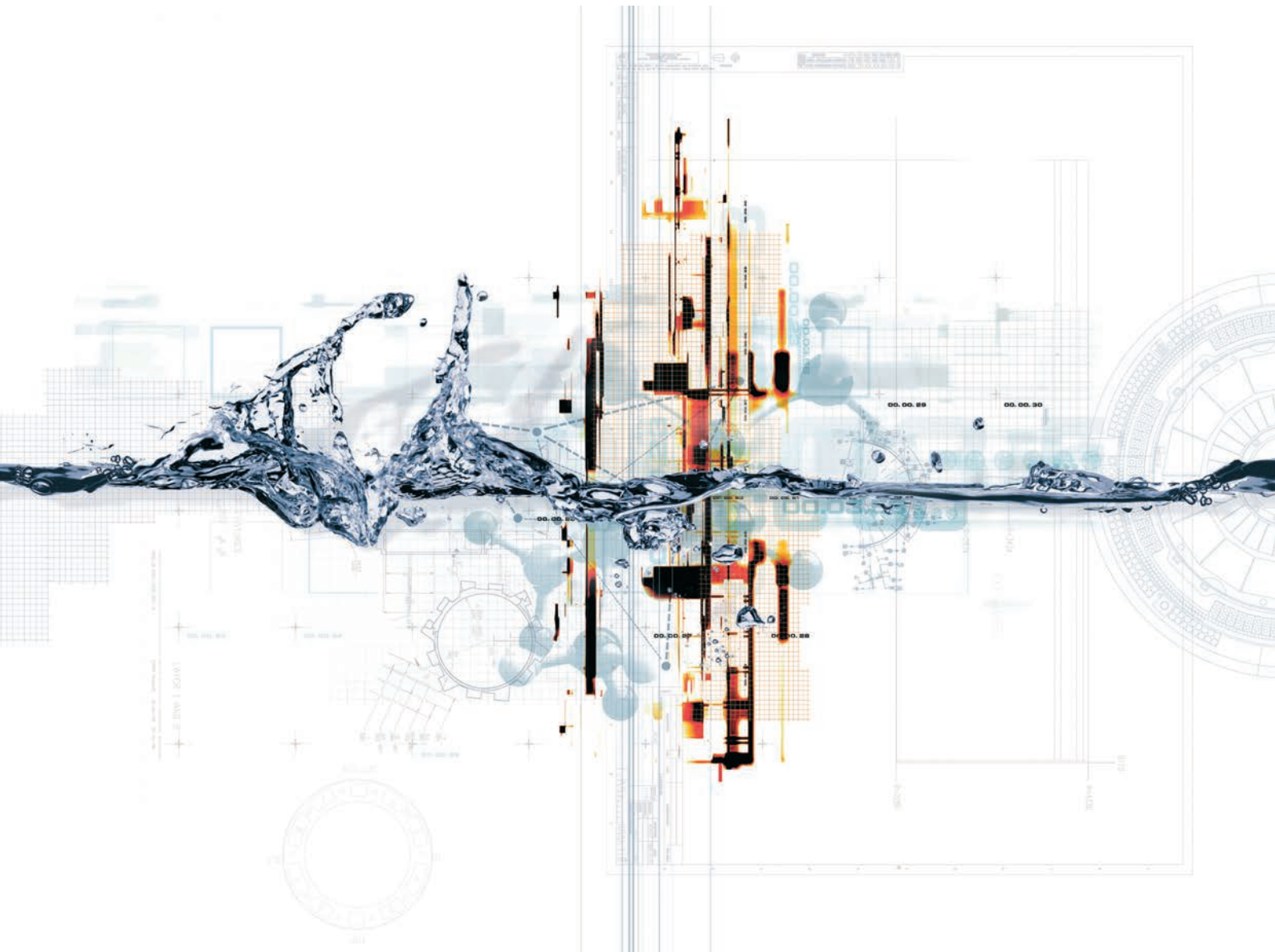


»Future Technology by SONOSYS® –
Efficient Megasonic Cleaning of Microstructures«

»High frequency Ultrasonic Cleaning Systems
determine the future«





The Origin

... this is the story of a terrific idea

SONOSYS® was founded 1995 by Johann Brunner and Joachim Straka.

Through development processes that took a huge amount of effort, they achieved solutions setting new standards to the world market. The production of modular, high-quality Megasonic Systems according to German and European standards could now start. After just a short time, Megasonic Systems were designed for LIGA Technology in cooperation with the Karlsruhe Institute of Technology (KIT - IMT) and shipped worldwide.

SONOSYS® is the first European company in the global market to provide ultrasonic cleaning systems in the frequency range from 400 kHz to 5 MHz. After all, **SONOSYS®** is a company with many years of experience and know-how in the development, production and sales of innovative technologies.

A merging of energies made it possible to reach a leading position.

This specialist company, which commits all its strengths and abilities, offers top performance.

The most important objective of **SONOSYS®** is always to offer the customer the maximum benefit.

SONOSYS® deploys its abilities with a precision that has no competition, to solve the problems and satisfy the requirements of its customers. For **SONOSYS®**, the continuously changing requirements and technical frame conditions mean continuous performance improvement.

»Mastering *microClean* together« is the guiding motto of **SONOSYS®**. The existing strengths are merged in close partnerships and complementary abilities are converted into synergistic benefit.

The result is the most compact megasonic generator and patented transducers in the world with a unique design. **SONOSYS®** has mastered, like no other company, the manufacture of high-frequency ultrasonic systems.

Reliable – with the after-sales service that one wishes for.

Standards – for every special solution and every technology



Performance optimization, hand-in-hand

It is not accidental that we are the first European company in the global market to provide ultrasonic cleaning systems in the frequency range from 400 kHz to 5 MHz. After all, **SONOSYS®** is a company with more than 20 years of experience and know-how in the development, production and sales of innovative technologies. Special competencies and synergies result from the close cooperation between our own research and development laboratory and world-renowned institutes and facilities like the Fraunhofer Gesellschaft, the IMEC in Belgium, the Otto-von-Guericke University Magdeburg (IMOS), the Karlsruhe Institute of Technology (KIT - IMT) and CSIRO Australia. This is a decisive contributory factor to our solutions in the area of ultrasonic systems being not just state-of-the-art, but also forward-looking.

