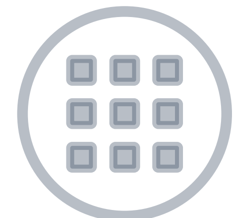
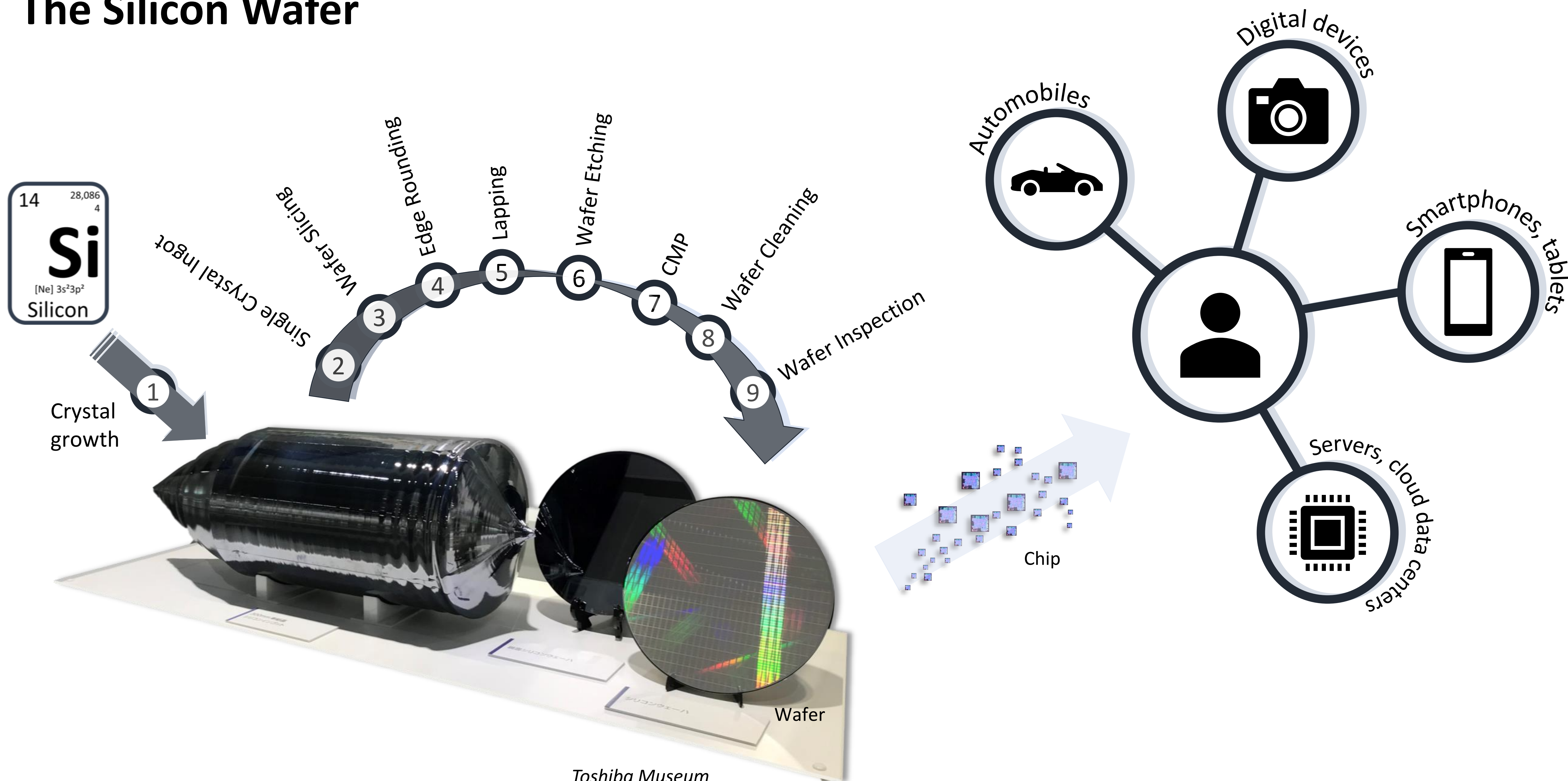
CHALLENGES FOR HIGH-FREQUENCY ULTRASONIC CLEANING SYSTEMS

EUROPEAN CMP USERS MEETING

NOVEMBER 2022



The Silicon Wafer



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KAIJO CORPORATION

KAIJO is a manufacturer of ultrasonic cleaning equipment.

