





Aquafine® Corporation  
A TROJAN TECHNOLOGIES COMPANY

## UV Technology for Microelectronics



# UV Applications

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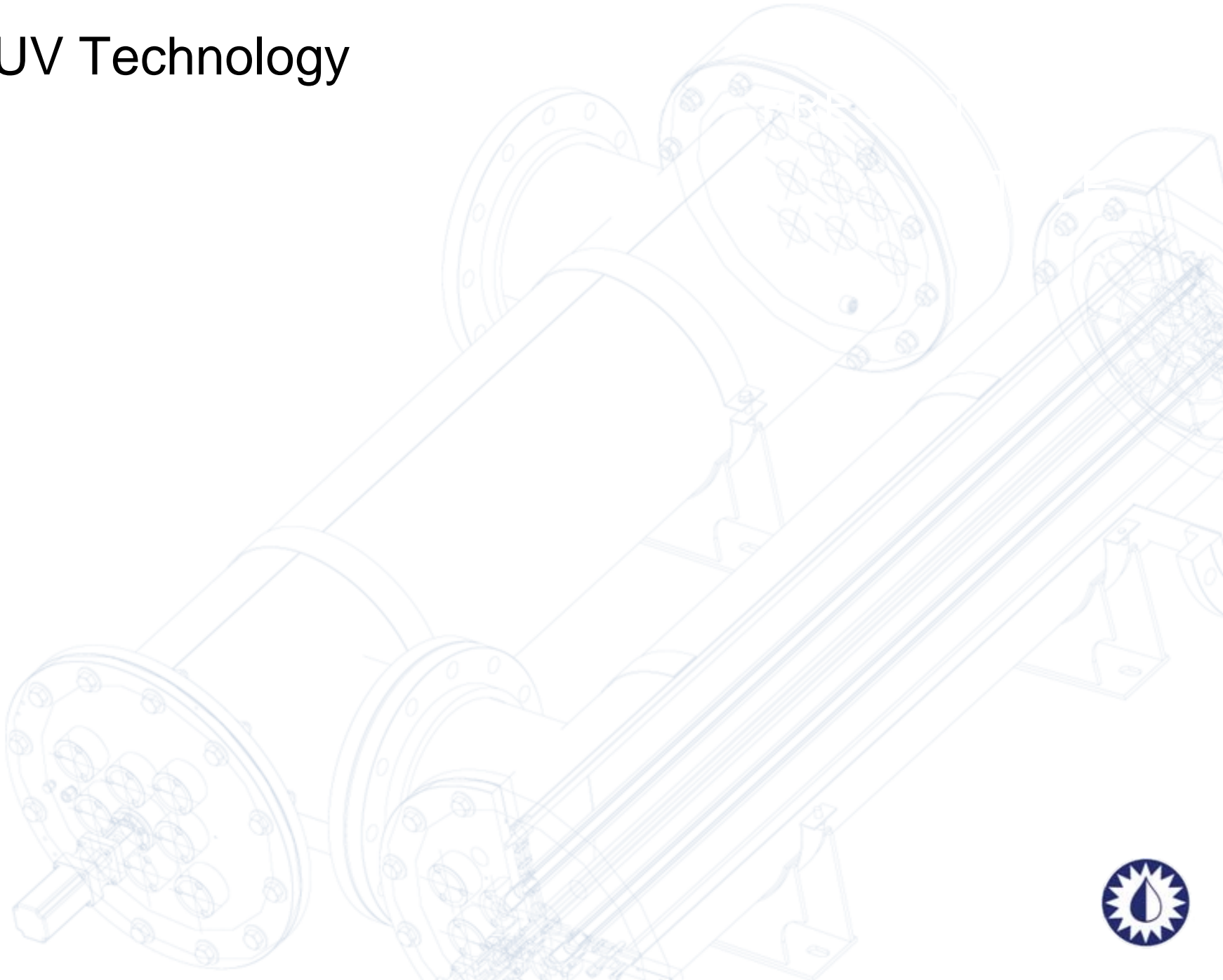
UV provides a non-capital intensive approach to multi-barrier treatment, as there are numerous UV applications in a typical plant:

## Pre-Treatment

- Filtration
- Post Storage
- Carbon
- Softening
- DI
- RO



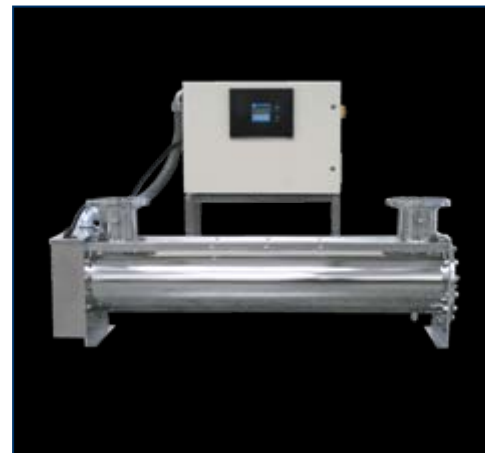
# UV Technology



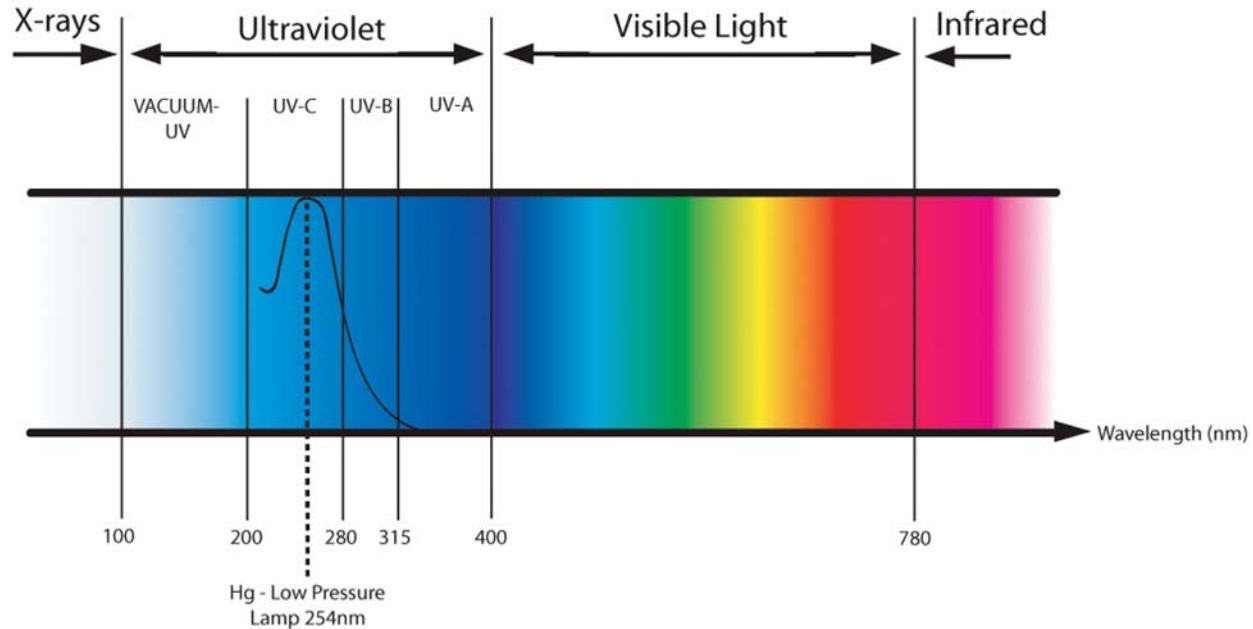
# History of Innovation

Established in 1949, Aquafine Corporation was founded by Louis Veloz, a Westinghouse scientist and pioneer in the development of commercial UV lamps for use in air and water purification.

After introducing the use of UV in the semiconductor industry in the early 1960's, Aquafine has expanded its UV product offering, meeting the changing requirements of commercial water treatment.



# What is UV?



**UV light is comprised of wavelengths ranging from 100nm to 200nm.**

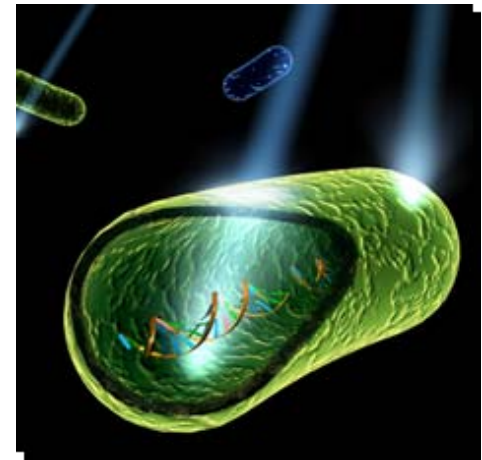
- |                               |                  |
|-------------------------------|------------------|
| <b>UV-A (Long Wave UV):</b>   | <b>315-400nm</b> |
| <b>UV-B (Middle Wave UV):</b> | <b>280-315nm</b> |
| <b>UV-C (Short Wave UV):</b>  | <b>200-280nm</b> |
| <b>Vacuum UV:</b>             | <b>100-200nm</b> |

*NOTE: 1nm = 10<sup>-9</sup>m = 10 Angstroms (one billionth of a meter)*



# How does UV work?

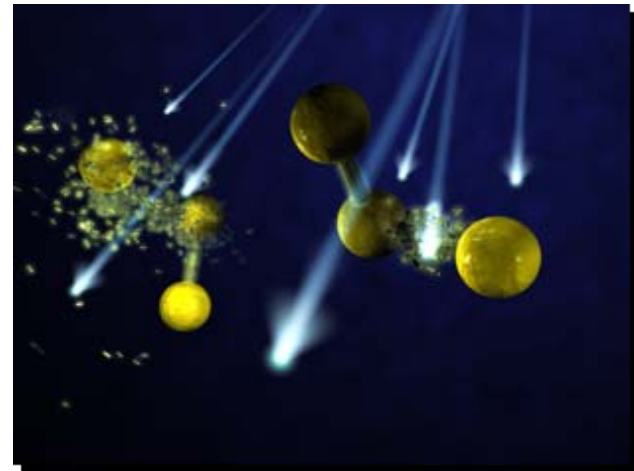
When biological organisms absorb UV light in the range of 200-300nm, the UV is absorbed by DNA and RNA. This causes cross-linking of the double helix strands and prevents splitting and replication.