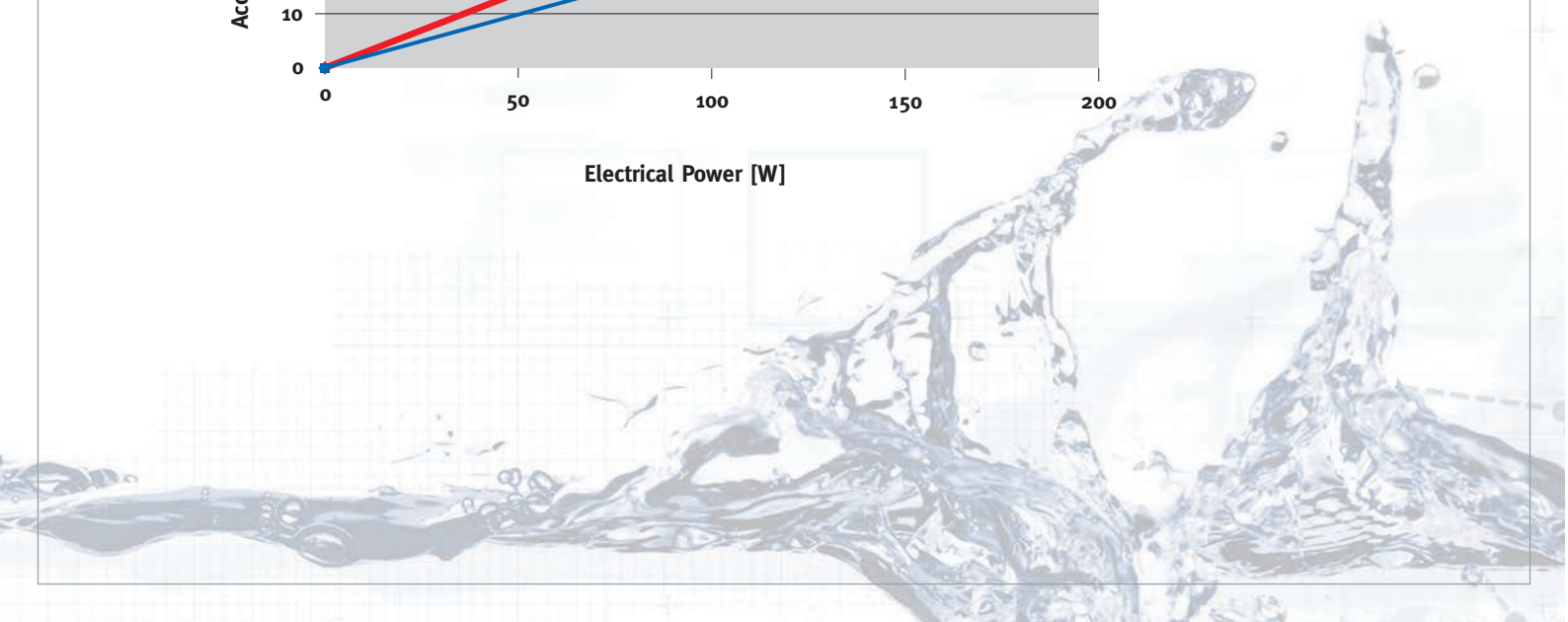
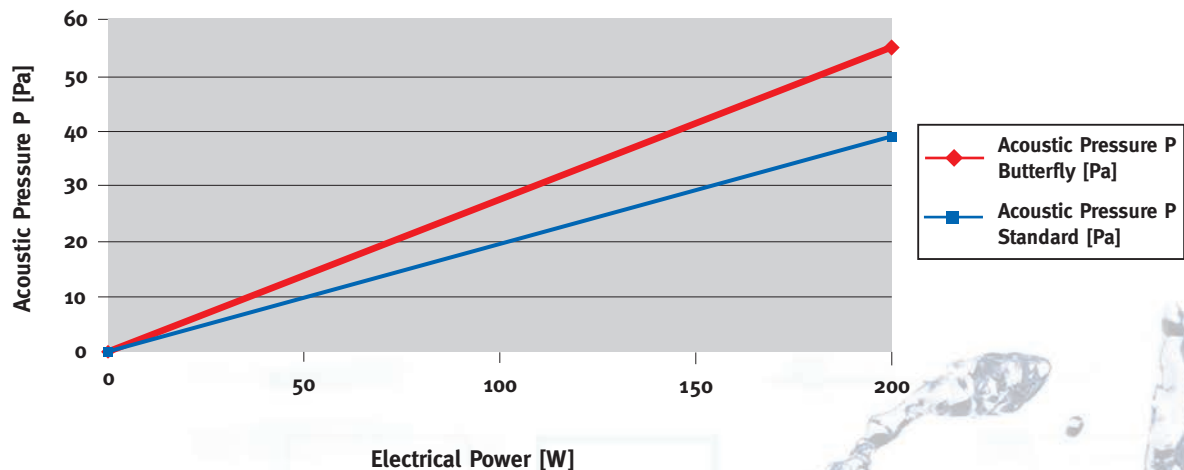


»Inside Sonosys« means: up to 30% more efficiency with patented Transducers

All over the world, **SONOSYS®** stands for unique and future-secured solutions. This particularly holds good for our Megasonic systems in the frequency range from 1 MHz.

The extremely uniform energy transmission ensures a so far unachieved cleaning performance, while at the same time providing the best protection to the microstructures. Unique in the world: our transducer systems, with patented piezo-ceramics, achieve a 40% higher sound pressure or an up to 30% higher efficiency.

Acoustic pressure „standard“ piezo ceramic versus „Butterfly“ technology





Ex-factory efficiency

Greatest possible flexibility, shorter process times, high performance. These are the important requirements that customers expect us to fulfill. It is precisely in this area that we offer efficient systems from a single source. Thus, in the development of the **SONOSYS**[®] Megasonic systems, our focus is not only on the maximum possible compactness of the generators or the total system. The unique modular design of our solutions is also a decisive factor. **SONOSYS**[®] Megasonic Systems are designed to be compact, modular and efficient by their very nature.

Almost anything is possible

In the development of our Megasonic systems, we attach a great deal of importance to a dialog with you. Then, you know exactly what results you expect. And we know exactly what is technically feasible. Your benefits: From **SONOSYS**[®], you will get state-of-the-art system solutions that are developed specifically customized according to your ideas, requirements and particular area of use. Other services for increasing your efficiency:
Information management, know-how workshops as well as new business consultancy.

Integration with SONOSYS[®] - is just so simple

The simplest operation, highly compact construction and low installation cost and efforts guarantee a problem-free integration of our systems into your equipment and processes.

Modular, nearly maintenance-free and service-friendly

The high service-friendliness is the result of the modular construction of our Megasonic systems. All components are nearly maintenance-free. We can supply any electronics module at short notice and these modules can be replaced in a jiffy.



How does Megasonic cleaning work

The Megasonic-/ Ultrasonic Generator transforms the mains voltage of 50/60 Hz to a frequency corresponding to the operative frequency of the Transducer.

Piezoelectric transducers bonded on a plate outside of a tank produces high frequency sound waves that propagate through a liquid. Each point along the wave oscillates between a maximum and minimum pressure. When the pressure minimum is below the vapor pressure of the liquid, bubbles are formed in the liquid. When the pressure increases to maximum pressure, the bubbles implode, sending out an intense shockwave of energy as the fluid rushes in to fill the void left by the collapsed bubble. This energy is referred to as cavitation energy, and is well-suited for removing particles or contaminants from a substrate.

