Measurement Techniques to Characterize an Ultrasonic or Megasonic Cleaning System

UIA Symposium, Orlando, FL

0NDA Corporation
www.ondacorp.com

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Ultrasonic Cleaning Market

- 1930’s - RCA discovers ultrasound can clean
- 1950’s - commercialization of ultrasonic cleaner
- Cleaning Tank Install Base – “hundreds of thousands”
- Market Segments
  - Precision: semiconductors, disk drives, LEDs, flat panel displays, solar, mobile, or other electronic devices, medical.
  - General: jewelry, food, aerospace, automotive, other industrial components
- Search for a reliable measurement technique has existed for decades … and continues today.
Connecting Ultrasound with Cleaning

Process Variables
- Ultrasound
  - Gas concentration
  - Chemistry
  - Mechanical
  - Temperature
  - Flow rate
  - Process Time

Metrology Requirements
- Acoustic Uniformity
- Acoustic Amplitude
- Frequency

Yield Impact
- Particle Removal Efficiency
- Damage Control
Developing the Process Window

Cleaning Efficiency

Acoustic Parameter

Process Window

Acoustic pressure (kPa)

Level of Damage

Low

High

Cleaning Efficiency

PRE (%)
“The most important process parameter driving the development of megasonic technologies is the need to provide a more uniform acoustic field in which the substrate is processed.”

- Prosys Systems
What is the ideal metrology?

- Meaningful
- Able to detect changes
- Trust-worthy
- Tool Matching
- Simple to Use
- Fast
- Affordable
## Scorecard

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Optical Defect Inspection

Measurement Principle:
• Scattered light

Unit of Measure(s):
• Defect map
• # of defects
• Particle size
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Aluminum Foil Test

Measurement Principle:
• Erosion of Aluminum

Unit of Measure(s):
• Visual erosion pattern
Ceramic Ring Test

Measurement Principle:
• Erosion of graphite on ceramic ring

Unit of Measure(s):
• Visual inspection of color change
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Sonoluminescence

Measurement Principle:
• Detecting photons as byproduct of cavitation

Unit of Measure(s):
• Photon count / seconds

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ONDA Confidential
Hydrophone Measurement

Measurement Principle:
• Piezoelectric transducer converts sound pressure into electrical signal

Unit of Measure(s):
• Voltage (time)
Cleaning Tank Probes
Hydrophone Measurement

[Not to scale]
Acoustic Maps from Hydrophones

Comparing Two Cleaning Systems, $f = 850 \text{ kHz}$

**System #1**
- Mean Pressure: 174 kPa
- Uniformity: 171%

**System #2**
- Mean Pressure: 184 kPa
- Uniformity: 23%
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Hydrophone Measurement

Ultrasonic or Megasonic Cleaning Tank

Cleaning Tank Hydrophone

HCT

MCT Meter

Computer

Scanning

[ Not to scale ]
Automating Hydrophone Measurement

Cleaning Tank Hydrophone

Ultrasonic or Megasonic Cleaning Tank

HCT

Scanning

MCT Meter

Computer

Software

[ Not to scale ]
Automated Scanning for Precision Cleaning

HCT Hydrophone

CTS Scanner (under development)
CTS Scanner

- X, Y, Z scanner mounted onto wafer carrier
- Scanner compatible with HCT hydrophone and MCT meter
- Full software control
- Designed to be able to measure “loaded” systems
A short demonstration...
Mapping Acoustic Distribution

Uniformity = 55%

Uniformity = 68%

Uniformity = 34%

Batch System

f = 40 kHz
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Closing Remarks

• Connection between ultrasound and cleaning performance continues to be explored

• Complexity in wet clean processes requires acoustic control to maximize cleaning efficiency and limit damage

• Various measurement techniques available; still, the need for standardization exists

• Hydrophone measurements with automated scanning offers a quantitative and systematic approach
BACKUP
Megasonic Sweeping (Crest Subsidiary)

**Hydrophone Results**

**Defect Maps**
Sonoluminescence

Physics Today: Mar. 12, 2012, Seth Puttermann UCLA
Acoustic Pressure Uniformity

f = 970 kHz
HCT Accessories

- HCT Hydrophone
- MCT Acoustic Meter
- Data Logger (Redfish)
- Two 9 V Batteries
- Calibration Certificate
Wireless Data Logger

- Apple iPad with Redfish App
- Data Logger (Redfish)
- MCT Acoustic Meter
- HCT Hydrophone
Healthmark Sonocheck

Neat, but not quantitative…
Good Correlation: 
AI Foil Erosion and HCT Acoustic Plot
Comparing Various Configurations

40 kHz Batch System

(1) Tank Empty

(2) Empty Cassette

(3) Cassette with 14 Disks

% Std Dev = 43.5%

% Std Dev = 55.0%

% Std Dev = 46.1%

\[ \Sigma P_{rms} (2) = 0.7 \times \Sigma P_{rms} (1) \]

\[ \Sigma P_{rms} (3) = 0.3 \times \Sigma P_{rms} (1) \]