Established	:	July 21, 1948
Location	:	Tokyo, Hamura-city (Headquarters) Nagano, Matsumoto-city (Factory)
Employees	:	293 (2022)
Paid-in Capital	:	JPY90M (USD$0.82M)
Parent Company	:	Shibuya Corporation
Main Business	:	Semiconductor Assembling Equipment, Ultrasonic Cleaning Equipment, OEM/ODM business.
Kaijo Shibuya Europe (KSE)	:	Wiesbaden, Germany (Established in October 2018)

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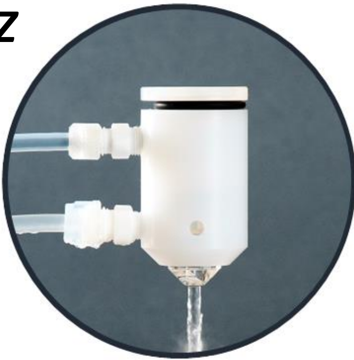
Ultrasonic Cleaning Equipment

- Specialized equipment for wafer cleaning after the polishing process

KAIJO
Supplies ultrasonic cleaning tools to CMP equipment manufacturers

CMP Equipment Maker, Japan

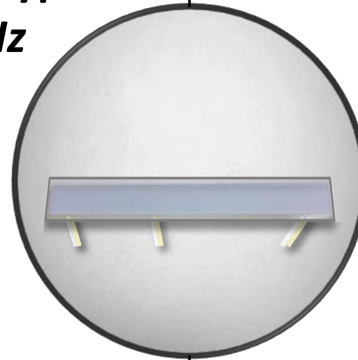
Shower Type
950*kHZ*



Worldwide Market

CMP Equipment Maker, USA

Plate Type
950*kHz*



Worldwide Market

CMP Equipment Makers, China

China Market

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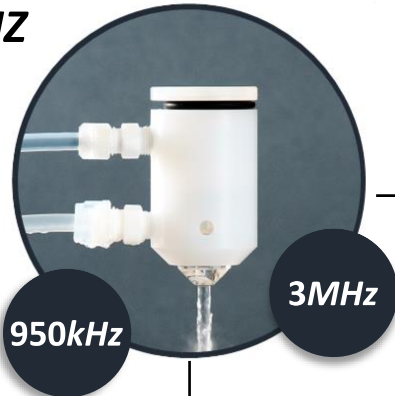

Worldwide Market

KAIJO QUAVA SPOT Shower

– Ultrasonic Cleaning Tool for a Single Wafer

Ultrasonic Generator

The ultrasonic energy passing through the DI water detaches the particles adhering at the wafer surface.

