PVA TePla
Digitised single-crystal growth

Semiconductors: ingot production perfected

How PVA TePla optimises single-crystal growth through automation

PVA TePla AG is a global leading provider of equipment and measuring technology for demanding industrial applications. Its high-tech systems are particularly sought after in the semiconductor industry.
"As a solution provider, we operate globally and are present wherever our customers are. Driven by strong demand from the semiconductor industry, we are currently especially well represented in the Asian market and in the United States," explains Jan Pfeiffer, Managing Director of the PVA TePla Group.
With its TechHub in Wettenberg, PVA TePla has positioned itself as a key driver of innovation in materials research for the semiconductor industry.

Silicon carbide – the key to electromobility

The subsidiary PVA Crystal Growing Systems (PVA CGS) can draw on more than 60 years of experience in crystal growing. A particular focus is placed on the production of silicon carbide (SiC) crystals.

The silicon carbide crystals produced on these systems are used, among other applications, in batteries for electromobility.

Silicon carbide puck: The required quality can only be achieved with precisely controlled process parameters.

"What sets silicon carbide crystals apart is their ability to handle extreme power densities," explains **Lukas Ewert**, team leader Electrical Design at PVA CGS. *"Compared with conventional silicon, the use of SiC enables, for example, the design of smaller batteries with the same power output. The resulting weight reduction is particularly beneficial for electromobility applications."*

> *"We use IO-Link wherever we want to extract more detailed information from the sensors. For example, we use the SM8000 for monitoring and controlling the cooling circuit.*

Extreme conditions require maximum precision

For the production of SiC crystals, PVA TePla designed the SiCma system, which operates according to the Physical Vapor Transport (PVT) method.

"In this process, a silicon carbon powder mixture undergoes sublimation in a graphite crucible at around 2,300 °C and deposits onto a seed crystal to form a boule," explains **Ewert**. *"To achieve a high-quality result, temperature and pressure in the process chamber must be precisely controlled throughout the entire crystal growing process. Even the smallest deviations can jeopardise the entire process and lead to significant quality losses."*

Because such a growth process can take up to three weeks, process monitoring and control must continuously meet the highest standards.

