Employing FilmTec™ Eco Platinum-440i to Recycle RO Brine Cost-effectively in a Semiconductor Plant

Fast Facts

Plant Location:	Taiwan
Application:	Microelectronic Industry
Products:	FilmTec™ Eco Platinum-440i
Feed Water Source:	RO brine from two semiconductor waste water reclaim system and mixed with organic waste water
Targeted Process:	Wastewater collection tank+ Activated Carbon Filter + Relay tank (Non-oxidative biocide added) + RO unit
Feed Water Quality:	High TDS and high TOC which has a high risk of fouling and scaling.
Process Challenge:	Retrofit a RO unit to recycle RO brine which contains much higher TDS. Low operating cost and high permeate water quality are both desired.
Start-up Date:	2014-6

RO brine from a Local Scrubber Wastewater Reclaim System (LSWRS) and a Copper Chemical-mechanical Polishing Wastewater Reclaim System (CCPWRS) was proposed to be recycled as makeup water for cooling towers. In order to reduce investment costs, one train of existing RO unit, which was used as standby for Acidic Wastewater Reclaim System (AWRS), was retrofitted. Since the feed TDS and TOC are both much higher than the RO unit was designed, elevated feed pressure was required and booster pumps had to be replaced if the existing FilmTec™ BW30HR-440i RO elements were used. This would increase investment cost by replacing booster pumps and also increased operating costs on energy consumption. Therefore, low energy RO elements were evaluated in order to lower feed pressure.

Compared to standard low-energy RO element – FilmTec™ BW30HRLE-440i, use of the state-of-the-art low-energy RO element – FilmTec™ Eco Platinum-440i, which employs novel membrane chemistry, has resulted in a nearly 60% improvement in membrane salt passage. In addition, low differential pressure (LDP) 28-mil spacer, which is used for the FilmTec™ Eco Platinum-440i RO elements could lead to a further 15% reduction in feed pressure and energy consumption. Therefore, employing the FilmTec™ Eco Platinum-440i RO element will not only deliver a significant energy cost reduction, but also can achieve a comparable performance to FilmTec™ BW30HR-440i RO element.

Table 1 shows the evaluation results of energy expense among different RO elements (simulated by ROSA). In comparison to FilmTec™ BW30HR-440i, the FilmTec™ Eco Platinum-440i RO elements can save energy expense by up to 7,490 USD every year. Furthermore, it will perform much better than FilmTec™ BW30HRLE-440i RO elements in terms of lower permeate TDS (49.8% less). Therefore, the FilmTec™ Eco Platinum-440i RO elements were identified as the best RO elements and then employed in the ROCRS system.

Three different streams of wastewater (200-250m³/day of organic wastewater, 300-400m³/day of RO concentrate from CCPWRS and 700-800 m³/day of RO concentrate from LSWRS) were collected and mixed in a tank (Table 2 shows the specific water composition of the three different streams of wastewater), and then fed into an activated carbon filter to remove oxidant and partial TOC. Non-oxidative biocide was added to protect the RO unit from biofouling. The RO unit contains two stages; five vessels are required in the first stage and two in the second stage (each vessel contains five RO elements). Figure 1 displays the flow chart of the RO Concentrate Recycling System (ROCRS).

The FilmTec™ Eco Platinum-440i RO elements have been employed in the ROCRS since June, 2014. Figure 2 and Figure 3 show the normalized permeate flow and the normalized pressure drop respectively. In the first couple of days, feed pressure was required at about 9.0 bar to produce 45m³/hr of permeate water, and then increased slightly to 10.0 bar over 60 days. This demonstrates the RO unit performed steadily. However, the normalized permeate flow rate decreased dramatically after that, and the required feed pressure increased from 10.0 bar to 13.6 bar. This indicates the RO elements encountered severe fouling. The fouled FilmTec™ Eco Platinum-440i RO elements were replaced with FilmTec™ HRLE-440i RO elements (former generation of FilmTec™ BW30HRLE-440i) on Sep. 05, 2014, and then cleaned off-site.