QUAVA SPOT Shower Transducer

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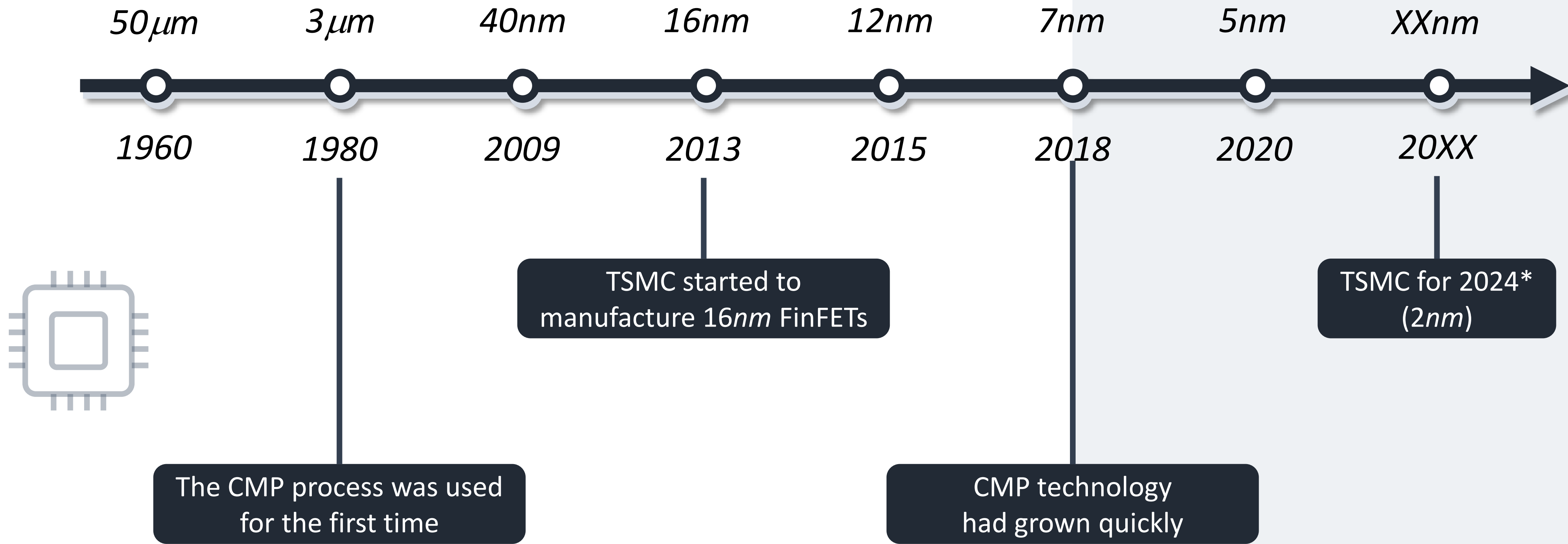
Technology Node Timeline

- Semiconductor lithography processes technology

- A more rigorous cleaning process is required from 7*nm* node



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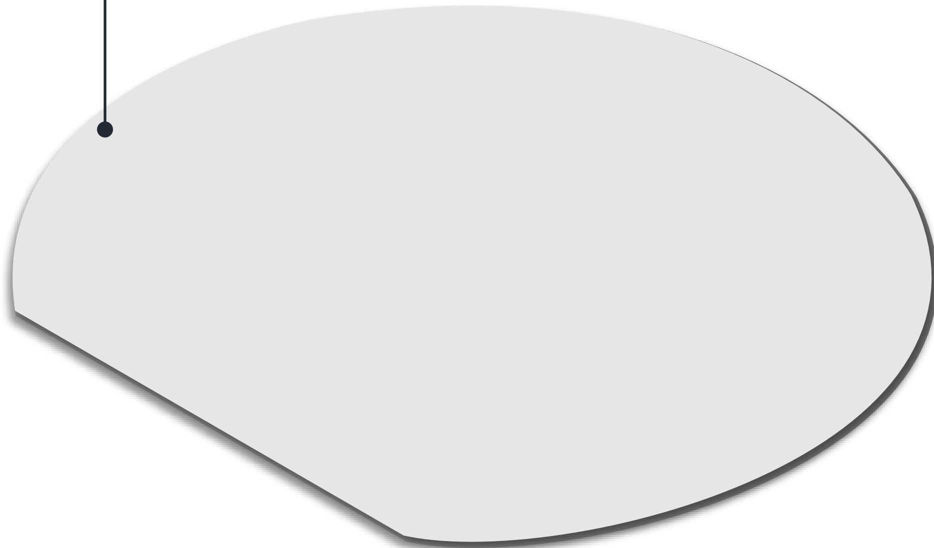
Silicon Wafer Particle Removal

1 Wafer



- CMP-induced defects caused by residual particles, foreign materials, scratches, corrosion, etc.
- Cleaning after CMP has become a crucial step in the process of wafer manufacturing to minimize defects such as residual particles, foreign materials, scratches and corrosion.
- Defects generated after the CMP process, especially particles on the wafer surface, can be removed with Megasonic cleaning.
- Megasonic cleaning removes particles on the wafer surface more effectively than chemical methods.