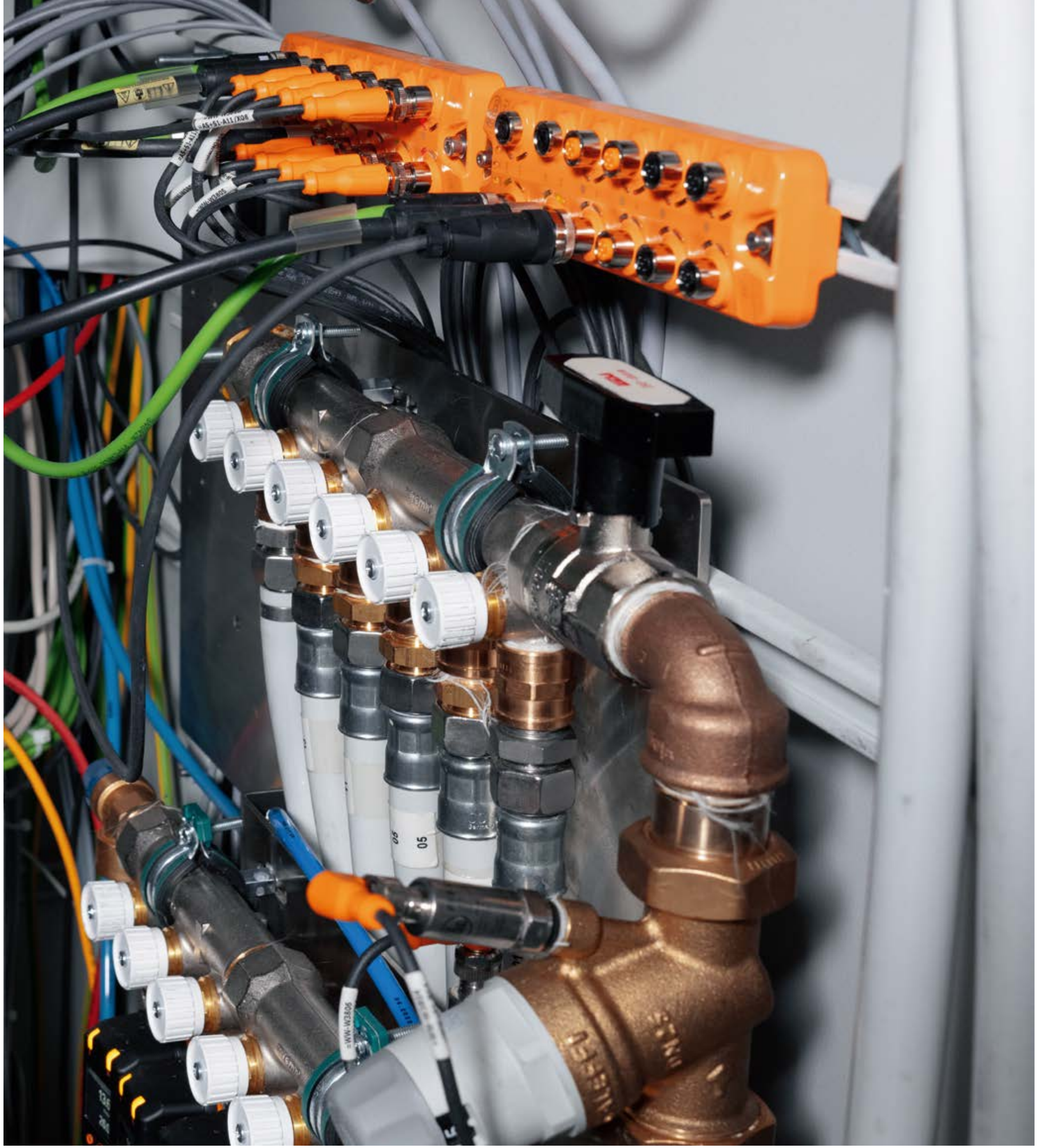
Intelligent sensors ensure stable process conditions

To ensure the required level of precision, PVA relies on IO-Link-capable sensors from ifm.

"For example, we use the SV4200 flow sensor from ifm to monitor and keep the cooling water flows constant. This is important not only for maintaining a stable process temperature, but also for protecting housings, pipes and components from overheating and thus from potential damage", explains **Ewert**. In addition, the PV8000 pressure sensor monitors the supply and return pressure as well as the temperature of the cooling medium. *"Previously, this monitoring was carried out manually. Now we can also retrieve these values via IO-Link and respond to any fluctuations more quickly and effectively,"* the team leader adds. The AL1202 IO-Link masters collect all sensor data and forward it for central evaluation. The DV signal lamp, which provides users with a visual indication of the current process status, is also controlled via the IO-Link master.

IO-Link: more information, greater system transparency

IO-Link has long been established as a manufacturer-independent standard for digital sensor communication in automation technology. Compared with conventional binary and analogue interfaces, IO-Link enables the transmission of high-resolution process values as well as comprehensive diagnostic information. Users benefit from standardised data structures, reduced cabling effort and seamless integration into control systems and IIoT architectures. The technology supports the transmission of multiple measured values per device, event-driven



The IO-Link master (top) collects and forwards data from the pressure sensor (centre, front) and the flow sensor (lower left).

diagnostics and remote device parameter setting. This results in improved system transparency, optimised maintenance and measurable savings in set-up and operating costs.

Digitalisation as the key factor for system availability

These aspects also play a central role at PVA TePla. *"Digitalisation is extremely important for us, especially with the SiCma system,"* emphasises Lukas Ewert. *"These systems are often installed in large numbers in production halls. Loading and unloading are usually fully automated. Our systems must be able to communicate with higher-level systems so that operators can monitor the process status centrally at any time."* PVA TePla uses ifm's comprehensive IO-Link portfolio as the basis for this.