Table 3 compares the initial operating data of FilmTec™ HRLE-440i RO elements with FilmTec™ Eco Platinum-440i RO elements. The comparison table shows that the FilmTec™ Eco Platinum-440i RO elements required 2 bar less of feed pressure and consumed 18% less energy. This reveals that the LDP feed spacers, which reduce pressure drop of the RO unit, are key to the advantage of lower energy consumption. In addition, the FilmTec™ Eco Platinum-440i RO elements result in better water quality than the FilmTec™ HRLE-440i RO elements.

The figures illustrate that normalized permeate flow decreased dramatically while the FilmTec™ HRLE-440i RO elements were in use for three weeks. Normalized system pressure drop elevated from 4.0 bar to 7.2 bar over the same period of time, and the second stage of the RO unit contributed mostly to the pressure drop. The results (low normalized permeate flow rate and high normalized pressure drop in the second stage) indicate that the FilmTec™ HRLE-440i RO elements encountered severe scaling.

The cleaned FilmTec™ Eco Platinum-440i RO elements were reloaded into the RO unit at the end of Sep., 2014. The figures demonstrate that the performance of the cleaned FilmTec™ Eco Platinum-440i RO elements are as good as new ones. This indicates that the cleanability of the FilmTec™ Eco Platinum-440i RO elements is remarkable, and the ROCRS can operate effectively and economically when the FilmTec™ Eco Platinum-440i RO elements are used.

Table 1: The Evaluation of Energy Expense among FilmTec™ BW30HR-440i, FilmTec™ BW30HRLE-440i and FilmTec™ Eco Platinum-440i

Project Overview			
Estimated feed water TDS (mg/l)		**1,643**	
Water production per train (m³/Hr)		**45**	
System recovery (%)		**75**	
RO elements per train		**35**	
Power cost ($/kWh)		**0.1**	
ROSA Projection Results			
RO type	**FilmTec™ BW30HR-440i**	**FilmTec™ BW30HRLE-440i**	**FilmTec™ Eco Platinum-440i**
Feed pressure (bar)	14.85	11.23	10.71
Pump specific energy (kWh/m³)	0.69	0.52	0.50
Permeate water TDS (mg/l)	21.70	49.15	24.67
Energy Expense Calculation			
Energy expense ($/m³)	0.069	0.052	0.050
System energy expense ($/year)	27,200	20,498	19,710
System energy saving ($/year)		6,702	7,490

Table 2: Specific Water Composition of RO Concentrates and Organic Wastewater

Item	Organic Wastewater	RO Concentrate from CCWRS	RO Concentrate from LSWRS
Water quantity (m^3/day)	200 – 250	300 – 400	700 – 800
Water quality			
pH	5.82	9.9	10.61
Conductivity (µs/cm)	14.32	3,190	2,890
Ammonium (mg/l)	0.12	0.83	0.12
Calcium (mg/l)	0.08	ND	5
Magnesium	ND	ND	1
Fluoride (mg/l)	1.12	2.2	99
Chloride (mg/l)	ND	797	238
Nitrate (mg/l)	0.6	ND	7.2
Alkalinity (mg/l, as $CaCO_3$)	2.5	150	720
Phosphate (mg/l)	0.05	0.01	7.5
Sulfate (mg/l)	ND	24	1
Silica (mg/l)	0.5	2.6	49.6
Total organic carbon (mg/l)	448	36	43

Table 3: A Comparison of Initial Operating Data between FilmTec™ HRLE-440i RO elements and FilmTec™ Eco Platinum-440i RO elements

RO element	Permeate flow rate (m^3/hr)	Feed pressure (bar)	System pressure drop (bar)	Specific energy consumption (kWh/m^3)	Permeate water quality (µs/cm)
FilmTec™ HRLE-440i	45	11.0	4.0	0.51	205
FilmTec™ Eco Platinum-440i	45	9.0	1.9	0.42	115

