AQUAPORIN

Dewatering semiconductor and microelectronics wastewater

Using Aquaporin Inside® forward osmosis

DELIVERS up to 14x VOLUME REDUCTION

UNIQUE CUTTING-EDGE PRODUCT

HIGH REJECTION
Complete rejection of copper and fluoride

HIGH WATER RECOVERY
93% of the water can be reused and recycled

LOW FOOTPRINT
Replacing chemical & biological treatment

IMPROVED LOGISTICS
Reduced waste disposal cost

EASY RETROFITTING
The Aquaporin Inside® FO process can be easily retrofitted to existing processes

- ✓ Up to 14x volume reduction for semiconductor wastewater
- ✓ Complete rejection of copper and fluoride & at least 87% rejection to boron
- ✓ 93% of the water can be reused and recycled
- ✓ Reduced volume to be sent to evaporator & possibly achieving Zero Liquid Discharge (ZLD)
- ✓ Potential to replace chemical & biological treatment resulting in smaller plant footprint
- ✓ Potential improvement in logistics & reduced waste disposal cost
- ✓ Lower operating cost due to reduced energy consumption and chemical usage
- ✓ The Aquaporin Inside® FO process can be easily retrofitted to existing processes and customized according to wastewater treatment needs
- ✓ Simple flush cleaning with water to regain process performance

WASTEWATER ZERO

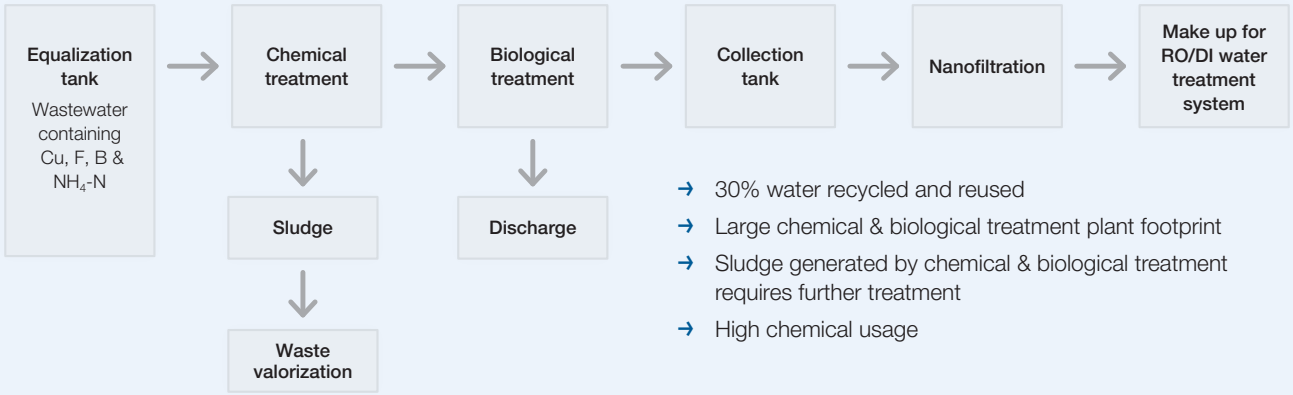
Semiconductor wastewaters are inherently difficult to treat. They are usually characterized by strong color, high COD, high levels of VOC and heavy precious metals. Conventionally, chemical coagulation and biological treatment are used to treat wastewater before discharge.

Diminishing freshwater supplies and growing concerns on the environmental impact from industrial wastewater discharges have propelled Zero Liquid Discharge (ZLD) to be the new paradigm in some countries for industrial wastewater treatment in the recent years.

Forward osmosis technology can potentially be incorporated to meet ZLD targets where all water is recovered and contaminants are reduced to solid waste.