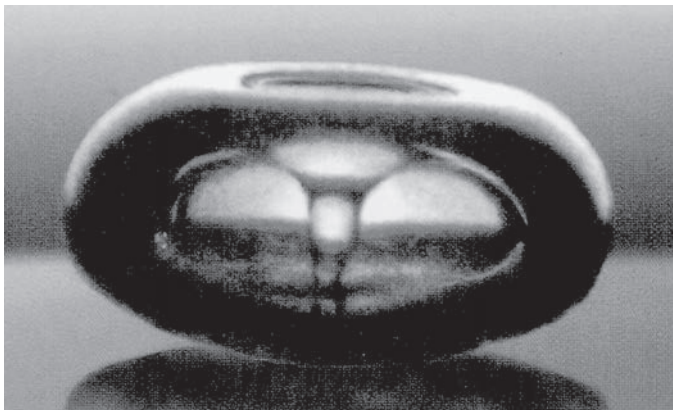
Megasonics compared to Ultrasonics

Different factors can affect the intensity of the cavitation energy in a Ultrasonic / Megasonic process, such as the surface tension of the liquid or the distance of the substrate from the transducer.

The most critical factor is the frequency of the sonic waves.

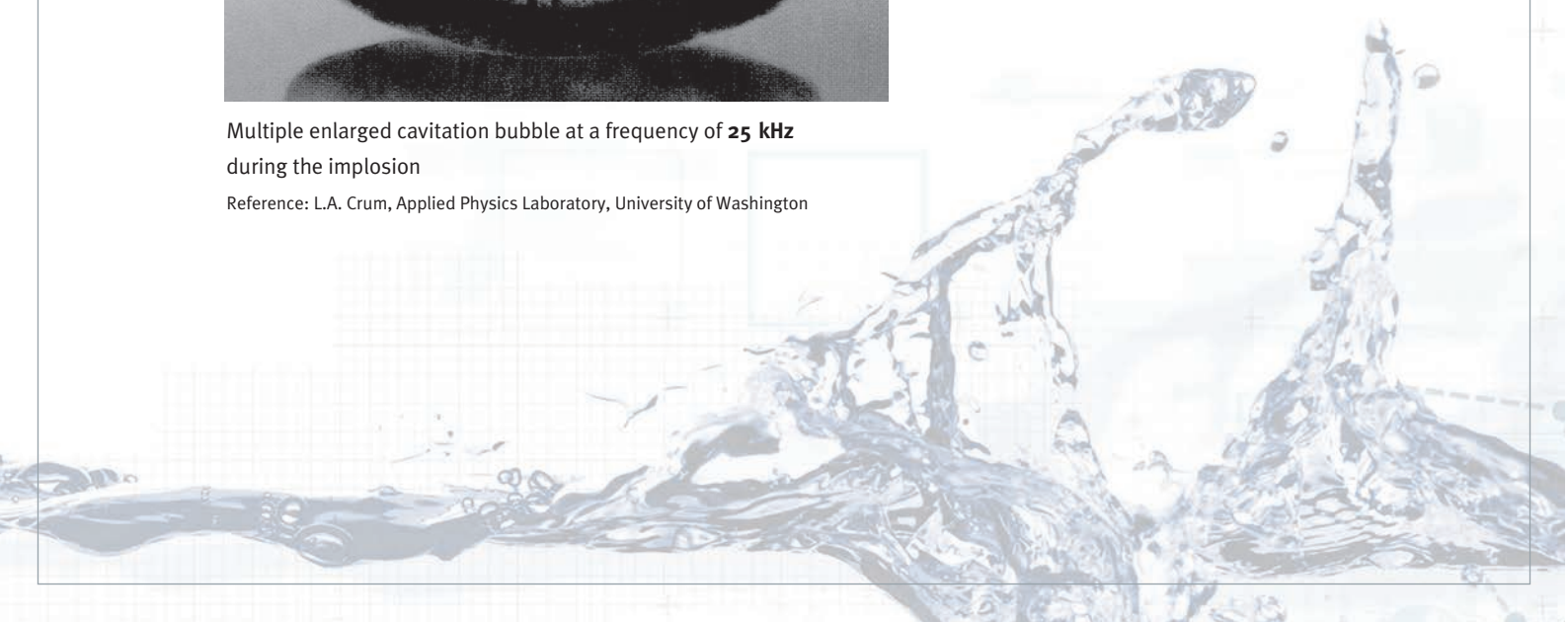
In a typical Ultrasonic cleaning process, the transducer works with a frequency between 25 kHz and 100 kHz. This lower frequency creates bigger bubbles up to diameters of 150 μm and creating higher cavitation energy when they collapse. Megasonic processes utilize frequencies from 600 kHz up to 5 MHz. These higher frequencies create smaller bubbles and when they collapse they are producing a proportionally smaller amount of cavitation energy.

The high cavitation energy produced in Ultrasonic cleaning can damage sensitive structures of substrates. The gentler cleaning energy produced by Megasonic waves is able to remove particles down to the nano range without damaging sensitive devices.



Multiple enlarged cavitation bubble at a frequency of **25 kHz** during the implosion