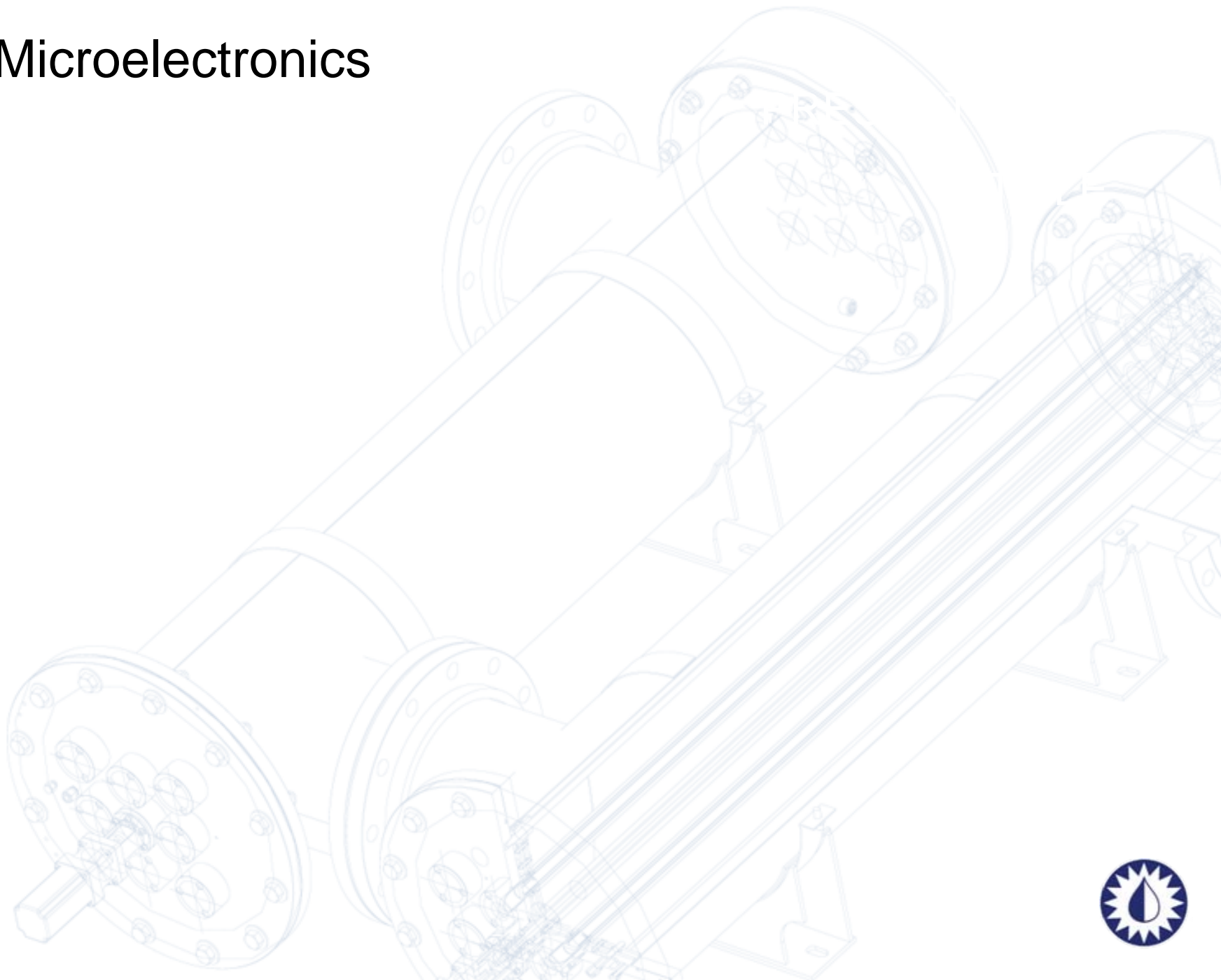
# How does UV destroy ozone?

Ozone is sometimes used as a complimentary disinfectant in aquaculture facilities. Residual ozone must then be removed using UV at a wavelength of 254 nm.

Ozone absorbs the UV energy and quickly dissipates, breaking down into  $O_2$  molecules. Typically, 1.0 ppm of ozone can be removed with a UV dosage of  $90 \text{ mJ/cm}^2$ .



# Microelectronics



# Aquafine and Trojan

Effective December 2, 2005, Hach's water treatment division acquired Aquafine Corporation of Valencia, CA. Aquafine joins Hach's environmental platform and will operate as a strategic business unit of Trojan Technologies Inc.

With Microelectronic installations around the world, Aquafine & Trojan provide the ultimate UV solution. With a combined experience of over 80 years, this combined entity proudly provides market focused expertise, leading edge research and the highest quality in customer support.



# Aquafine and Trojan: A Solid Team

Aquafine and Trojan are uniquely positioned to bring innovative, technology-based solutions to municipalities, industrial enterprises and consumers to solve their water related and process problems in an environmentally responsible way.



# UV Advantages for Microelectronics

- Instantaneous Mechanism (takes only a few seconds)
- No Byproducts
- No Chemicals or Associated Hazards
- Does not alter the color, odor, taste or pH of product
- Environmentally-Responsible Technology
- Proven & Trusted
- Lowest Cost Strategy
- Broad Spectrum Protection
- Reliable, Trouble-Free Bio-Security

