

## Slurry handling

# Customised fix for abrasive PV slurry

The manufacturing of wafers for photovoltaic (PV) solar panels requires a precise process that puts production equipment to the test. Several of these processes involve highly abrasive slurries, which are a mixture of glycol and powdered silicon carbide. The challenge is to find equipment that can handle both wet and dry applications in a corrosive environment.

Slurries are used as the cutting agent when silicon ingots pass through the wire saw machine, producing thin silicon wafers. Eventually, the slurry becomes contaminated by silicon particles, iron and other by-products from the sawing process, which render it unusable. Since slurry is one of the more expensive products used in the solar wafer manufacturing process, many solar wafer manufacturers have invested in systems that reprocess and reuse the slurry on site rather than discard it after use.

Headquartered in Louisville, Kentucky, USA, CRS Reprocessing Services is a large provider of silicon carbide slurry reprocessing, enabling the recycling and reuse of more than 150,000 MT of slurry

annually. CRS is responsible for recovering spent slurries for companies that serve the solar PV and semiconductor industry, including three of the top solar wafer manufacturers in the world.

### The CRS process

CRS's process for recovering spent slurries incorporates diluents and mechanical processes devoid of chemicals to facilitate the separation of recoverable grit and carrier. As part of this process, CRS offers Optimized Reprocessing Management (ORM), which involves designing, building, installing, operating and maintaining the reprocessing infrastructure at its customers' facilities to ensure a consistent, high-quality product at a low operational cost.

To help guarantee that slurry reprocessing is running as efficiently and effectively as possible, CRS installs customized equipment and provides operating technicians and engineering support within a customer's infrastructure.

Slurry is often second in cost only to the raw material silicon, so any cost savings can impact the bottom line in a substantial way. Optimizing slurry reprocessing can have dramatic, lasting effects on wafer product costs and overall quality.

"Our business model is to provide slurry reprocessing on-site for the customer, and we are obligated to provide a 24-hour-7-day-a-week service," says Scott Radeker, Vice President of Operations for CRS. "So when we go to design a system at a customer's facility, we have to consider component up-time and identify the possible weak points in the process. We need to ensure our customers always have slurry available to them. When we have equipment failures or outages, we put our customers at risk of being down, which would be a huge cost to them, and we could potentially be obligated to help cover that cost."

### The problem of pumping slurry

Heavy-duty industrial pumps play a vital role in slurry reprocessing: they transport the silicon carbide slurry through the slurry recovery process. This enables CRS to separate the reusable carrier fluid (polyethylene glycol or light mineral oil) and the silicon grit, from the diluting substance,



Almatec E-Series pumps installed at one of CRS Reprocessing Services' newest slurry reprocessing facilities in Korea.



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which is used to facilitate the separation of the recoverable grit and carrier fluid. The pumping equipment must be made from materials that are able to resist the etching or galling caused by the abrasive slurries. It is critical that the pumps remain reliable despite these demanding conditions.

"When you are trying to transport slurry from point A to point B, one of the things that can be challenging is selecting the correct pump for the application because they have a tendency to wear very quickly," explains Radeker. "One of the biggest costs for us – and for our customers – is interrupted supply. So, from our perspective, a pump needs to be reliable and able to feed the process consistently. It has to have a long mean time between failure, and an extremely low rate of breakage."



Silicon carbide slurry is an extremely abrasive material.

### Slurry applications

Since becoming involved with slurry reprocessing, CRS has utilized a number of different types of pumps for its slurry applications, but found that most of them were not suitable for handling slurry. For instance, many slurry processes involve both wet and dry applications, and few pumps are well suited for both. CRS also found that pumps made with metal parts frequently corrode quickly due to the abrasive slurry, and the sealing oil's lubricating properties degrade under the sharp silicon particles. Another problem experienced by some pumps is pulsation during liquid transfer, which can interrupt or clog the flow of material, resulting in pressure spikes and, ultimately, leakage and breakdowns.

