Characterization of Ultrasonic Ultra-High Purity Final Cleaning of Metal Oxide Plasma Coated Parts
Osama Khalil*, John Treviño, John Deem, David Zuck

Global Headquarters: Quakertown, PA, USA  ▲  Global Center for R&D: Phoenix, AZ, USA

Introduction
- Part and sub-component cleanliness for ultra-high purity semiconductor manufacturing tools is becoming increasingly critical for maximizing tool productivity and product yield.
- High volume manufacturers continue to redefine critical particle characteristics and contamination concentrations as technologies advance.
- Ultrasonic particle removal from metal oxide plasma coated parts is a focus area for improving chamber performance.
- Optimal ultrasonic parameters minimize substrate or coating damage, while removing process-affecting loosely or partially-adhered particles, leading to Atomically Clean Surface® through the QuantumClean Final Surface Finish™ process.

Experiment Overview
- The purpose of this study was to characterize the impacts of ultrasonic cleaning parameters such as: power, sub-component orientation, concentration, and water.
- Samples for this experiment were prepared using various common substrates with QuantumClean® coatings including:
  - C-Coat™
  - M-Coat™
  - Z-Coat™
  - White Yttria
- Particle behavior was traced with an in-line liquid particle counter (LPC).
- Particle behavior can be modeled and controlled by applying experimental data to a model derived to describe particle behavior (y) in a flowing rinse tank as a function of ultrasonic power (u) as:

\[\frac{dy}{dt} = \frac{2\sqrt[3]{T_d}}{T_{0.8}^{2/3}} + \frac{y}{K} \left( \frac{du}{u} + \frac{u}{K} \right)\]
- A microscope was used to demonstrate the change of surface morphology as the result of ultrasonic processing.

Results

Particle Generation by Power Input
Finely tuning ultrasonic power input to maximize loose particle removal and minimize substrate impact is critical to attaining improved chamber performance by reducing risk of particle shedding in the chamber.

Particle Generation by Part Orientation
Orienting samples at varied angles relative to the transducers affects steady-state particle generation.

Surface Damage by Power
A time-variant finite element simulation of particle trajectories within the flowing fluid space of an ultrasonic rinse tank.

Model-Based Design
- A full characterization of ultrasonication for final parts cleaning goes beyond particle removal dynamics.
- The figures below show two examples of QuantumClean’s use of model-based characterization and design.
- Experiment and model driven design enable QuantumClean to develop optimized ultrasonic equipment for robust particle removal.

Conclusion
Final Surface Finish™ (FSF™) is the process most critical in parts cleaning for achieving Atomically Clean Surfaces® (ACS®) sub-10 nm manufacturing. The ultrasonic parameters that can remove the process-affecting loosely adhered and surface particles without damaging the substrate have been quantitatively determined. Through experiments such as this, and use of computer simulation-based design, QuantumClean® continues to broaden its technology leadership through full characterization and optimization of parts cleaning processes to critical to yield.

Contact
Author: Osama Khalil
osama.khalil@quantumclean.com
3235 S. Works Drive, Ste 1000 Phoenix AZ

References:

QuantumClean®
Advanced Technology Cleaning Centers®
United States
Asia & Europe
Tallahassee, FL
Phoenix, AZ
Tampa, FL
Glenrothes, UK
Glasgow, UK
San Jose, CA
CA
PA USA
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