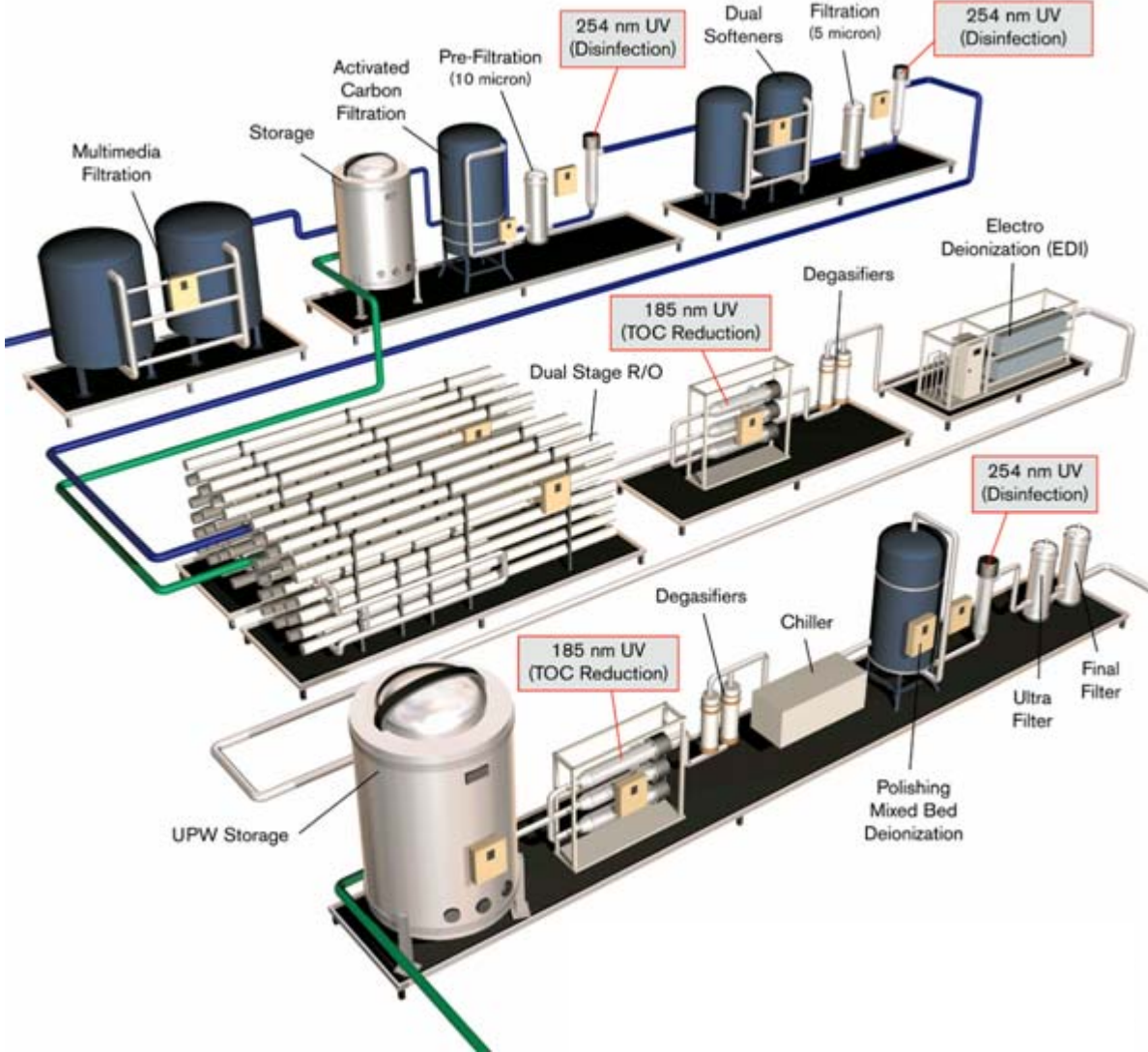


# UV System Design for Microelectronics

- No residual
- Influenced by water quality
- Application specific



# UV Applications Microelectronics



# UV Applications

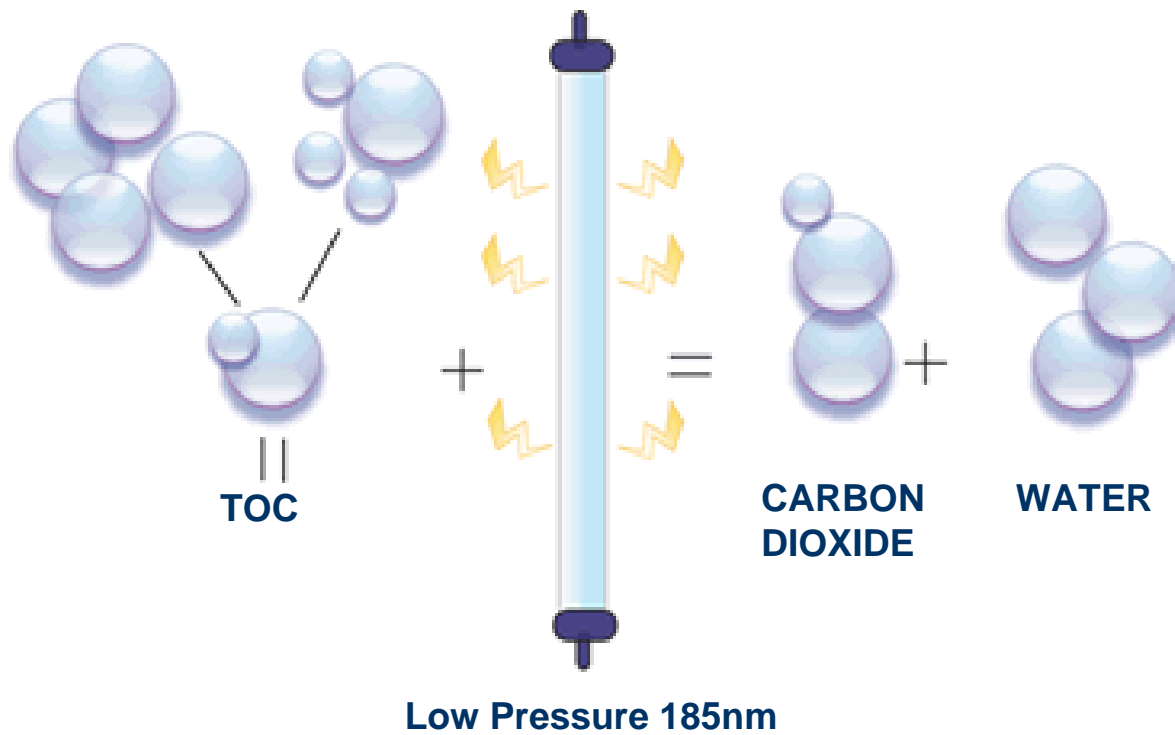
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Just as there are different types of markets, there are different types of UV applications *within* those markets such as:

- Disinfection
- Chlorine/Chloramine Destruction
- TOC Reduction
- Ozone Destruction
- Advanced Oxidation



# TOC Reduction

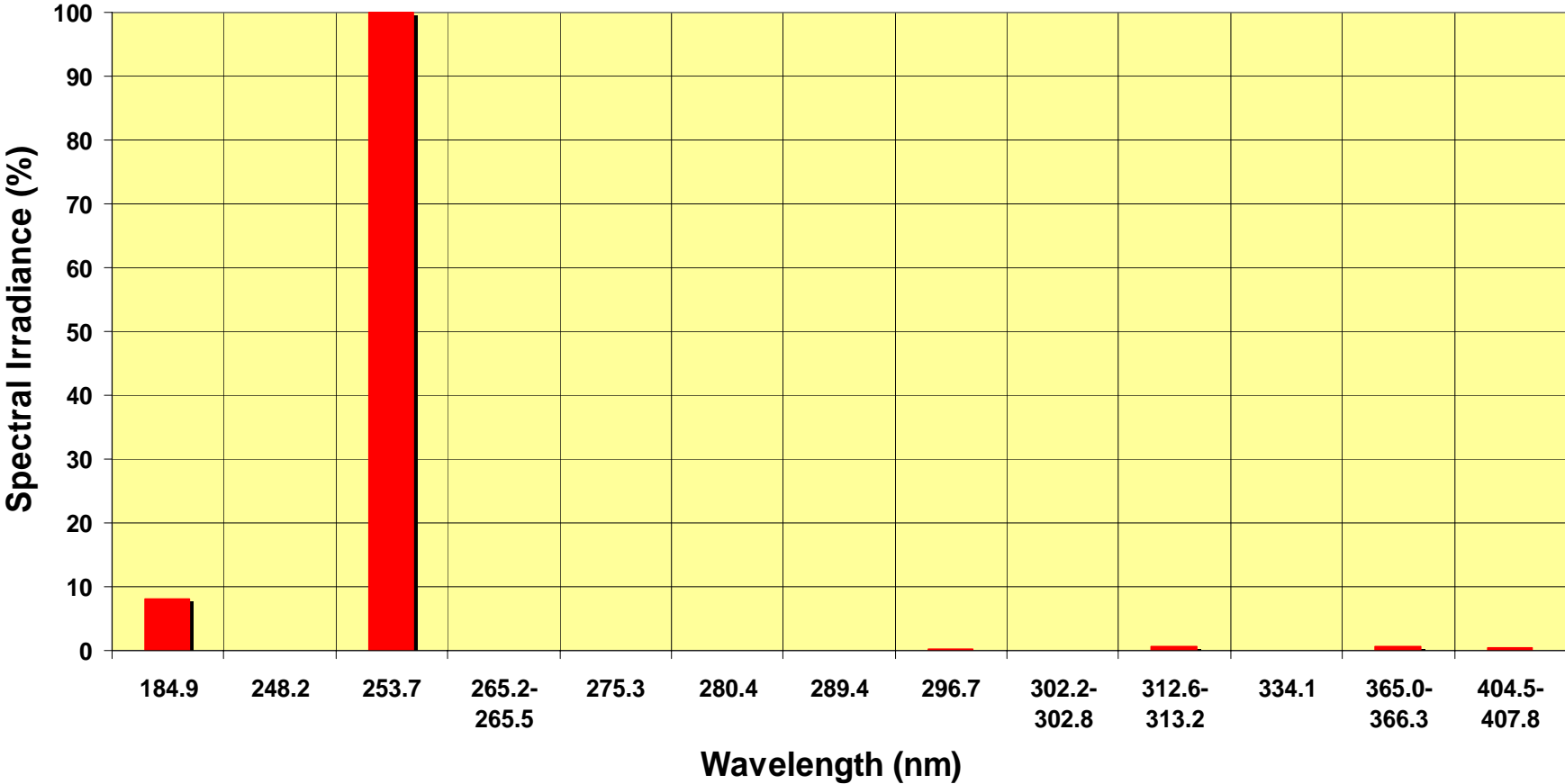


# TOC Reduction Mechanism

- 185 nm radiation generates  $\text{OH}^\bullet$  radicals (hydroxyl radicals) which helps oxidize the hydrocarbons.
- While most organic compounds are decomposed to  $\text{CO}_2$  and  $\text{H}_2\text{O}$ , other more resistant molecules are weakly charged or ionized.
- Their removal is facilitated by downstream DI resins.
- The optimum wavelength for the generation of  $\text{OH}^\bullet$  radicals (hydroxyl radicals) is 185 nm.
- 185 nm radiation is abundantly present in the output spectrum of a low-pressure UV lamp.
- The  $\text{OH}^\bullet$  radicals produced by the 185 nm radiation play a pivotal role in the oxidation of the trace organics.



# Low-Pressure TOC Lamp UV Spectrum



Reference: "Photochemistry", J. G. Calvert and J. N. Pitts, Jr., Wiley, New York, 1966, p.696.