Reference: L.A. Crum, Applied Physics Laboratory, University of Washington

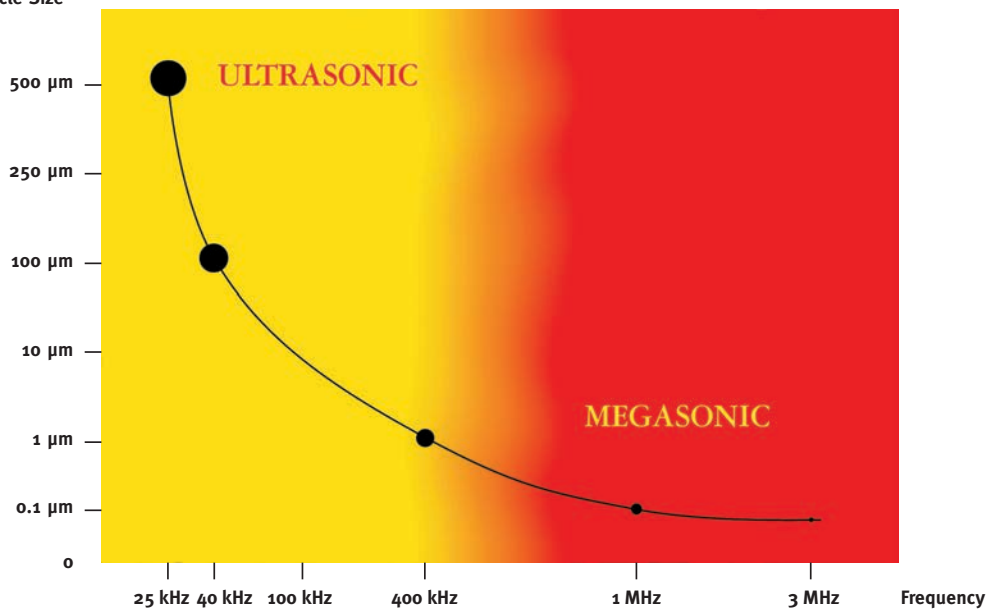


We prevent your microstructures

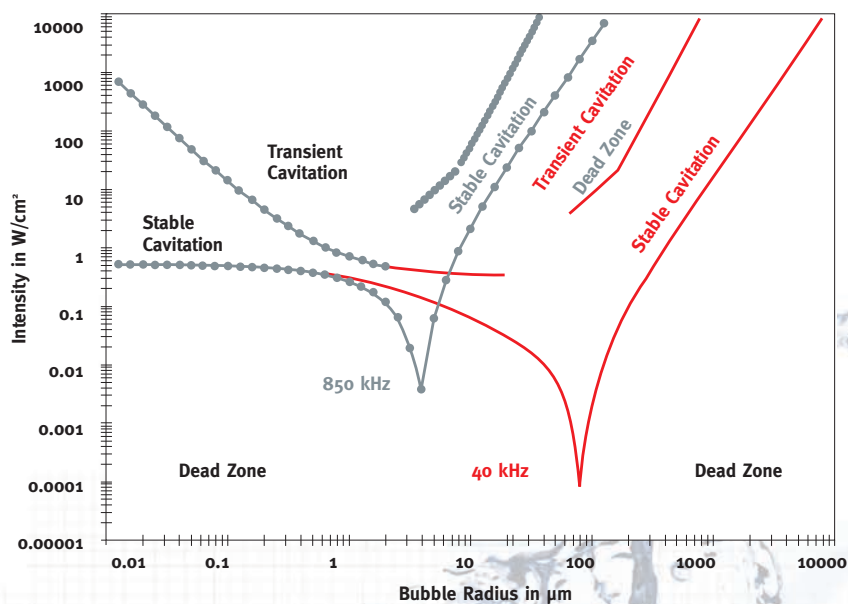
With ultrasonic (<400 kHz), particles of up to 4 µm can be removed. For smaller particles down the nano-range, Megasonic (600 kHz up to 5 MHz) is necessary.

In comparison to the conventional ultrasonic methods with e. g. 40 kHz the cavitation energy is substantially lower with the Megasonic system and it's relatively high ultrasonic frequencies. The micro structures are therefore not destroyed.