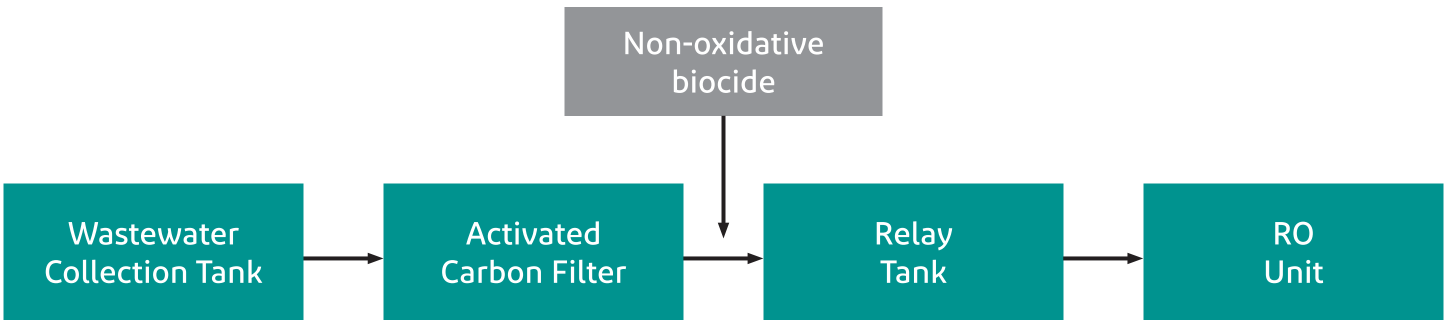

Figure 1: Flow Chart of the RO Concentrate Recycling System

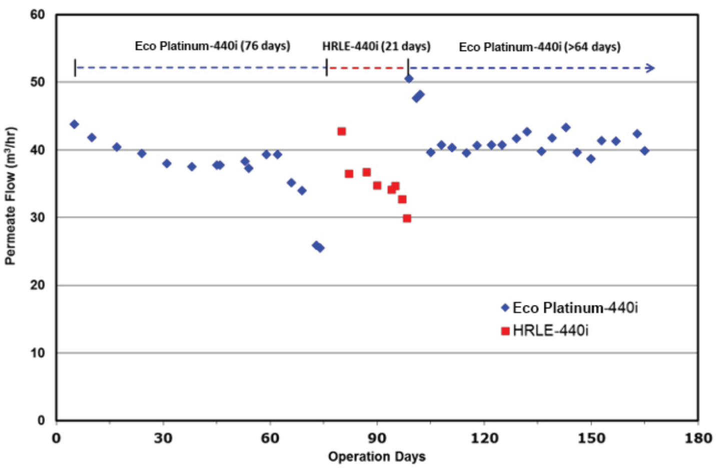

Figure 2: Normalized Permeate Flow Rate of the RO unit in the ROCRS

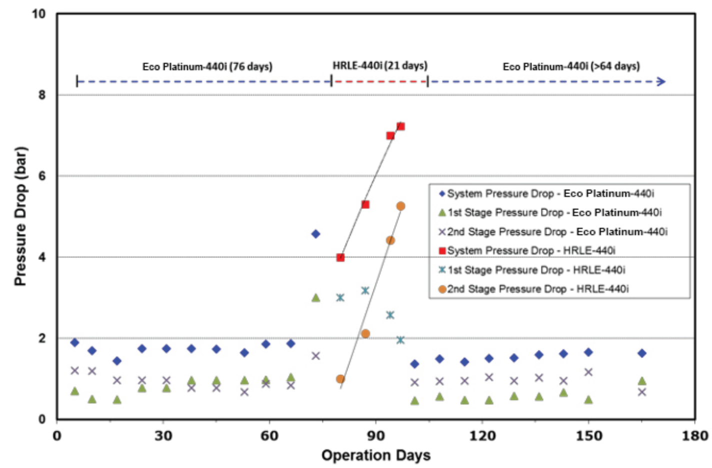

Figure 3: Normalized Pressure Drop of the RO unit in the ROCRS

Literature – Ronald Wen-Jung Chang et al., EMPLOYING NOVEL REVERSE OSMOSIS ELEMENTS TO RECYCLE RO CONCENTRATE COST-EFFECTIVELY IN A SEMICONDUCTOR PLANT, IDA World Congress Sep., 2015.

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