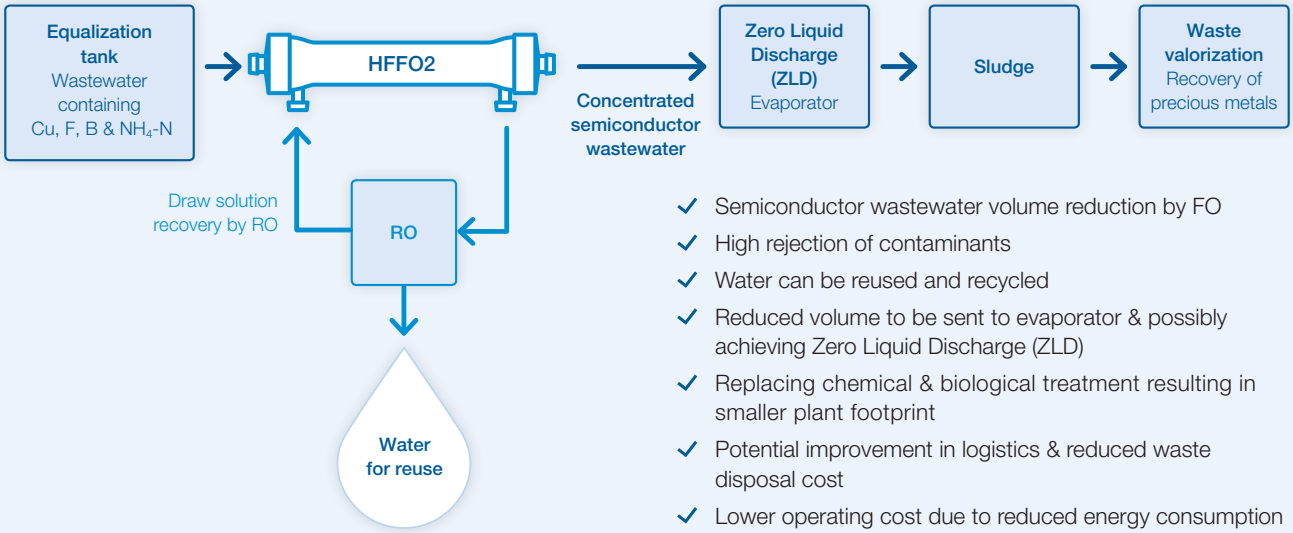
DEWATERING SEMICONDUCTOR WASTEWATER USING FORWARD OSMOSIS

Current process with conventional treatment



- 30% water recycled and reused
- Large chemical & biological treatment plant footprint
- Sludge generated by chemical & biological treatment requires further treatment
- High chemical usage

Incorporating Aquaporin Inside® FO

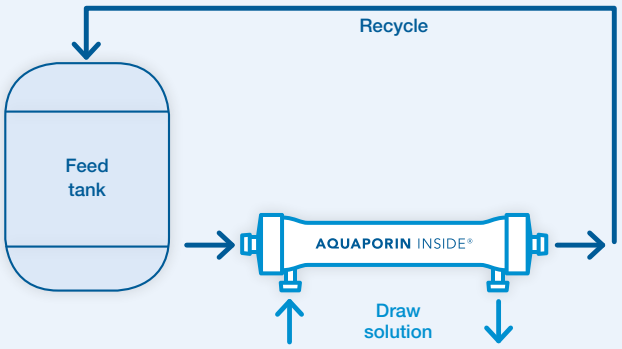


- ✓ Semiconductor wastewater volume reduction by FO
- ✓ High rejection of contaminants
- ✓ Water can be reused and recycled
- ✓ Reduced volume to be sent to evaporator & possibly achieving Zero Liquid Discharge (ZLD)
- ✓ Replacing chemical & biological treatment resulting in smaller plant footprint
- ✓ Potential improvement in logistics & reduced waste disposal cost
- ✓ Lower operating cost due to reduced energy consumption and chemical usage

CASE STUDY

Method

A lab-scale study using Aquaporin Inside® HFFO2 was carried out to validate technical feasibility. Experiments were performed in FO mode where the active layer of the membrane was facing the feed side.