Particle Size

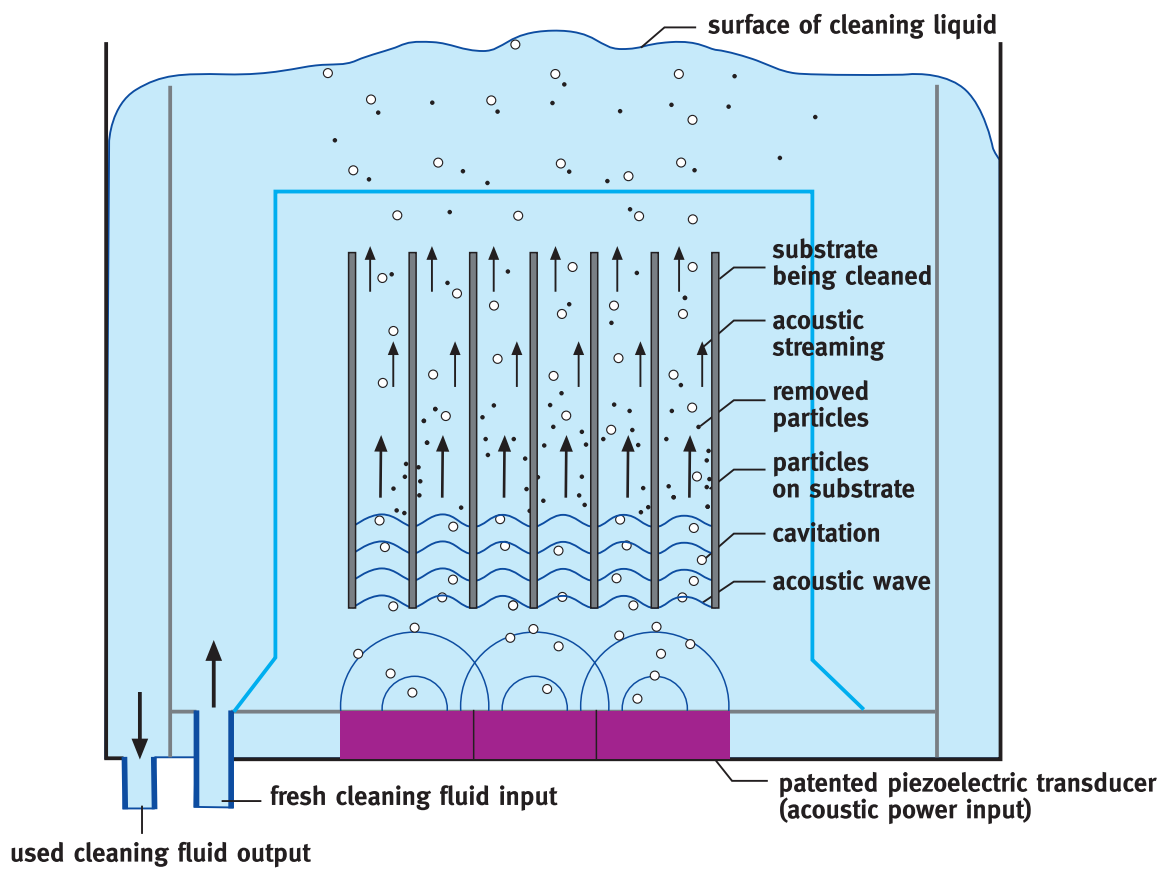


Size of the cavitation bubble depending on power and frequency

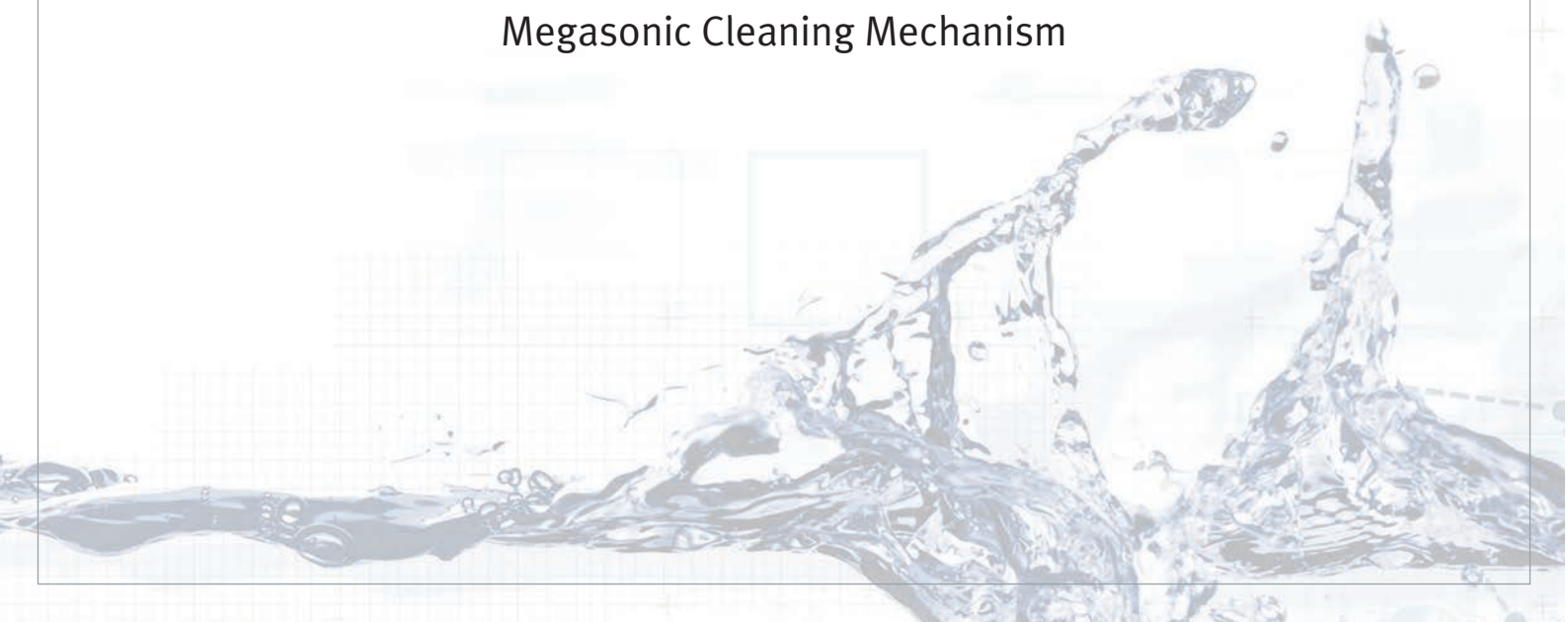


Nanoclean · particle free · SONOSYS®

During processing, the transducer generates high frequency (600 kHz - 5 MHz) sonic waves with controlled cavitation and micro streaming, which is transmitted to the surface of substrates in a liquid medium. Both, chemical and Megasonic action are utilised to break down the attraction forces holding the particle to the surface.



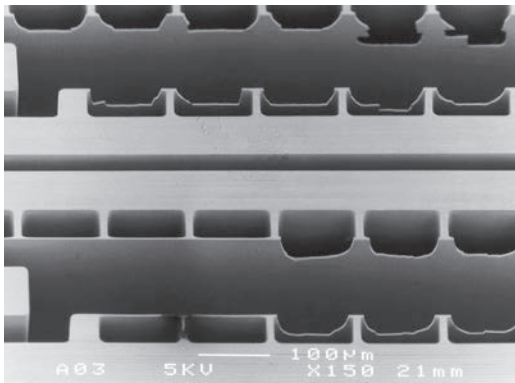
Megasonic Cleaning Mechanism



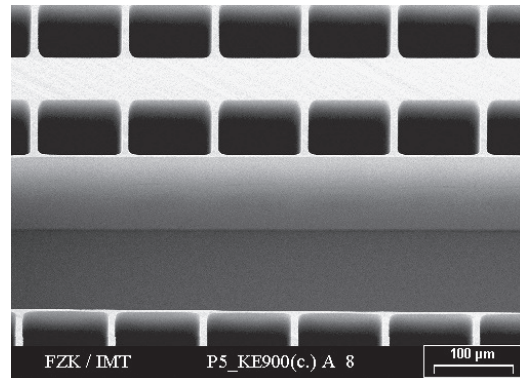
Convincing comparison

Comparison of the ultrasonic frequency of 40 kHz and 1 MHz during the developing process within the LIGA-Technique

An important advantage of the application of Megasonic is the smooth cleaning of extremely fragile microstructures. The figure on the left shows that the microstructure has been destroyed by the high cavitation energy at the ultrasonic frequency of **40 kHz**. The destroyed ridges have a thickness of approx. 4 µm. At an ultrasonic frequency of **1 MHz**, the microstructure remains undamaged (fig. on right).



Destroyed fragile microstructure approx. 200 µm high, developed at a frequency of **40 kHz**.



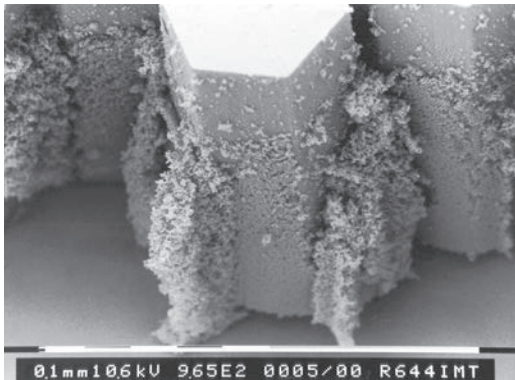
Undamaged fragile microstructure 400 µm high, developed at a frequency of **1 MHz**.

Decrease the development time by a factor of 7 with SONOSYS®

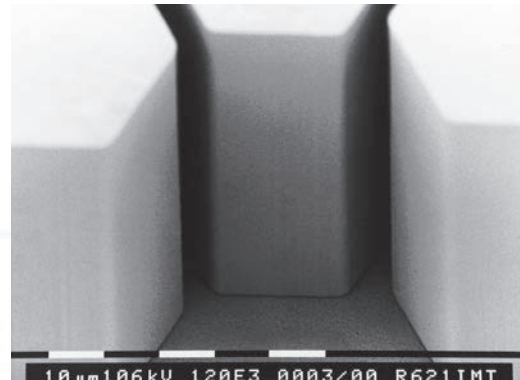
Process support for the development of microstructures with high aspect ratios

The residue-free development of dense and deep structures is of particular importance when it comes to producing microstructures via X-ray lithography.

During the development process of microstructures (**e.g. LIGA technology**) with high aspect ratio, the particles are completely flushed out due to the created microstream, and the development time is reduced by a **factor of 7**. For fragile structures, the depth of the structures can be increased by a **factor of 2**.



Microstructure developed **without** Megasonic support



Microstructure developed **with** Megasonic support

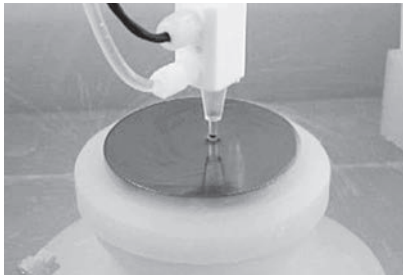
Concentrated Cleaning - Contactless with Megasonic Single / Dual Nozzle

Particle removal of semiconductor wafers:

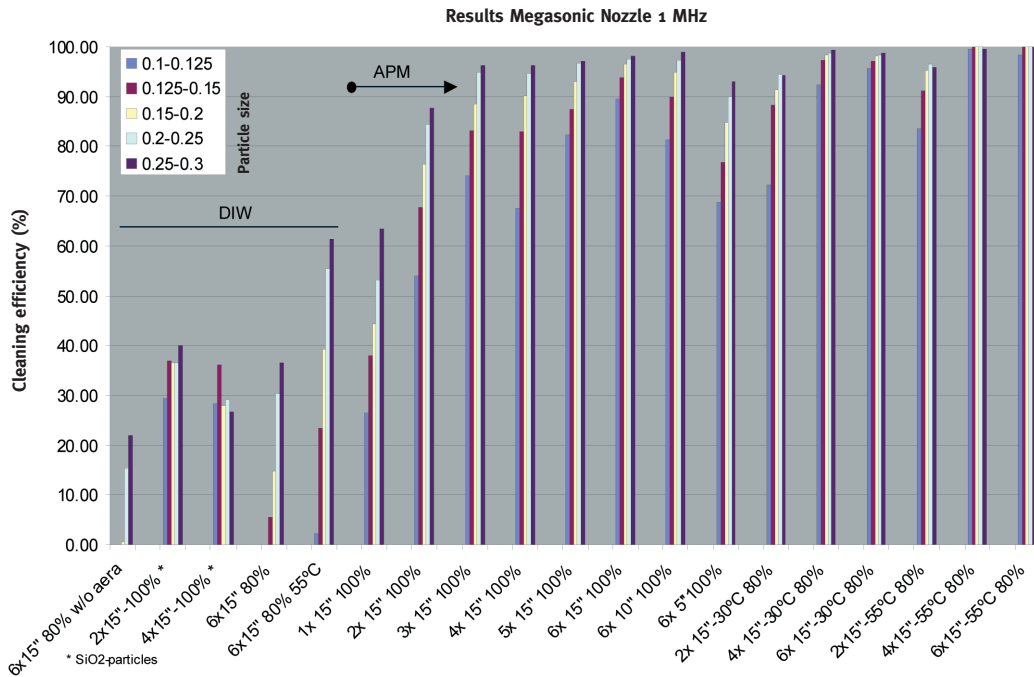
Experiments carried out at the Research Center for Microelectronics IMEC (Leuven / Belgium) with SONOSYS® 1MHz Nozzle system on experimental spinning tool with Rotagoni® drying technique

Test condition for all 200 mm wafers:

- 1MHz Nozzle at 80% and 100% output power
- Medium flow = 1.0 l/min.
- Distance Nozzle opening to wafer surface 22 mm
- Cleaning sweep 15 sec. above the wafer
- Si₃N₄, SiO₂ - Contamination (~12000 particles) very uniform for all wafer
- Media: DIW (DI-water) or APM (SC₁) 1:2:50 (NH₄OH:H₂O₂:H₂O)
- Temperature of media RT, 30°C and ~55°C.



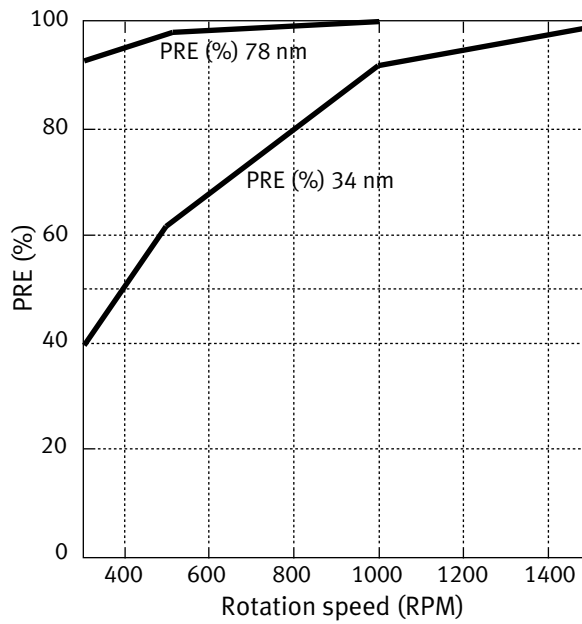
Experimental set-up



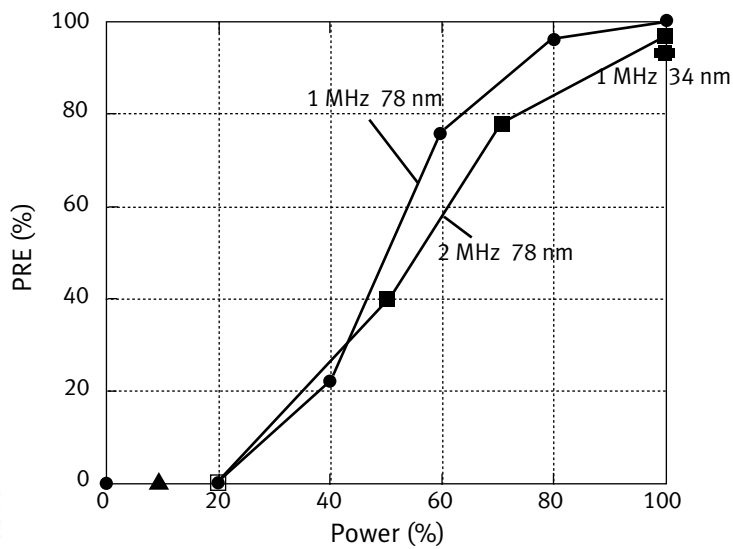
The results show that particles of the size from 0.3 µm to 0.1 µm can be removed with DI-water at room temperature to 40% and at 55°C to more than 60%.

Using APM (SC₁) at 55°C with 4 cleaning sweeps (within 1 minute) at 80% Megasonic output power of the nozzle, 100% of the particles are removed.

Co-operation Imec Research Platform
on (sub-) 32nm CMOS: ultra clean processing



34nm and 78nm SiO₂ particle removal efficiency for a 1 MHz Nozzle, 60sec process time using ultra pure water at different rotation speeds



78nm SiO₂ particle removal efficiency (PRE) for 1MHz Nozzle using ultra pure water and variable power (dots) and 34nm SiO₂ particle removal efficiency for variable frequency. Wafer on a spinning tool operating at 1000 rpm

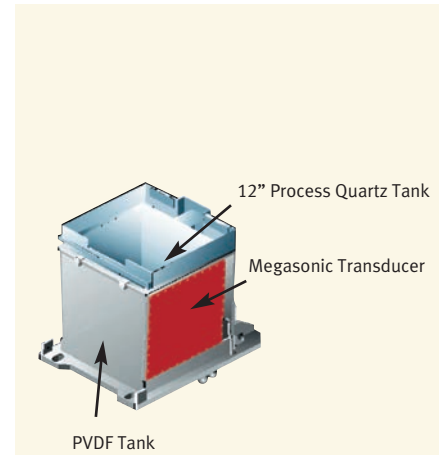
SONOSYS® Megasonic systems and transducer models at a glance

Serial special solutions -

Megasonic tanks / Megasonic transducer plates for integration

The transducer plates are adapted to the application or substrate size and number of carriers. In connection with quartz glass tanks, these transducer plates are integrated outside in a PVDF tank. The Megasonic sound waves are transferred to the process tank via a transfer medium. The tank design is customized in a variety of materials e.g. stainless steel with a welded Megasonic bottom plate. For the integration of the transducer plates in plastic tanks, these are coated with PFA.

Application: Cleaning of semiconductor wafers of a size of 100 mm, 150 mm, 200 mm and 300 mm in single or dual carriers.