No defect generation

High-quality wafer output

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Ultrasonic Wafer Cleaning by Spot Shower

Equipment used

- QUAVA SPOT Shower Transducer.
- Ultrasonic output power of 30*W*.
- Working frequency of 950*KHz* and 3*MHz*.

Ultrasonic cleaning conditions

- Ultrasonic cleaning of bare wafer.
- Particles to be removed SiO_2 (≥80*nm*).
- Wafer spinning of 400*rpm.*
- DI water as cleaning liquid ($2^L/_{min}$).
- Cleaning time of 30s (6 sets of 5*s*).

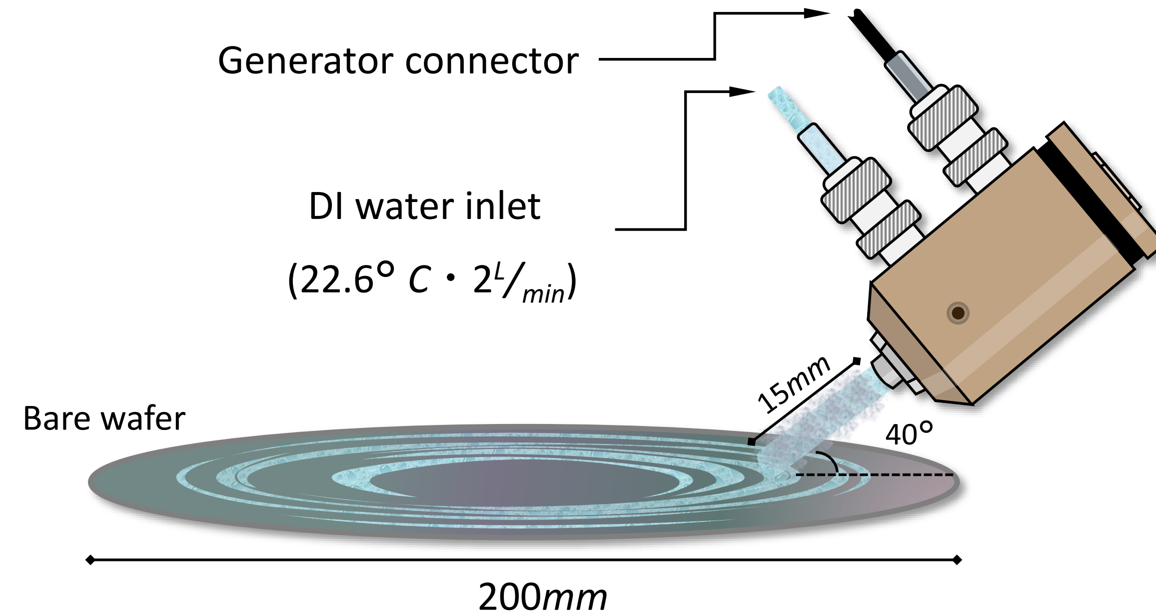
Particle Removal Efficiency

$$PRE(\%) = \frac{n_i - n_f}{n_i} \times 100$$

where

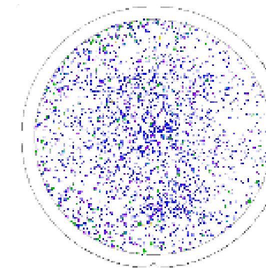
$$n = Number\ of\ particles$$
$$n_i = n_{After\ adding\ SiO_2} - n_{Before\ adding\ SiO_2}$$
$$n_f = n_{After\ ultrasonic\ cleaning} - n_{Before\ adding\ SiO_2}$$

Ultrasonic cleaning scheme

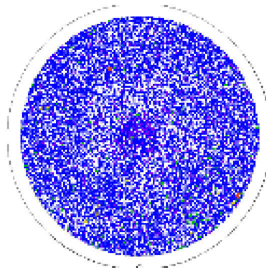


Ultrasonic cleaning results (MAP)