Predictive maintenance for maximum production efficiency

PVA is also working intensively on predictive maintenance concepts in order to provide early indication of upcoming maintenance requirements or process deviations. *"This allows operators to maintain maximum machine availability while consistently achieving the highest possible product quality,"* explains Ewert. The sensors from ifm supply the data required to continuously monitor system condition and to detect potential issues before they result in costly downtime.

Silicon crystal growth using the Czochralski process

PVA places similarly high demands on silicon crystal growth using the Czochralski process. In these systems, silicon ingots up to 3.50 metres in length are grown by slowly pulling a seed crystal from molten silicon at a temperature of around 1,400 °C. The resulting wafers are used primarily in the semiconductor industry and form the basis for a wide range of electronic components.

Silicon ingots up to 3.5 metres in length are "pulled" in this system for wafer production.

Flow sensors monitor the cooling circuit of the Czochralski system.

Low-vibration processes for the highest product quality

"In the SC32 system, automation technology is implemented as a combination of IO-Link and ProfiNet," explains **Ewert**. *"We use IO-Link wherever we want to extract more detailed information from the sensors. For example, we use the SM8000 for monitoring and controlling the cooling circuit."*

This magnetic-inductive flow sensor measures not only the flow rate but also the temperature of the medium. In addition, PVA uses the three-axis IO-Link vibration sensor VVB3 to monitor the two process drives. The VVB3 detects vibrations along three measurement axes and calculates indicators for evaluating the machine condition. Information on fatigue, friction, impacts or bearing wear is transmitted conveniently via IO-Link.

"Extremely low vibration levels during the pulling process are essential to ensure ingot quality. The transmitted data also allows us to monitor the condition of the gear units and the drive shaft very precisely and to schedule maintenance activities at an early stage."

Reliable components for long-term operation

PVA TePla's systems are designed for continuous operation over many years.

"For this reason, all components, sensors in particular, must deliver consistently precise performance over the long term", emphasises **Lukas Ewert**. *"Over many years, we have had only positive experiences with ifm in terms of robustness and reliability in long-term operation. Likewise, when new questions arise or new automation approaches are considered, we can rely on our direct contact at ifm and receive expert support at short notice."*

Under high pressure, individual layers are bonded together into a single structure in this machine.

Easy to read: flow sensors on a diffusion bonding system.

Diffusion bonding for the most demanding material requirements

ifm solutions are also used in diffusion bonding technology, another business area of PVA TePla. This solid-state joining process is used, for example, to produce cooling plates for the semiconductor industry, which must meet the highest requirements in terms of strength and corrosion resistance. Patrick Müller, Team Leader Diffusion Bonding at PVA Löt- und Werkstofftechnik GmbH, explains: *"To achieve the desired results, process conditions such as temperature, pressure, vacuum and the applied force must be closely monitored throughout the process, which can last several weeks in some cases. The flow sensors from ifm we use to monitor the cooling circuit ensure that the system does not overheat at any point during the process, but remains in a safe operating state."*

User-friendliness as added value

Another advantage of ifm's solutions is their ease of use. Müller highlights the clear, intuitive design of the sensors: *"As an operator, you can see at a glance what condition the machine is in. Another clear benefit is how easily older machines can be retrofitted with the sensors. It is effectively plug and play."* This user-friendly design not only simplifies day-to-day operation, but also reduces training requirements for operating personnel.

A collaborative partnership as the foundation for innovation

At PVA TePla, the long-standing cooperation with ifm as an automation partner is highly valued: *"I'd describe our collaboration with ifm as very cooperative, reliable and based on trust,"* summarises Lukas Ewert. *"We can always approach our contacts directly and work together to drive innovation and automation projects forward."*

Conclusion

The requirements in high-tech materials manufacturing are extremely demanding, particularly in terms of precision, reliability and availability. With ifm as its automation partner, PVA TePla successfully meets the challenges associated with advanced crystal growing processes.

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