# OH• Radicals (hydroxyl free radicals)

- These OH• radicals (hydroxyl radicals) are extremely ephemeral (short-lived). Their half-life is in microseconds.
- But, they are also extremely aggressive, with very large oxidation potentials (ORP values).
- During their extremely short life, they aggressively attack the hydrocarbon compounds and abstract hydrogen atoms from the hydrocarbon sites.

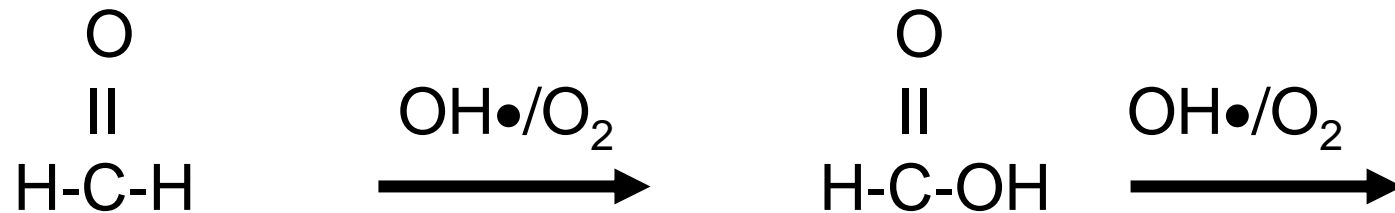
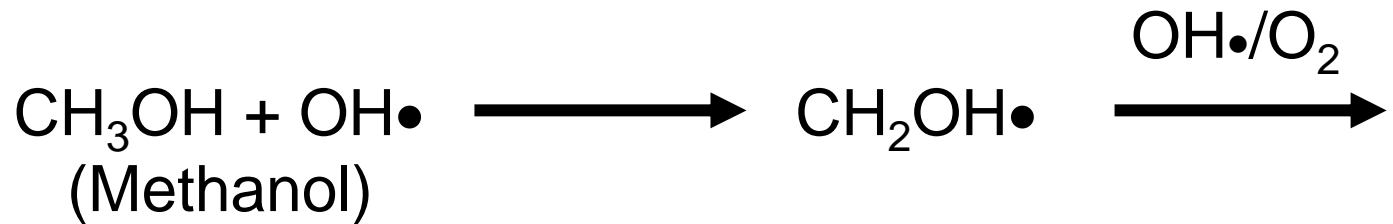


# TOC Reduction Mechanism

- UV mediated chemical process
  - $\text{H}_2\text{O} + 185 \text{ nm UV} \longrightarrow \text{H}^\bullet + \text{OH}^\bullet$
- The  $\text{OH}^\bullet$  radicals help oxidize the hydrocarbon compounds
- Examples of Photochemical reactions
  - Reduction of Formic Acid



# TOC Reduction Reaction Chemistries



$\text{CO}_2 + \text{H}_2\text{O}$  (end-products)

