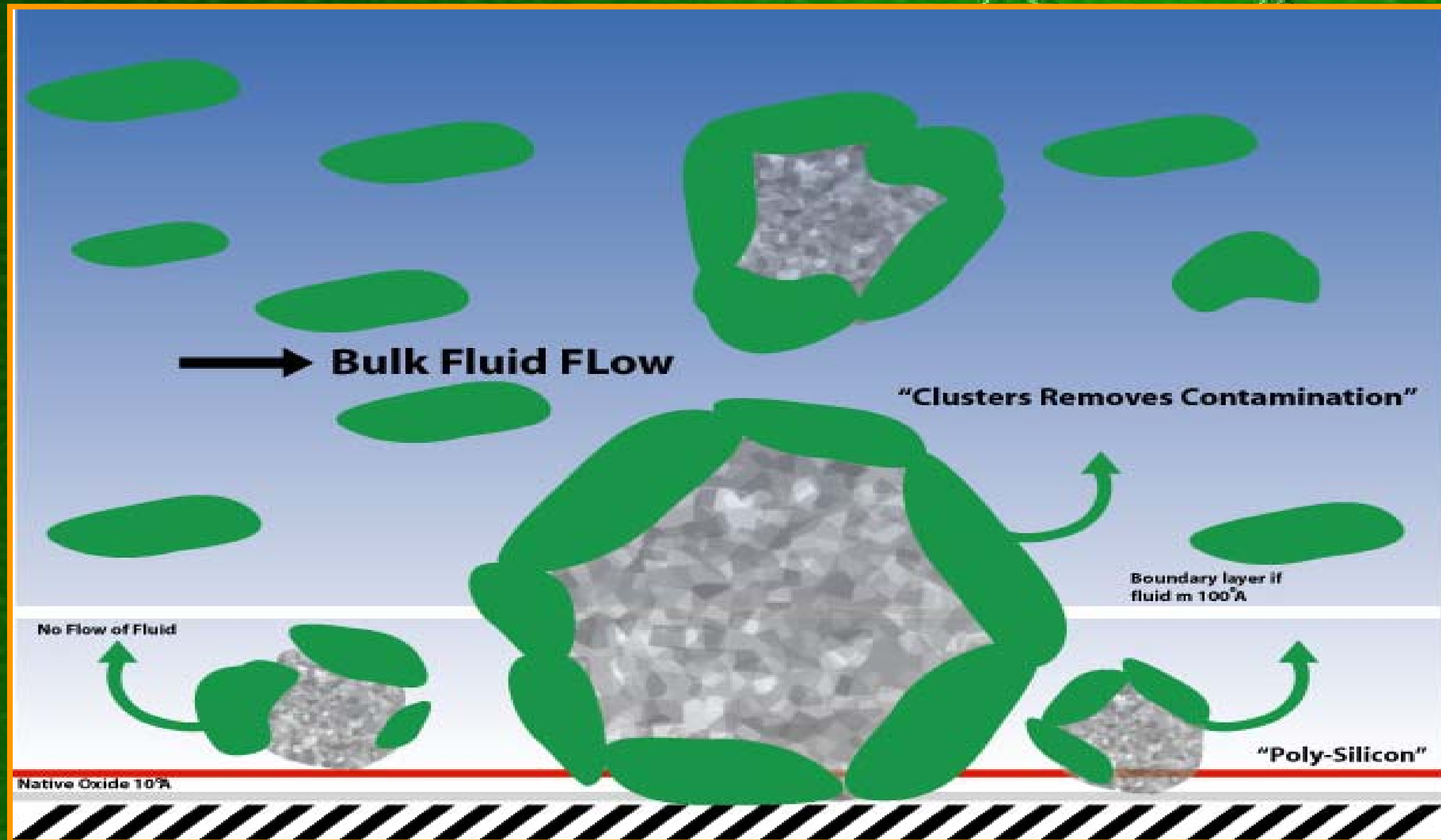


# SC1 Legacy Cleaning Process




**Current cleaning method RELIES ON ETCHING, which causes SURFACE ROUGNENING**

# NGT – ETCH-FREE MEGASONIC CLEANING




*No Surface roughness*
*No loss of topography*
*No re-deposition of particles*

# NGT's Plug and Play Design

- Integrate with and apply this technology to ANY tool platforms--for ALL types of cleaning applications