"When we first started getting involved with slurry, we had pumps that would last for a matter of days or even hours," says Radeker. "We were using a brand of diaphragm pumps that were just not holding up. In terms of reliability and total cost of ownership, we needed to go in a different direction with our pumping technology."

Before becoming the Global Project Engineering Manager for CRS, Andreas Franke worked as a field technician in one of CRS's facilities in Germany. While in the field, one of his responsibilities was to maintain the pumping equipment, and it became obvious that the pumping equipment

being utilized by CRS was turning into more of a problem than a solution. Over the years, he has seen his fair share of costly pump breakdowns and failures.

"When I was still a field technician, all of our slurry regulation systems were designed for use with oil-based slurry, so we were able to use diaphragm pumps manufactured from aluminium," says Franke. "But when we started using a slurry with PEG as the carrier, we learned pretty quickly that aluminium pumps were not resistant enough against this type of slurry. We had all sorts of pump failures. The main reasons were either



*Almatec E-Series pumps have reduced CRS's maintenance costs by roughly 80% versus other pumps.*

broken diaphragms, or the bolt check valves wore out too quickly. We knew we needed a new pumping solution. This was about the time we discovered Almatec."

### PE pumps to the rescue

In the summer of 2005, Almatec®, a German-based manufacturer of air-operated double diaphragm (AODD) pumps, approached CRS with an idea. They provided an alternative pump, with features and materials of construction more ideally suited to slurry applications.

Franke explains: "Almatec conducted some tests comparing different types of materials to find out which materials held up best against abrasive liquids. They compared aluminium, polypropylene (PP) and polyethylene (PE). After the results were in, it became pretty clear that PE was going to be a much better solution."

As a result of these tests, and after discussing additional features with CRS, Almatec began manufacturing modified plastic air-operated diaphragm pumps that feature a solid body design constructed with PE material, which has an abrasion resistance seven times higher than that of polypropylene and 1.6 times higher than steel. By utilizing a dense solid body construction, Almatec was able to create a harder, more reliable pump that has the capability to handle the demands of working with slurry, all the while lengthening the pump's life cycle and eliminating many maintenance concerns. This solid body construction also provides a wide range of advantages to CRS, including increased pump safety due to a ring-tightening structure; increased product capacity; decreased air consumption; reduced noise level; optimized flow pattern; and a screwed-on or flanged pulsation damper.

"Almatec gave us a few test pumps and we installed them in one of our reprocessing

systems in Germany and they lasted for over three months," explains Franke. "At the time, three months was extremely impressive to us. It became clear that these pumps were far superior to the pumps we were previously using, mainly because these pumps were machined from solid PE material. They lasted so much longer than our previous aluminium pumps. In fact, the pumps worked so well, we asked Almatec to provide us with a 3" model of the pump. We needed a bigger pump for our long slurry loops. Almatec provided one, we tested it, and it worked great!"

In addition to solid body construction, Almatec designed the pumps with diaphragms that have larger overall diameters combined with shorter than normal stroke lengths, which facilitates low flex loads and equates to a longer diaphragm life. This results in lower operational costs and fewer pump breakdowns.

"Prior to switching to Almatec pumps, we were spending quite a bit on pump maintenance costs, and our field technicians were spending 60 - 70% of their time servicing pumps," says Franke. "With Almatec, we cut our pump maintenance costs by roughly 80%. Since these Almatec pumps feature a long lifetime and easy maintenance, it really cuts down on our operating costs."

### A success story

After the success CRS experienced with Almatec pumps in its German facilities, CRS has purchased and installed Almatec pumps for all of its current reprocessing systems. Almatec pumps will also be used in any new systems.

"From a customer and vendor perspective, Almatec was extremely willing to work with us and develop these pumps to the specifications we needed," says Radeker. "They listened to our employees worldwide and learned what pump improvements were needed. We use perhaps 25 to 30 different vendors to build one of our systems. As far as Almatec is concerned, I can't recall a time when we've had a supply issue that wasn't resolved quickly. We get the parts and the pumps when we need them. Almatec pumps have definitely been worth it from a cost of ownership standpoint. We have adopted Almatec pumps on all of our systems ever since."

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