Most compact **2000 Watt Generator** on the market -

With minimal space requirements in the tool. Auto tuning for ideal operation of the Piezo Transducer Array. Uniform Megasonic energy transfer under different operating conditions. Adaptable to a variation of different Megasonic Transducer types (also from other manufacturers). Flexible use with 50 Ohm output impedance and phase control. Up to 4 Megasonic High Power Modules fitted in a high-quality EMC-screened 19" enclosure together create remarkable **2000 Watt output power at 400 kHz, 600 kHz or 1 MHz and 1200 Watt at 2 MHz.**



Flexible and cost-effective upgrading -

Megasonic Submersible transducers with frequencies of **400 kHz / 600 kHz / 1 MHz or 2 MHz**

Completely encapsulated transducers made of stainless steel or plastic (e.g.: PP, PVDF or PFA) to be positioned at the bottom or at the side wall of an existing tank. Besides the standard systems for 4", 6" and 8" substrates, custom-specific solutions of Submersible transducers are available. This very flexible configuration allows cost-effective upgrading of process tanks with a Megasonic system.

Application: Cleaning of substrates, semiconductor wafers, micro parts, micro systems (MEMS) and masks of up to 200 mm. Support of the development process in the »LIGA Technology«, as well as etching processes.

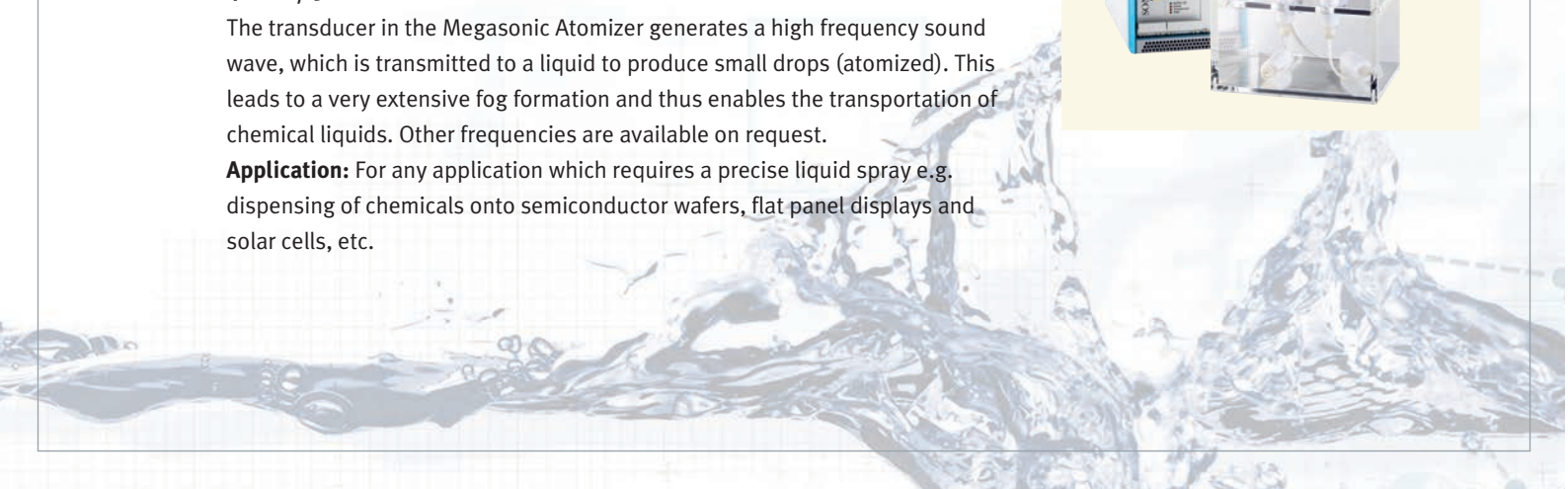


A worldwide novelty -

Megasonic Atomizer with frequencies of **800 kHz / 1 MHz / 2 MHz / 3 MHz / 4 MHz / 5 MHz**

The transducer in the Megasonic Atomizer generates a high frequency sound wave, which is transmitted to a liquid to produce small drops (atomized). This leads to a very extensive fog formation and thus enables the transportation of chemical liquids. Other frequencies are available on request.

Application: For any application which requires a precise liquid spray e.g. dispensing of chemicals onto semiconductor wafers, flat panel displays and solar cells, etc.



Uniform performance - **FTF (Face-To-Face) Transducer** with the frequency of **400 kHz and 1 MHz**

Hermetically encapsulated transducer made of PFA, to be mounted above the rotating substrate. The Megasonic energy is transmitted homogeneously with a uniform power distribution via an active Piezo Transducer surface of e.g. 150 mm x 25 mm to the substrate.

Application: Cleaning of substrates and wafers of up to 300 mm in single process.

Concentration on the essentials - contactless cleaning with **Megasonic Single / Dual Nozzle** with frequencies of **600 kHz / 1 MHz / 2 MHz / 3 MHz / 4 MHz or 5 MHz**

The transducer in the Megasonic Nozzle generates a Megasonic wave, which is transmitted via a flowing liquid (e.g.: DI-water) to the surface of the substrate. The Megasonic energy is concentrated on a small point of 4 mm. The use of the nozzle mounted on a movable arm over a rotating substrate is the most successful configuration.

This tankless Megasonic Nozzle system enables a concentrated cleaning process with a cleaning medium free from particles.

Application: Cleaning of single wafers, masks, LCD's, substrates and Micro Electro Mechanical Systems (MEMS).

Megasonic Shower Nozzle with the frequency of **1 MHz**

The transducer in the Megasonic Shower Nozzle generates a sonic wave which is transmitted to the flowing water (e. g. DI-Water) and the Substrate surface. The Megasonic energy is concentrated on a small slot of 1,8 mm. Besides the standard systems with a length of 44 mm, 118 mm, 405 mm, 670 mm, customs specific solutions can be offered.

This Megasonic Shower Nozzle provides advanced non contact cleaning processes with a cleaning medium free from particles.

Application: Cleaning of substrates for flat panel displays and masks.