BATCH

CCS-1000
Will integrate to Batch or SWP

SWP

RCA Clean
Post BOE
Pre Sacrificial Oxide
Pre Poly Gate
Post Metal
Gate Oxide

Pre Metal Etch
Poly Gate
Pre Photoresist
Post CMP
Pre Diffusion

# *Key Advantages and Benefits*

## Problem—Critical Cleaning

- Damage to devices due to megasonic energy.
- Damage to devices due to etching.
- Ineffective removal of Nano particles below 45nm.
- Expensive chemicals costs.
- Bulk fill and handling.
- Volatile organic compounds.
- High-waste treatment costs.
- Metal contamination is added.

## Solution—NGT Processing

- No Megasonic due to highly energized clusters.
- No loss of topography because there is no reaction with native oxide.
- No chemicals—virtually.
- No special handling costs.
- No bulk fill.
- No VOCs are generated.
- No waste treatment.
- No metallic ions added during NGT's process.
- Cleans surfaces at the molecular level.
- No physical limitation to size of particle due to molecular level clusters.

# Surface Preparation Cleaning Conference
# Presented by Sematech – SPCC

# INDUSTRY CHALLENGES

## April 24 - 26, 2007
## Austin Texas, USA

# Driving Force: Cleaning Beyond 65nm

- As the semiconductor industry develops processes for the 65nm, 45nm and 32nm nodes, wafer cleaning faces new challenges for both FEOL and BEOL:
  - fragile device structures and materials
  - stringent requirements for cleanliness and material loss
- Current "etching" cleaning methodology causes pattern damage and excessive material loss.
- Not environment friendly.

# Historical Approach

- Particle removal by SC1 + Meg.
  - >Surface etching to undercut particles
  - >Megasonic energy to detach particles