SPOT Shower
950*kHz*/30*W*
PRE of 90.4%



SPOT Shower
3*MHz*/30*W*
PRE of 24.5%



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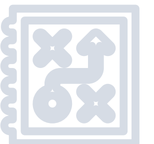
New Spot Shower Design

Parabolic Reflexional High Power (PRHP)
Ultrasonic Transducer

- Designed for high frequency cleaning
- High sound pressure
- Damage reduction

Challenge to efficiently remove nanoparticles without damaging the wafer surface



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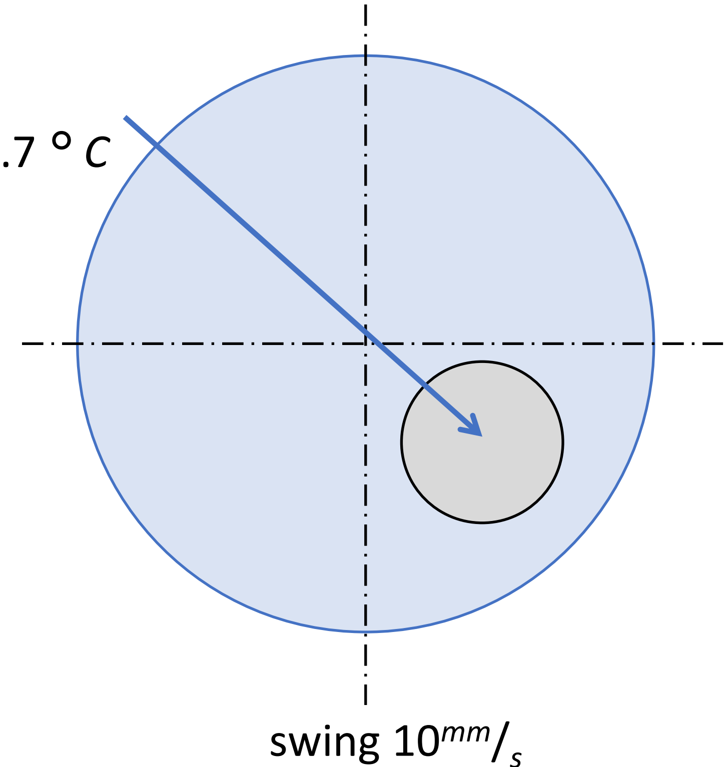
Ultrasonic Wafer Cleaning by PRHP

Equipment used

- Parabolic Reflexional High Power Transducer.
- Ultrasonic output power of 34.1W.
- Working frequency of 1.5MHz.

Ultrasonic cleaning conditions

- Ultrasonic cleaning of bare wafer.
- Wafer spin of 60rpm.
- DI water as cleaning liquid (1$^{L}/_{min}$).
- Cleaning time of 60s (6 sets of 10s).



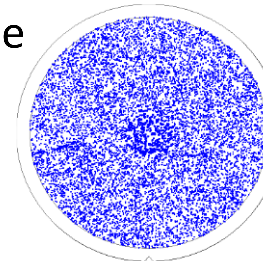
Particle Removal Efficiency

$$PRE(\%) = \frac{n_i - n_f}{n_i} \times 100$$

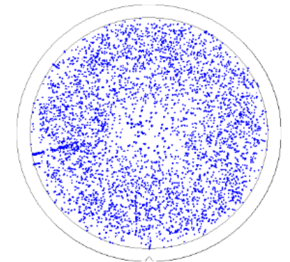
where

$$n \quad = Number\ of\ particles$$
$$n_i = n_{After\ adding\ SiO_2} - n_{Before\ adding\ SiO_2}$$
$$n_f = n_{After\ ultrasonic\ cleaning} - n_{Before\ adding\ SiO_2}$$

Reference
Before
Cleaning



PRHP
1.5MHz/34.1W
PRE of 37%



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New Spot Shower development schedule

<u>September 2022</u>

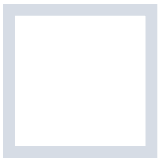
Complete preliminary tests and determine the basic construction of the transducer.

<u>December 2022</u>

Finalize the design of the transducer unit.

<u>March 2023</u>

Complete development and accumulate evaluation data for sales promotion.



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