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Title: TRUMPF Optimises Ion Exchange System With Reliable and Continuous Data From Real-Time Arsenic Analyzer

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Challenge:

- minimise water loss
- protect water resources
- boost treatment efficiency/effectivity (process control & optimisation)
- recycle water (reuse; recovery of resources)
- combat climate change
- value water (awareness raising; participatory monitoring)
- attract talent (counter effects of an aging work force)
- other:

Location: TRUMPF Photonics, Inc., (TRUMPF), Princeton, N.J, United States

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Introduction & background information

TRUMPF Photonics, Inc., (TRUMPF) in Princeton, N.J., is a manufacturer of laser diodes made from Gallium Arsenide substrates (GaAs) wafers. The GaAs wafers must be thinned as part of the product requirements, a process that allows arsenic to dissolve into the wastewater stream creating hazardous waste that must be treated prior to discharge.

In 2019, TRUMPF implemented a new wafer thinning process to move away from lapping, a low capability process, as compared to grinding, a high capability process. TRUMPF needed to attain reliable and continuous measurements of arsenic concentrations in its wastewater in order to ensure compliance of the process wastewater so that it can be safely discharged. As a result, TRUMPF selected an online Arsenic monitor, MetalGuard™ Arsenic, manufactured by Aqua Metrology Systems. The analyser continuously measures influent and effluent arsenic levels in real-time, providing TRUMPF with a stream of accurate and reliable arsenic data to measure the performance of its ion exchange (IEX) system and ensure regulatory compliance.

Water quality challenge

In an effort to improve its laser diodes manufacturing processes, TRUMPF implemented, grinding, a new high-capability wafer thinning process to move away from lapping, a low capability process. However, deionized water (DI) is used in the grinding operation to serve as a lubricant and as a carrier vehicle for the grinding wheel to pull the Gallium Arsenide (GaAs) particles away from the grinding wheel and into the waste stream.

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Both lapping and grinding create a wafer with a thinness of 110 um while generating 1-2 kg of GaAs waste per week; however, the grinding process creates 30 times more hazardous wastewater by volume than the lapping process requiring treatment. The lapping process generated (12) 55-gallon drums of wastewater per week with associated treatment costs averaging \$185K per year, while the grinding process was predicted to produce (346) 55-gallon drums a week, posing a severe logistical constraint for TRUMPF given the facility cannot accommodate the large amount of waste, at an estimated cost of \$5M per year to treat.

Approach and implementation

To ensure a cost-effective wastewater treatment solution for its new wafer thinning technology and high capability grinding process, TRUMPF undertook a threefold treatment approach, including removal of particles through cartridge filtration; removal of the dissolved ionic arsenic through ion exchange (IEX); and containment, measurement, reduction trace arsenic particle amounts in wastewater, and release compliant wastewater to the city sewer.

Following a third-party engineering report to determine a suitable IEX treatment method, TRUMPF implemented a multi-stage treatment approach including 1- and 5-micron cartridge filtration (CF) to remove GaAs particulates, followed by IEX filtration system composed of one carbon filter for organic removal, and two arsenic resin tanks and two mixed-bed resin tanks to remove dissolved ionic (free) arsenic.

TRUMPF must meet a regulatory requirement of 500 parts per billion (ppb) or less of arsenic to be discharged to the local municipal treatment facility. However, the wafer thinning process generates untreated influent wastewater with arsenic levels of 42.1 parts per million (ppm).

The online Arsenic monitor MetalGuard™ Arsenic provided TRUMPF with reliable and continuous measurements of arsenic concentrations in its wastewater. With the high frequency of data, TRUMPF was able to trend results at multiple stages in the wastewater remediation system to identify patterns and develop learning opportunities. The timely and accurate arsenic results enabled TRUMPF to optimize rinse water reuse as well as reduce IEX backwash frequencies, increasing media performance and reducing hazardous waste generation. The online analyser also afforded TRUMPF the flexibility to monitor performance of the wastewater remediation system while the grinder is running product or in stand-by. The real-time arsenic data also eliminated the requirement for TRUMPF to store treated wastewater until lab results were returned and confirmed regulatory compliance.