**RESULTS -**

- **Leads to oxide and silicon loss**
- **Associated with pattern damage**

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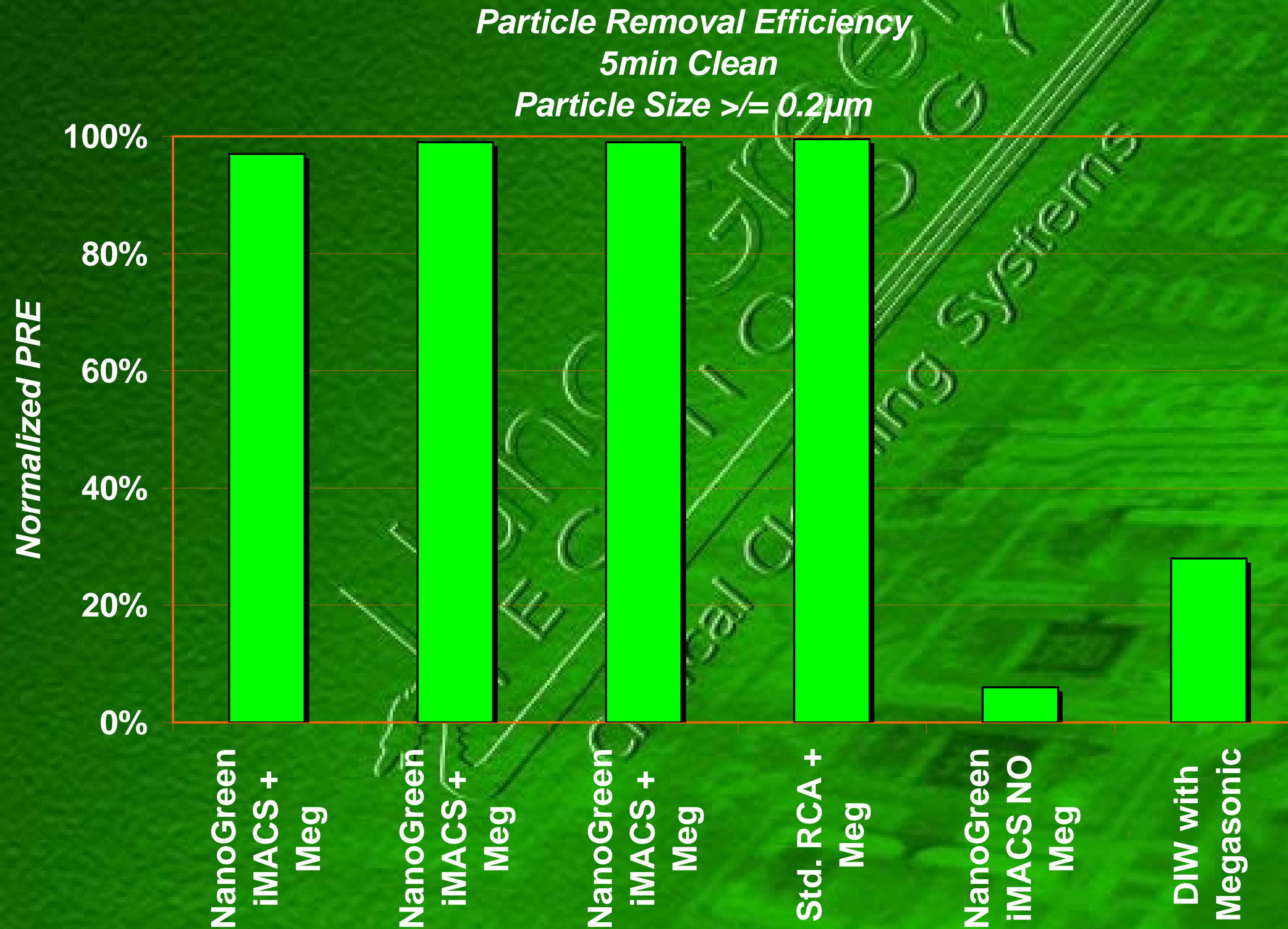
# SPCC 2007 Roadmap & Challenges

