

## Water Reclaim in Silicon Processing – Pall’s Contribution to Process Optimization in the PV Industry

### State of the Art Silicon Processing

Pre-shaping of silicon ingots prior to wafering comprises several cutting and grinding operations. Cutting is performed by saws, equipped with either cutting discs or cutting bands. The discs and bands are coated with diamond grains. Grinding machines have rotating grinding discs with diamonds.

Water is used as a cooling agent for tools and silicon surfaces, as a lubricant, and also for rinsing off the resultant ground silicon fines. Whereas the semiconductor industry uses ultrapure water, the photovoltaic (PV) industry process water quality ranges from tap water to deionized (DI) water. Some manufacturers re-circulate the water after solids removal. Their motivation is either to meet discharge limits or to save water. Until recently, centrifuges or sedimentation tanks were typically employed to remove silicon particles. However, they proved ineffective, resulting in serious contamination of machines, pipes and other components. Today membrane processes are considered “state of the art”.

### Effect of water quality on cutting/ grinding operations

Pall’s extensive experience with silicon-water suspensions in the semiconductor industry, as well as with studies performed in co-operation with the PV industry and tool manufacturers, shows that varying water purity significantly affects productivity and silicon surface quality. It has been clearly demonstrated that water with the lowest turbidity, colloidal load and ionic strength enables the operator to achieve:

- higher cutting / grinding speeds
- lower surface roughness
- less fouling of machines, tools and piping

Using DI water only once, however, is not practical. The cost of DI water feed and subsequent disposal is a major concern. Moreover, DI water is more aggressive than potable water and can be corrosive to certain older machinery.

### Pall’s sawing / grinding water reclamation systems

Pall’s technology for sawing/grinding water reclamation helps to overcome these disadvantages. The heart of the reclaim system is a dynamic membrane filtration process together with physicochemical treatment of the spent process water. These systems completely clarify the contaminated process water. Typically 90% of the water is recovered as particle-free permeate, ready for re-use. The remaining concentrate may be discharged, mixed with other wastewater streams, or further treated to meet discharge regulations or to reclaim the silicon particles.

The dynamic membrane filtration system incorporates porous hollow fiber membranes to separate particulate and colloidal matter from soluble components in the water. The membranes are arranged in compact modules (fig. 1).

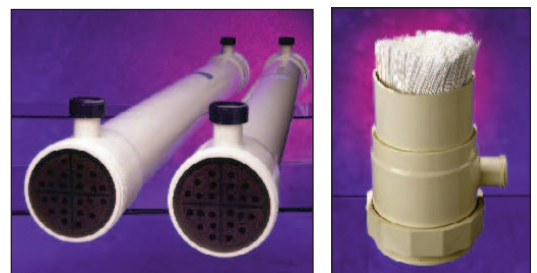


Fig. 1: Pall Microza\* Membrane Module (left) and cutaway showing hollow fibers

\* Microza is a trademark of Asahi Kasei Corporation



Fig. 2: Pall dynamic membrane system for 10 - 30 m<sup>3</sup>/hr / 44 - 132 gpm of spent sawing/grinding process water, 2 x 75% capacity for redundancy, with process water supply unit

The Microza hollow fiber membranes are very permeable resulting in high water production rates. Each hollow fiber module provides a large active surface area of up to 50m<sup>2</sup>. These modules are used in Pall water treatment systems of various sizes and capacities (fig. 2).

Pall's dedication to a simplified process and control design has produced a family of systems that are characterized by:

- Robust, long service, hollow fiber membranes
- Operator friendly controls
- Simple spent water treatment without coagulation
- Unique air scrub and flush operation
- Excellent compatibility with chlorine, common treatment chemicals and dissolved hydrogen
- Minimal cost of operation
- Compact system footprint
- ISO 9001 certified manufacturing

Throughout a filtration cycle, PLC-controlled process steps are performed to assure maximum efficiency and lowest total cost of ownership. Those steps are:

**Filtration:** This is the normal production mode where dirty water enters the bottom of the module, is distributed uniformly to the fibers, and for the most part passes through the membranes and exits as permeate (filtered water).

**Air Scrub & Reverse Filtration (AS & RF):** These procedures are fully automated, hydrodynamic processes that remove debris from the module and control the rate of increase in transmembrane pressure.

**Enhanced Flux Maintenance (EFM):** This fully automated process uses warm water with mild chemical solutions to keep the membranes free of fouling matter.

**Chemical Clean In Place (CIP):** This semi-automated, infrequent operation removes particulate matter and foulants, and returns the modules to a “nearly new” condition.