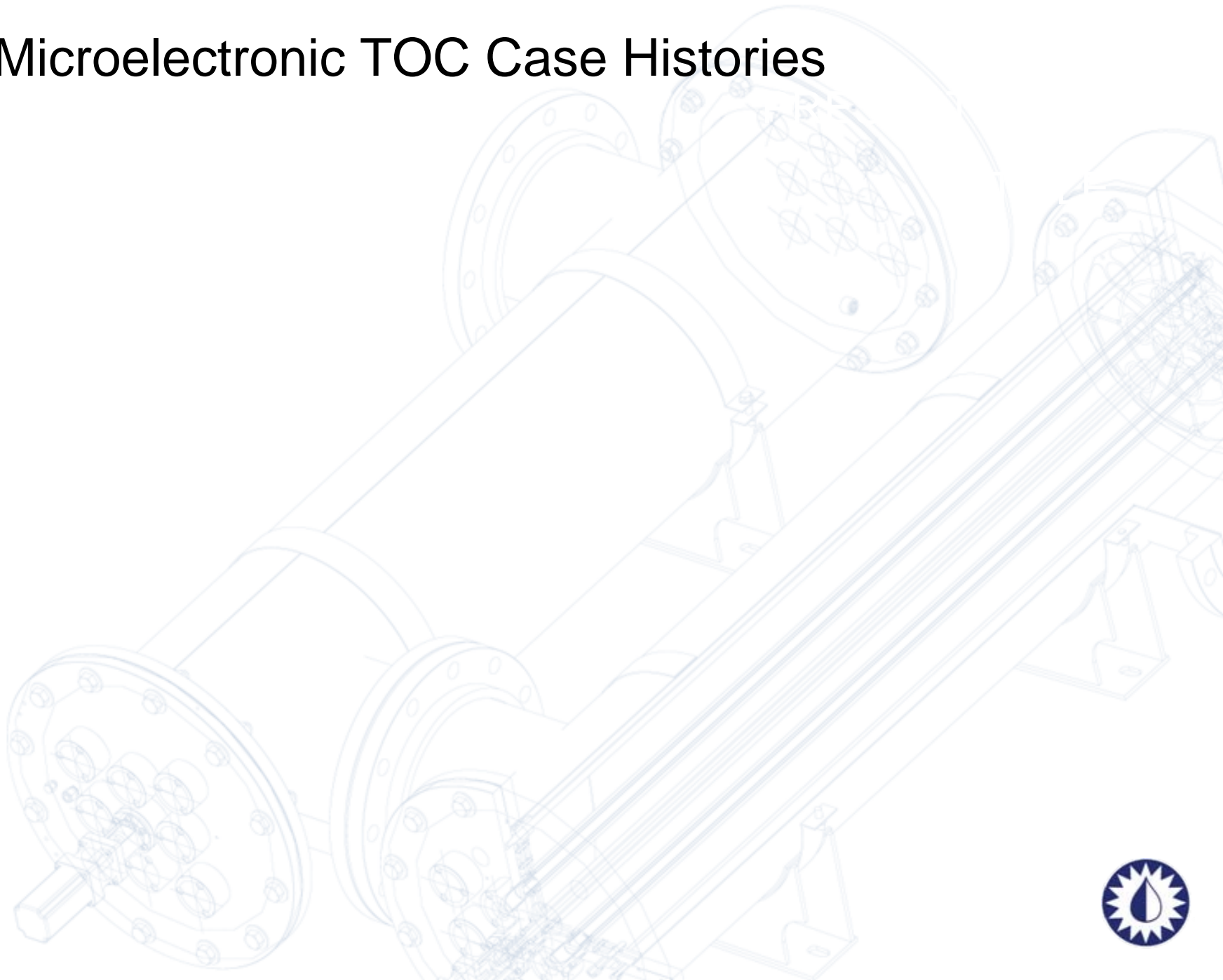


# TOC Reduction Process

<b>Consequences</b>	<b>Solutions</b>
<ul style="list-style-type: none"><li>• Resistivity drop and ionization of some organics</li></ul>	<ul style="list-style-type: none"><li>• Place polishing DI beds downstream of TOC UV units</li></ul>
<ul style="list-style-type: none"><li>• Generation of CO<sub>2</sub></li></ul>	<ul style="list-style-type: none"><li>• Place degasifier down-stream of TOC UV units</li></ul>
<ul style="list-style-type: none"><li>• Degradation of up/downstream polymeric piping</li></ul>	<ul style="list-style-type: none"><li>• Incorporate UV light traps to protect piping</li></ul>



# Microelectronic TOC Case Histories



# Microelectronics TOC Reduction

- Today's state-of-the-art semiconductor manufacturing processes and products demand ultra-low levels of TOC in the wafer rinse-water streams.
- Typically, <1 ppb; preferably  $\leq 0.5$  ppb.
- This is one of Aquafine's distinctive strengths / expertise.
- Trace organics (TOC) would cause a 'haze' on wafer surface and thereby contaminate the wafer.
- Bacteria on wafer surface will cause a short-circuit on the chip and render it a total waste.
- Ozonated water is used for sanitizing piping loop and storage tanks and needs to be eliminated prior to POU.



# Microelectronics TOC Reduction

These ultra-low TOC specs are driven by

- A pursuit of greater wafer yields and/or
- A switch to smaller chip geometry such as  $\leq 0.07 \mu\text{m}$  line-width.  
0.036  $\mu\text{m}$  on the horizon.
- A drive toward upgrading to state-of-the-art UPW specs.