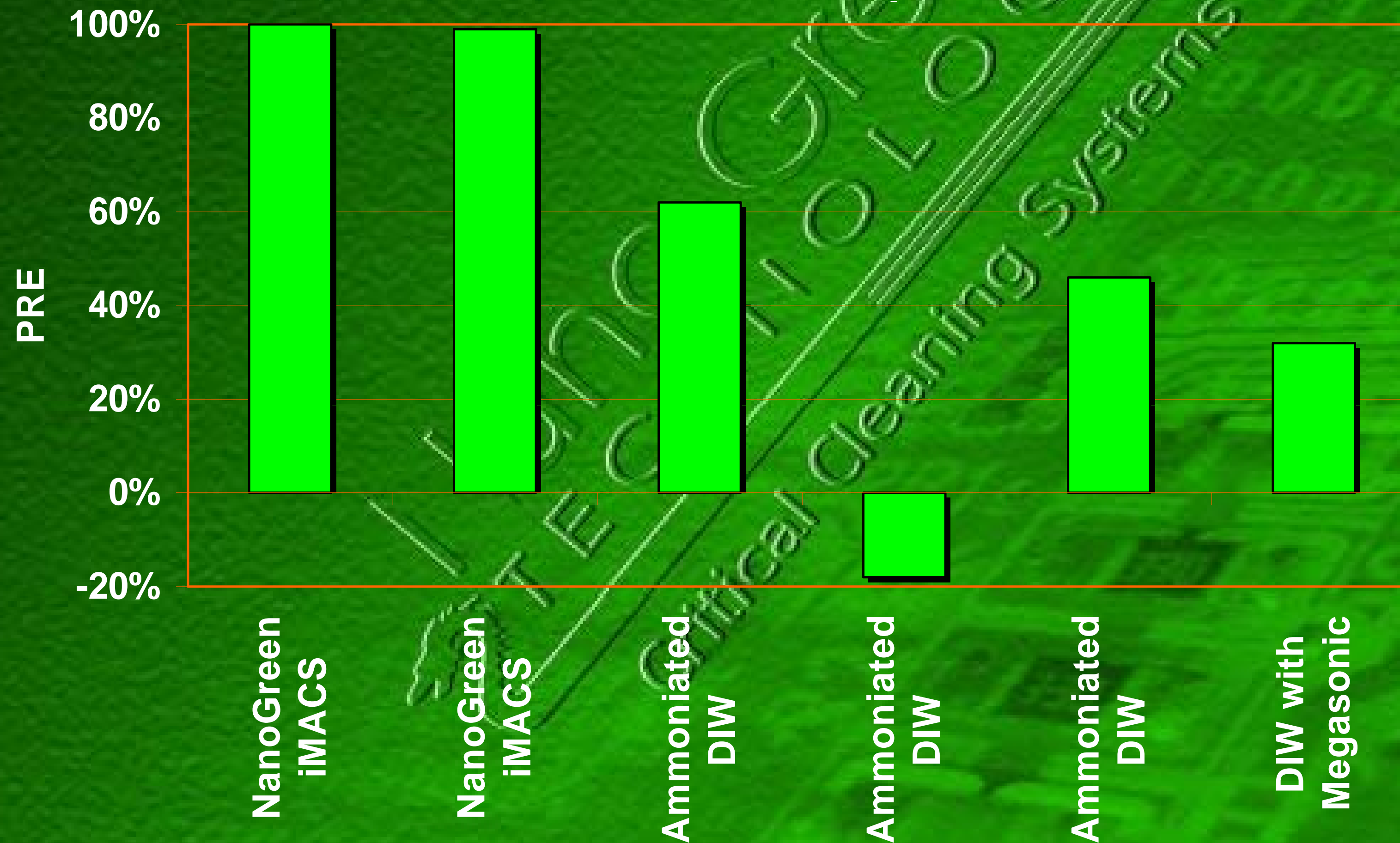
| | YEAR | | | | | | |
|---|---|---|---|---|---|---|---|
| Critical Particle | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
| Diameter (nm) | 31.8 | 28.4 | 25.3 | 22.5 | 20.1 | 17.9 | 15.9 |
| Count | 75.2 | 94.8 | 59.7 | 75.2 | 214.8 | 135.3 | 170.4 |

- Achieving low counts with small diameter particles
  - >Without significant oxide or silicon loss.
  - >With minimum surface roughness .
  - >Measuring below 25nm on bare silicon not yet possible.
  - >Very little published experimental data correlating small particles on circuit performance.