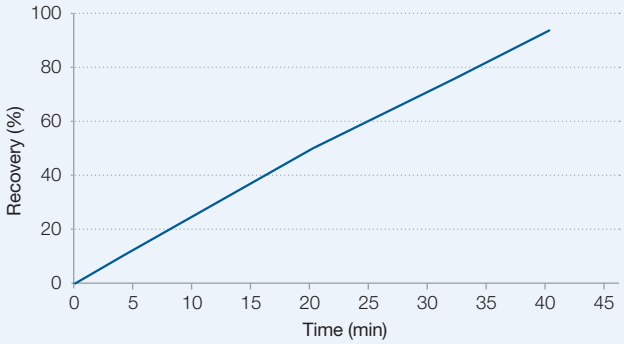


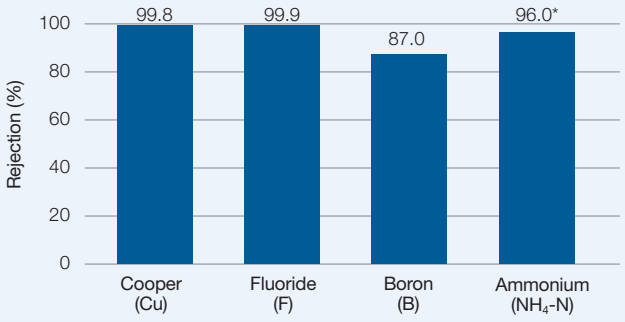
Mode of operation	Feed solution in batch mode Draw solution in continuous mode
Draw solution	0.8 M NaCl
Feed solution	60L simulated semiconductor wastewater solution Copper: 200 mg/L Fluoride: 200 mg/L Boron: 0.1-0.3 mg/L Ammonical nitrogen: 18.5 mg/L
Rejection test	Copper, fluoride, boron & ammonical nitrogen
Operating conditions	1.0 LPM feed inlet | 0.4 LPM draw inlet | Minimum of 0.2 bar TMP FO mode (feed in lumen side), counter-current, 20°C
Membrane type	Aquaporin Inside® Hollow Fiber Forward Osmosis Module (2.3m²)

Results

Hollow Fiber FO batch concentration results:

- ✓ 14x volume reduction of semiconductor wastewater, (93% recovery)
- ✓ Complete rejection of copper and fluoride
- ✓ High rejection to boron & ammonical nitrogen





Excellent permeate quality and high potential for lower operating costs

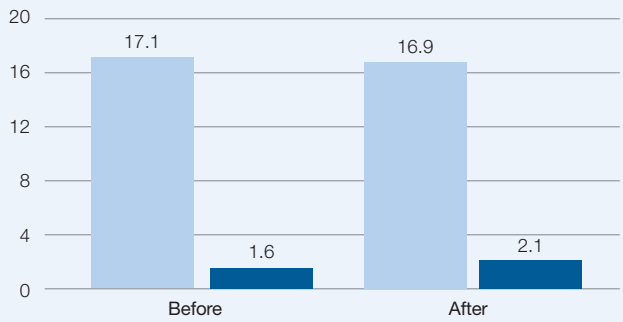
Based on encouraging results from the trial tests and economic simulations of full-scale FO costs, which show both excellent permeate quality virtually free of heavy metals and high potential for lower operating costs, our test partner, Darco Water Technologies, have decided to move on to industrial on-site piloting.

*pH adjusted to 3.5

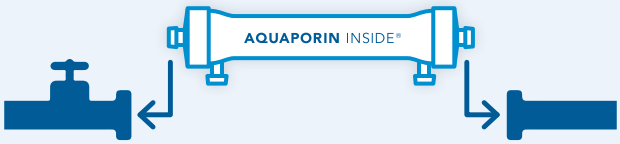
Quality control test

FO membrane performance is fully recovered after cleaning.

Membrane QC tests before and after applications with subsequent cleaning



CONCLUSIONS



The Aquaporin Inside® FO process can be easily retrofitted to existing semiconductor wastewater treatment facilities.

The draw solution can be regenerated with RO systems. Overall, FO is capable of delivering better results at lower costs.

About Aquaporin

Aquaporin A/S is a global water technology company located in Denmark.

Aquaporin is dedicated to revolutionizing water purification with its' novel membrane technology.

The main goal of Aquaporin is to develop the Aquaporin Inside® technology which is capable of separating and purifying water from all other compounds.

The Aquaporin Inside® platform uses biotechnological principles in a technological context, which is a novel upcoming field with large commercial perspectives. This is a field where Denmark has taken an early global lead.

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