Costs and maintenance

The total cost of TRUMPF's wastewater treatment project for its new high-capability grinding process, including the Arsenic monitoring solution, was \$350,400.

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The MetalGuard™ Arsenic, which uses Anodic Stripping Voltammetry (AVS) technology to measure arsenic concentrations in real time, is well suited to provide unattended automated water quality analysis. The system requires semi-annual maintenance and comes with an inclusive service plan. It is also designed to run self-diagnostics, is auto-calibrating, features field-replaceable modules for ease of maintenance, and comes with a replaceable reagent tray, which provides up to 1,000 measurements.

Data handling

The analyser continuously measures influent and effluent arsenic levels in real-time, providing TRUMPF with a stream of accurate and reliable arsenic data to measure the performance of its IEX system and ensure regulatory compliance. The high frequency of arsenic data enabled TRUMPF to operate its IEX to treat actual arsenic levels, not dated values produced from standard analytical methods that can take up to two weeks to produce results.

With the online arsenic analyser, TRUMPF obtained measurement results in 30 minutes to better understand the effect of the different treatment stages on arsenic within the wastewater management system. In addition, the data from the online arsenic analyser was in excellent agreement with external lab results and provided TRUMPF with an extremely high degree of confidence.

Evaluation of successes and limitations

The MetalGuard™ Arsenic high-frequency data enabled TRUMPF to trend results at multiple stages in the wastewater remediation system to identify patterns and develop learning opportunities. The timely and accurate arsenic results enabled TRUMPF to optimize rinse water reuse as well as reduce IEX backwash frequencies, increasing media performance and reducing hazardous waste generation. The online analyser also afforded TRUMPF the flexibility to monitor performance of the wastewater remediation system while the grinder is running product or in stand-by. The real-time arsenic data also eliminated the requirement for TRUMPF to store treated wastewater until lab results were returned and confirmed regulatory compliance.

With a reliable method to continuously measure performance of the arsenic remediation system in real time, TRUMPF was able to move to close-looped system within months, instead of years. The high frequency of accurate and reliable results from the online arsenic analyser gave TRUMPF the confidence to recirculate the treated water back to the grinder as the DI source input reducing its water consumption by 90%. By treating and recirculating the wastewater, the overall DI water consumption of the grinding process was reduced to a lower level than the lapping process. All combined, this allowed TRUMPF to not only minimize costs, but ensure that it operates in a greener, more sustainability-focused and environmentally responsible manner.

The three-fold wastewater treatment approach undertaken by TRUMPF to ensure a cost-effective solution for its new wafer thinning technology and high capability grinding process has resulted in

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process improvements that have provided an estimated annual cost savings of approximately \$150K with a return on investment of less than one year. And the closed-loop system design leaves open the opportunity to possibly reclaim the Gallium from the GaAs left in the particle filters, which would bring TRUMPF an additional estimated \$3K annually.

Lessons learnt

To ensure regulatory compliance of 500 parts per billion (ppb) or less of arsenic in order to discharge its wastewater safely into the local municipal treatment facility, TRUMPF needed to attain reliable and continuous measurements of arsenic concentrations and confirm the effectiveness of its wastewater treatment.

The use of the online MetalGuard™ Arsenic analyser provided confidence and the ability to create trend data to evaluate the effectiveness of the waste treatment system as it was being used and refined. The implementation of the online arsenic monitoring system to sample, measure and analyse data in real-time internally saved both time and money for the facility.

In addition, the arsenic abatement system was converted to a closed-loop system which resulted in 90% effective water conservation system over the open-loop system. The use of the online MetalGuard Arsenic analyser and IEX systems delivered process knowledge and cost savings (over \$150K) compared with the prior drum and contain system.