# Results: Particle Removal Efficiency @ >0.2nm NGT + Meg Vs. SC1 + Meg



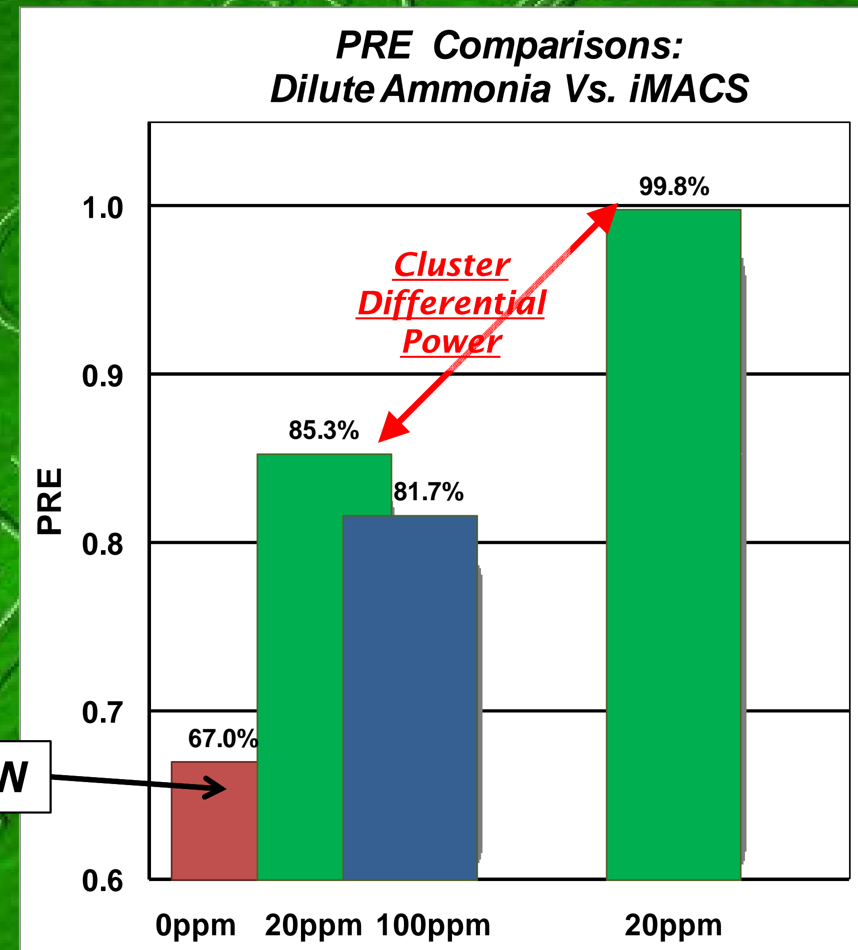
# Particle Removal Efficiency (PRE)