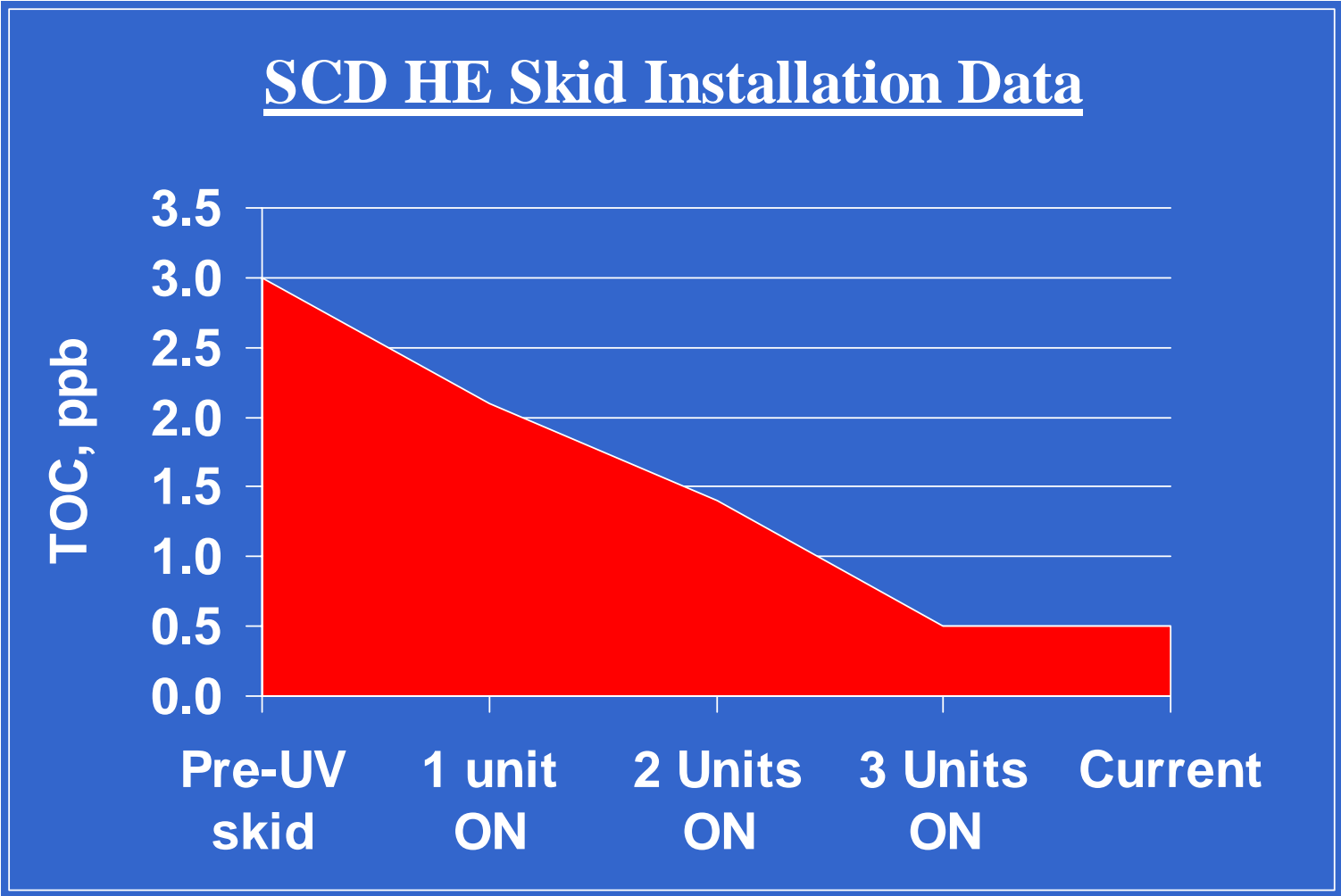
# Microelectronics Case Study - 1

## Austin, Texas

- Two loops, Loops A & B; 600 GPM each.
- One skid per loop.
- Each skid features Three SCD-HE-TOC units in parallel. Skid Engineered by Aquafine.
- 200 GPM per unit. Total 600 GPM per skid.
- UV Inlet TOC level 3-4.8 ppb.
- UV Outlet TOC level <0.5 ppb consistently.



# Microelectronics Case Study - 1



# Microelectronics Case Study - 1

## Austin, Texas.

- The unprecedented and incredibly consistent TOC level of <0.5 ppb has had a tremendous impact on the bottom-line of the Fab.
- The Fab's wafer yield has reportedly increased by at least 2% since the HE UV installation.
- Due to the increase in the wafer yield, the skid's estimated payback period is reportedly only ONE DAY!!!



# Microelectronics Case Study - 2

## Nitto-Denko, Japan.

- Four skid-mounted SCD-TOC units in parallel. Skid Engineered by Aquafine.
- 66 GPM / unit. Total 264GPM.
- UV Inlet TOC level 20 ppb.
- Product TOC level <2 ppb.
- Product water used in the manufacture of RO/UF membranes (for rinsing membranes).
- Standard Aquafine equipment.



# Microelectronics Case Study - 3

CIRRENT Semiconductor, Orlando, Florida (formerly AT&T / Lucent).

- Four UV units in parallel.
- Total 200 GPM (46 m<sup>3</sup>/hr).
- UV Inlet TOC level 25 ppb.
- Product TOC level <5 ppb.
- Product water used in semiconductor manufacture (for rinsing wafers).



# Microelectronics Case Study - 4

## Texas Instruments R&D, Dallas.

- Ten ENH-SCD-TOC units in parallel.
- 50 GPM per unit.
- UV Inlet TOC level 25 ppb.
- Product TOC level <2 ppb.
- Performance was guaranteed by Aquafine.
- Product water used in semiconductor manufacture (for rinsing wafers).



# Microelectronics Case Study - 5

## ProMOS, Taiwan [Mosel + Siemens joint venture].

- Eight SCD-TOC units in parallel.
- 25 m<sup>3</sup>/hr per unit. Total 200 m<sup>3</sup>/hr.
- UV Inlet TOC level 10-12 ppb.
- Product TOC level <1 ppb.
- Product water used in semiconductor manufacture (for rinsing wafers).



# Microelectronics Case Study - 6

## Vanguard International Semiconductor Corp., Taiwan.

- Two sets of Six SCD-TOC units in parallel. 12 units in all.
- 16.7 m<sup>3</sup>/hr per unit. 100 m<sup>3</sup>/hr per set. Total 200 m<sup>3</sup>/hr.
- Product TOC level <1 ppb.



# Microelectronics Case Study - 7

## Hyundai Semiconductor, Korea.

- Two sets of Six CSL-TOC units in parallel.
- 300 GPM per set (68 m<sup>3</sup>/hr).
- UV Inlet TOC level 30 ppb, Product <5 ppb.
- Performance was guaranteed by Aquafine.
- Water used in semiconductor manufacture.



# Microelectronics Case Study - 8

## MOSEL-VITELIC, Taiwan.

- Three SCD-TOC units in parallel.
- UV Inlet TOC level 10 ppb.
- Product TOC level <2 ppb.
- Product water used in semiconductor manufacture (for rinsing wafers).



# Microelectronics Case Study - 9

## STMicroelectronics, Carrollton, Texas.

- 800 GPM. 4-pk SCD-HE-TOC skid.
- Inlet TOC  $\approx$ 5 ppb. <2 ppb at POU.
- Performance was guaranteed by Aquafine.
- In operation since December 1998.
- Performance Exceeded.



# Microelectronics Case Study - 10

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## Winbond Fab I, Taiwan.

- Two SCD-HE-SE-TOC units in parallel.
- Product TOC level <1 ppb.



# Microelectronics Case Study - 11

## Texas Instruments (KFAB), Dallas, Texas.

- 3-pk SCD-1200-HE-TOC skid system.
- 250-300 GPM, 2+1 redundant design.
- Product TOC level 0.3-0.4 ppb.
- Since 1999.
- Product water used in semiconductor manufacture (for rinsing wafers).





*Aquafine, along with its sister companies, continues its investment in new products and technologies.*

*A solid team focused on meeting customers needs, with a founding commitment to excellence, will continue to advance Aquafine, and the industry as well, in the years to come.*





# Thank you.

For further information, please contact your distributor  
or call Aquafine customer service at  
1.800.423.3015 (outside CA) or 1.661.257.4770  
or go to [www.aquafineuv.com](http://www.aquafineuv.com)

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