### Integrated water reclaim systems

The generic process block diagram of a Pall Sawing / Grinding Water Treatment System (fig. 3) depicts typical process water pathways. Based on a modular concept and depending on individual conditions and needs, the technology includes, in addition to membrane filtration, other components such as:

- lift units to collect spent water near the tools
- buffer/pre-treatment tanks for spent water
- holding tanks and pumps for feeding the tools
- DI water system for loop make-up
- ion exchangers for silicate/metal level control
- dewatering and drying units for waste treatment and silicon reclaim

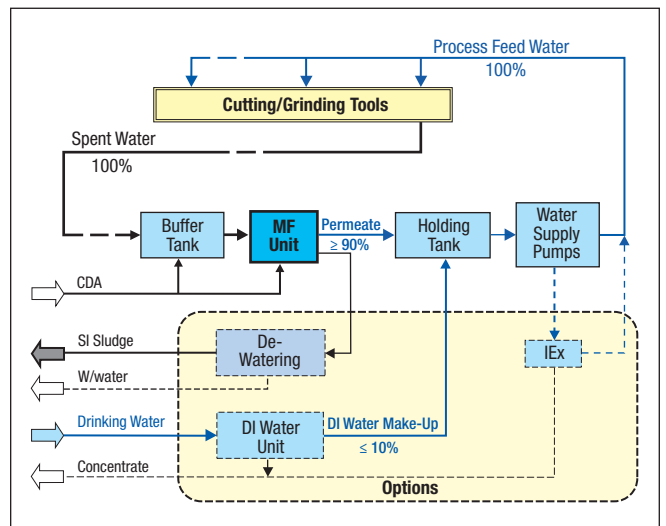



Fig. 3: Block diagram of a Pall sawing / grinding wastewater treatment system



There is no fixed design since local conditions and demands vary significantly. Separation units already in operation but not sufficiently effective, e.g., centrifuges or settlers, may be integrated into the membrane-based separation system. They can help to prepare the feed water or to further treat the RF/AS/CIP waste prior to discharge or reclamation.

Systems similar to the one shown in Fig. 2 can be used to clarify and re-circulate other spent water in PV manufacturing, e.g., rinse water from wafer cleaning operations.

### Summary

Sawing/grinding water treatment by means of Pall reclamation systems enables PV wafer manufacturers to

- typically re-use 90 % of spent process water as high-quality feed
- reduce wastewater discharge volume
- use DI water only for loop make-up
- increase cutting / grinding speed
- improve silicon surface quality after cutting and grinding
- reduce machine fouling and uncontrolled sedimentation in pipes, tanks and sinks
- reduce chemical hazards due to silicon-water interaction by controlled pre-treatment of spent process water
- avoid contamination of silicon debris for easier silicon re-use

### References

1. Pall GmbH, Scientific & Laboratory Services, Internal Report, 2006
2. Berndt, R. and J. Rossius: Ein Beitrag zur Methodik der Auslegung von Membrananlagen (dt.) (A contribution to the sizing of membrane systems). Proceedings VDI-GVC Conference FA "Mechanical liquids Separation", Strasbourg, March 2000
3. Berndt, R. and L. Dalitz: Filtration von CMP-Slurries als Voraussetzung für Qualitätssicherung und Entsorgungssicherheit. Chem.-Eng.-Techn. 75(2003)6, 750-753
4. Berndt, R.: Optimization of Sawing and Grinding Operations by Process Water Reclamation. Rožnov p.R.: Silicon 2006, Nov 2006, Proceedings
5. Krygier, V. and R. Berndt: Waste Treatment in Photovolatics. SMET Conference, San Francisco, July 17, 2008



Pall Corporation

#### Microelectronics

25 Harbor Park Drive  
Port Washington, NY 11050  
+1 516 484 3600 telephone  
+1 800 360 7255 toll free US

Portsmouth - UK  
+44 (0)23 9230 3303 telephone  
+44 (0)23 9230 2507 fax  
processuk@pall.com

#### Visit us on the Web at [www.pall.com/web](http://www.pall.com/web) location

Pall Corporation has offices and plants throughout the world. For Pall representatives in your area, please go to [www.pall.com/contact](http://www.pall.com/contact)

Because of technological developments related to the products, systems, and/or services described herein, the data and procedures are subject to change without notice. Please consult your Pall representative or visit [www.pall.com](http://www.pall.com) to verify that this information remains valid.

© Copyright 2009, Pall Corporation. Pall, and  are trademarks of Pall Corporation.

® Indicates a trademark registered in the USA. *Filtration. Separation. Solution.<sup>SM</sup>* is a service mark of Pall Corporation.