# "Cluster Differential Power" @ 37nm

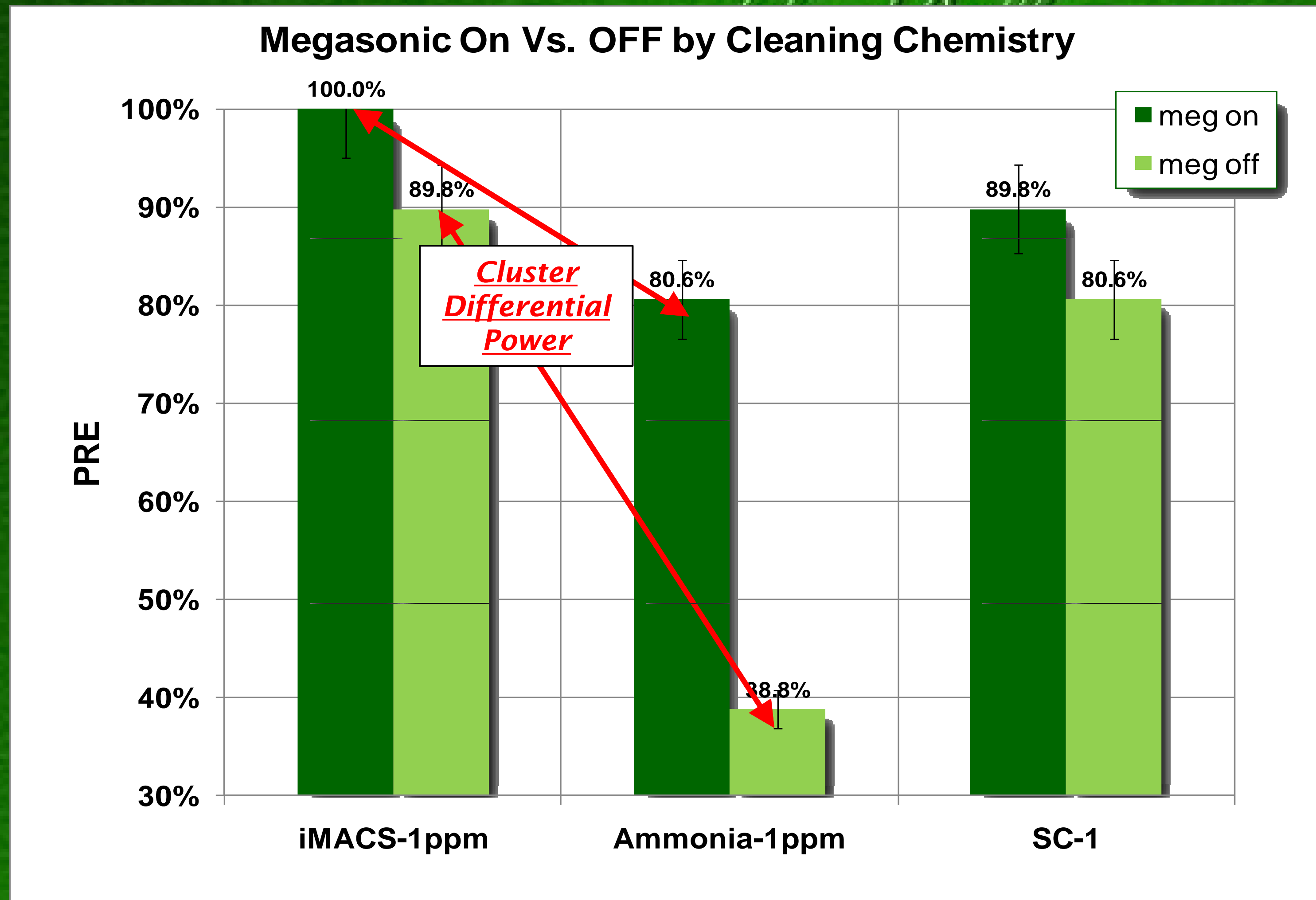
- Three groups are compared:
  - Dilute Ammonia WITHOUT iMACS "clusters"
  - Dilute Ammonia WITH iMACS "clusters"
  - Plain DIW
- All were cleaned with megasonic @50C for 3min.