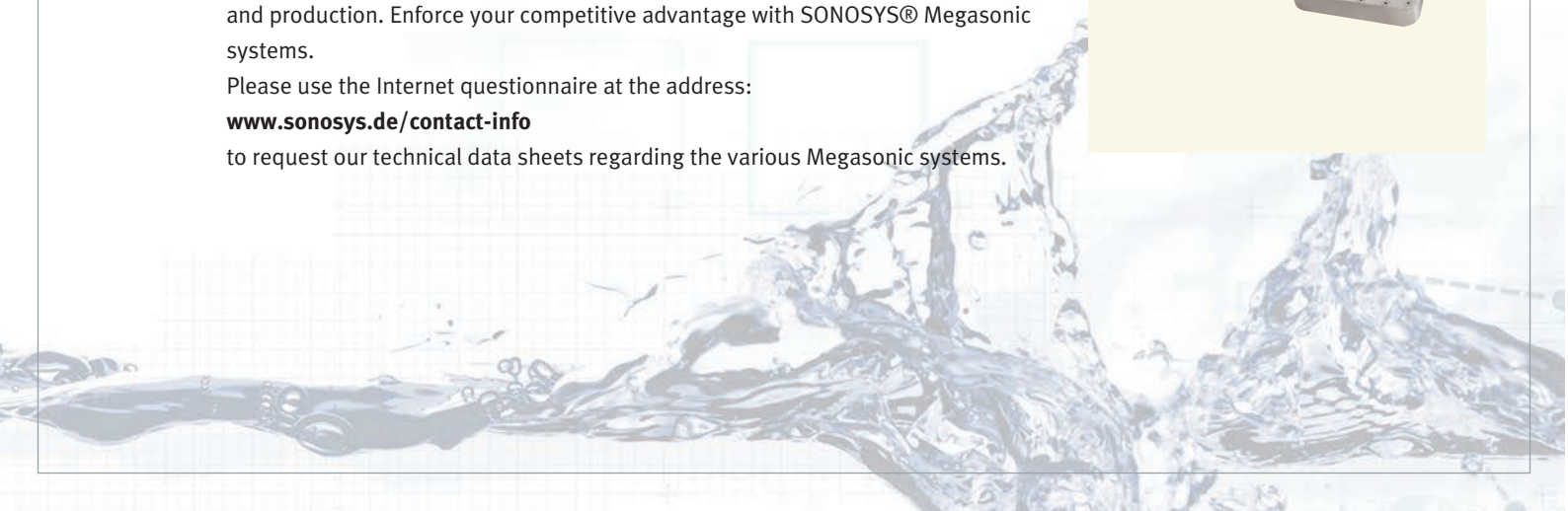
Life is life - first test, then decide

Would you like to know more? We recommend you get in touch with us. Take advantage of our offer to demonstrate our Megasonic cleaning systems in your company. Alternatively, just hire the SONOSYS® Megasonic system for a few weeks and see for yourself what a great leap in quality it brings to development and production. Enforce your competitive advantage with SONOSYS® Megasonic systems.

Please use the Internet questionnaire at the address:

www.sonosys.de/contact-info

to request our technical data sheets regarding the various Megasonic systems.





Please copy this form and fax it to: +49 (0)7082/79184-99

In order to be able to give you detailed information about our product range, please provide the following details:

Company: _____

Name: _____ Departement: _____

Street: _____ City: _____

State/Country: _____ Zip/Postal Code: _____

Phone: _____ Fax: _____

E-Mail: _____

1. Intended application:

- Semiconductor technology / Wafer production Microsystems (MEMS)
 Others _____

2. Material to be cleaned:

- Silicon Glass Metal Plastic / PMMA
 Others _____

3. Kind of process:

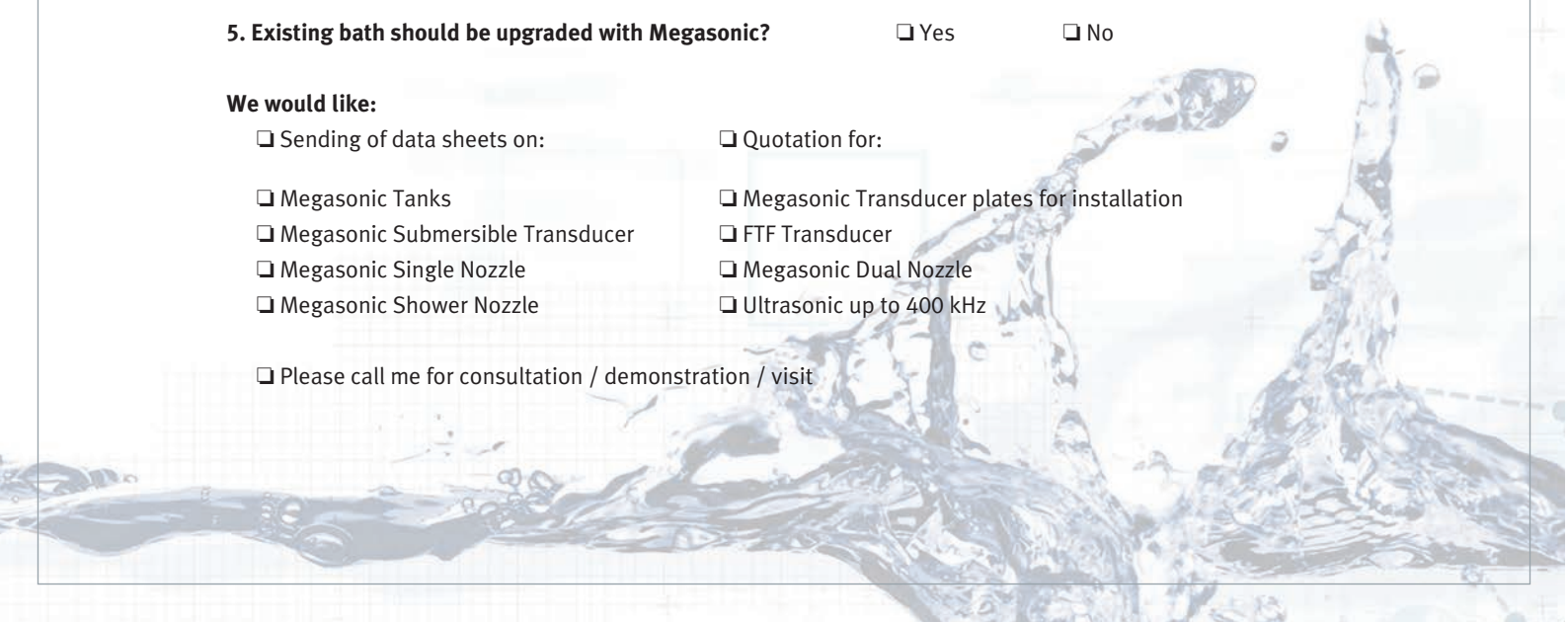
- Developing Etching Cleaning
 Others _____
- Batch Process Single Wafer Process
- Substrate size 4" 6" 8" 12"
- Number of Carrier 1 2
- Other dimensions _____

4. Used media / chemicals: _____

5. Existing bath should be upgraded with Megasonic? Yes No

We would like:

- | | |
|--|---|
| <input type="checkbox"/> Sending of data sheets on: | <input type="checkbox"/> Quotation for: |
| <input type="checkbox"/> Megasonic Tanks | <input type="checkbox"/> Megasonic Transducer plates for installation |
| <input type="checkbox"/> Megasonic Submersible Transducer | <input type="checkbox"/> FTF Transducer |
| <input type="checkbox"/> Megasonic Single Nozzle | <input type="checkbox"/> Megasonic Dual Nozzle |
| <input type="checkbox"/> Megasonic Shower Nozzle | <input type="checkbox"/> Ultrasonic up to 400 kHz |
| <input type="checkbox"/> Please call me for consultation / demonstration / visit | |





SONOSYS® Ultraschallsysteme GmbH
Daimlerstraße 6 · 75305 Neuenbürg / Germany
Phone +49(0)7082 79184-0 · Fax +49(0)7082 79184-99
info@sonosys.de · www.sonosys.de