***NGT'S IMACS HAS BEEN ABLE TO CLOSE THE GAP IN REACHING 100% PRE***



# Mask PRE of iMACS Vs. Ammonia Vs. SC1 - Meg ON Vs. OFF @ 43nm

***Purpose:** Evaluate PRE comparing chemistry with Megasonic **ON or OFF***



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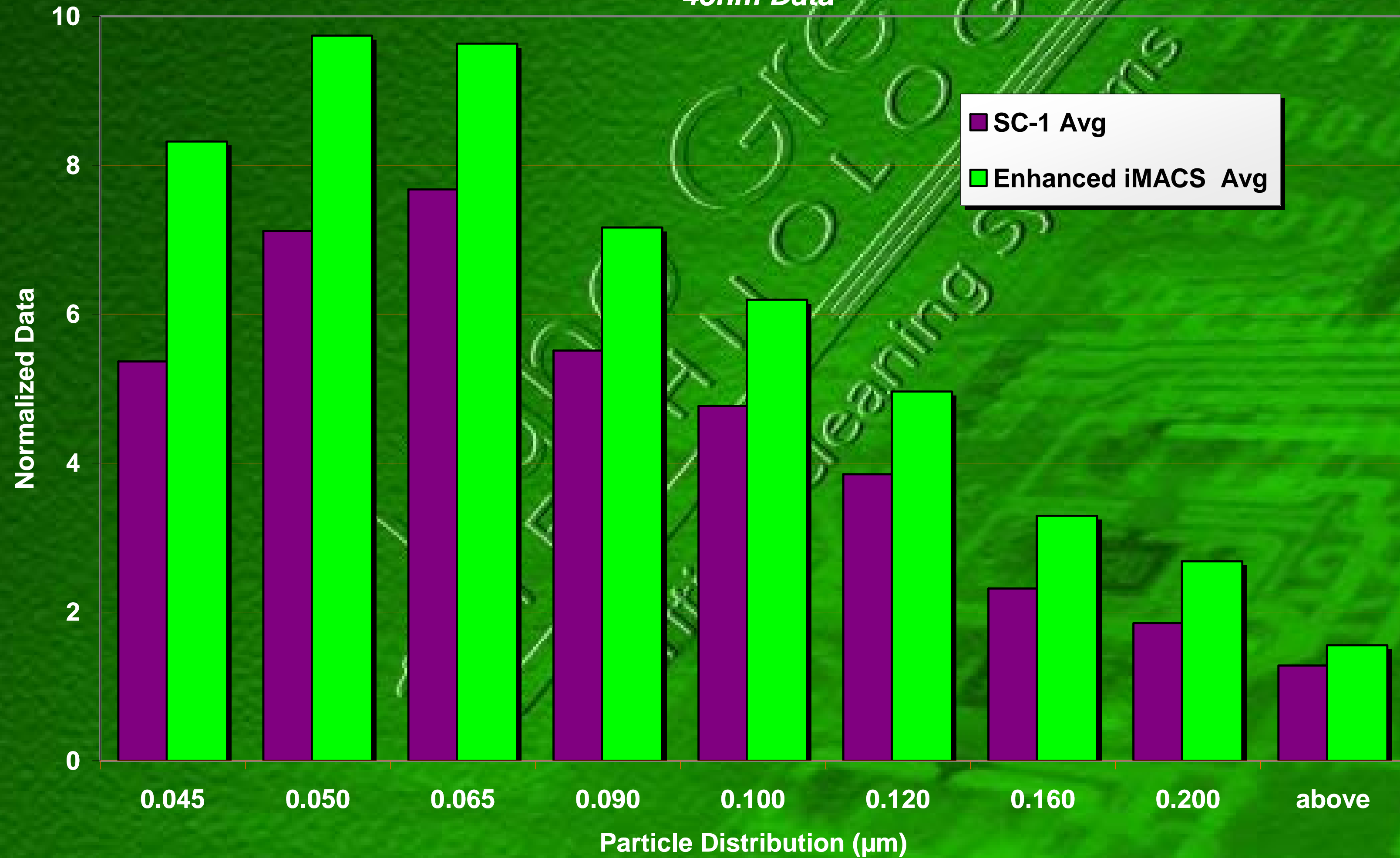
# PRE Comparison iMACS™ with POR

# NGT 's Process Optimization Breakthrough 300mm/45nm



# Fundamental Technology Difference

## Legacy Approach (Newtonian Physics)

- Leads to oxide and silicon loss
- Associated with pattern damage
- 100% PRE

## NGT Solution (Quantum Electro Dynamics)

- NO Device Damage
- NO surface etching
- NO LOSS of topography because there is no reaction with native oxide
- 100% PRE

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# Technology Recap

- NO cleaning solution for future geometries below 45nm.
- Current cleaning chemistry is simply not good enough cleaner.
- Current concentrated cleaning solution are not as effective – as they cause significant device damage and require additional steps to remove heavy chemical buildup – driving down yield and productivity.
- Current concentrated cleaning solutions requires elaborate solutions for disposal.

# Conclusions:

- Recent breakthroughs have enabled NGT to fine tune the iMACS "cluster" formation to achieve a 10 fold increase in activation level.
- PRE improves with increased iMACS cluster activation levels.
- The ultra-high activation levels achieved, have made it possible to eliminate the megasonic in the cleaning process.

***iMACS clusters are POWERFUL and ESSENTIAL choices NOW for the Semiconductor industry to lead the way for a REVOLUTIONARY GREEN dynamic cleaning process .***

Solid State Green TECHNOLOGY Critical Cleaning Systems