

APPLICATION NOTES



Temperature Control for **Semiconductor Chip Manufacturing**

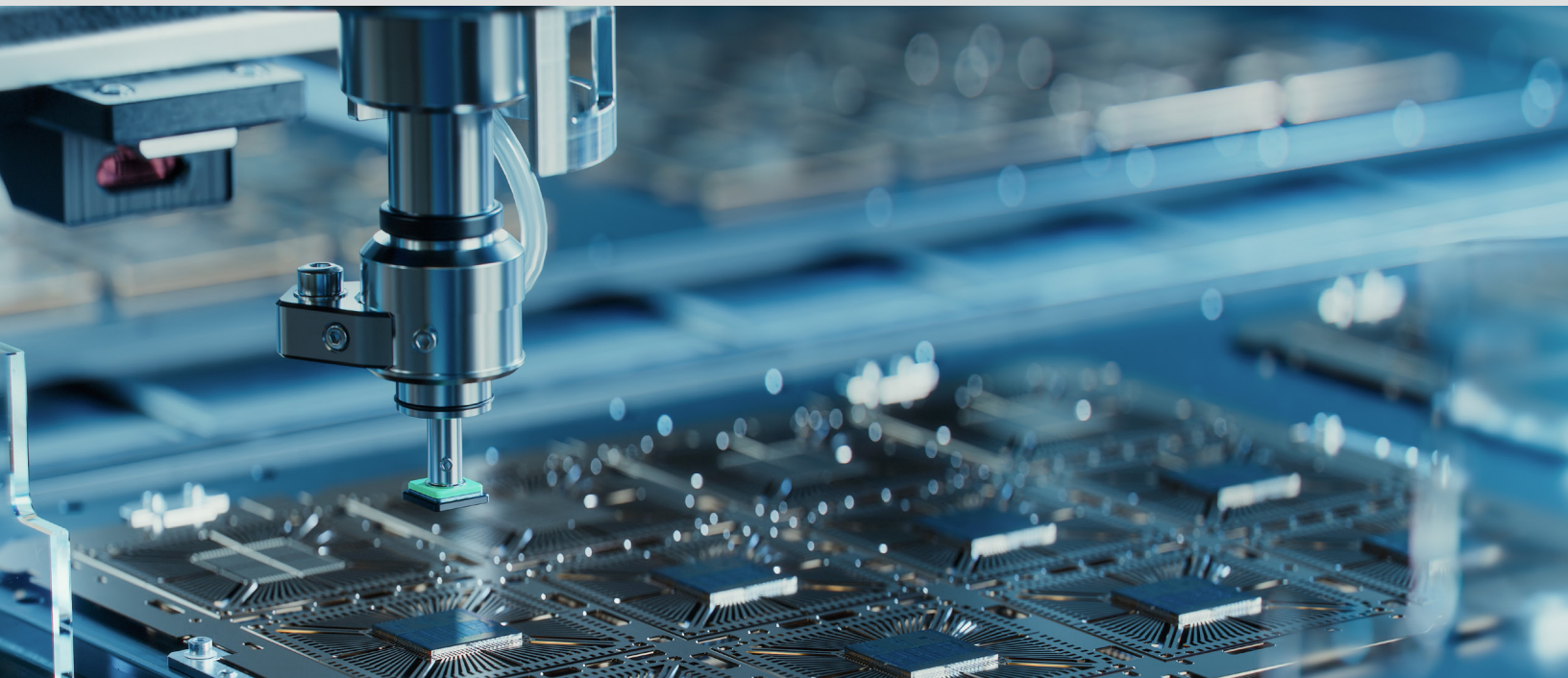
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T E M P E R A T U R E C O N T R O L

Microchips and the Modern World

Recent chip shortages have highlighted the critical importance of the semiconductor industry. Today's most convenient products depend on the chip, or the microchip, including smartphones, computers, video games, medical devices, wearable technologies, data storage devices, GPS systems, and smart home devices connected to the Internet of Things. Many industries also depend on the semiconductor industry for success, including aerospace and defense, avionics, healthcare, electronic payment systems, automotive, and renewable energy.

Manufacturing innovations heavily rely on a steady supply of chips. Recent chip shortages delayed product launches and impacted many supply chains. In addition to innovation, concerns about global warming have increased investments in renewable energy, such as solar power, which requires advanced semiconductor technologies. In this application note, we will discuss the importance of precise liquid temperature control in semiconductor manufacturing and highlight the solutions provided by JULABO that can help semiconductor manufacturers meet the growing demand for more chips and the products that rely on them.

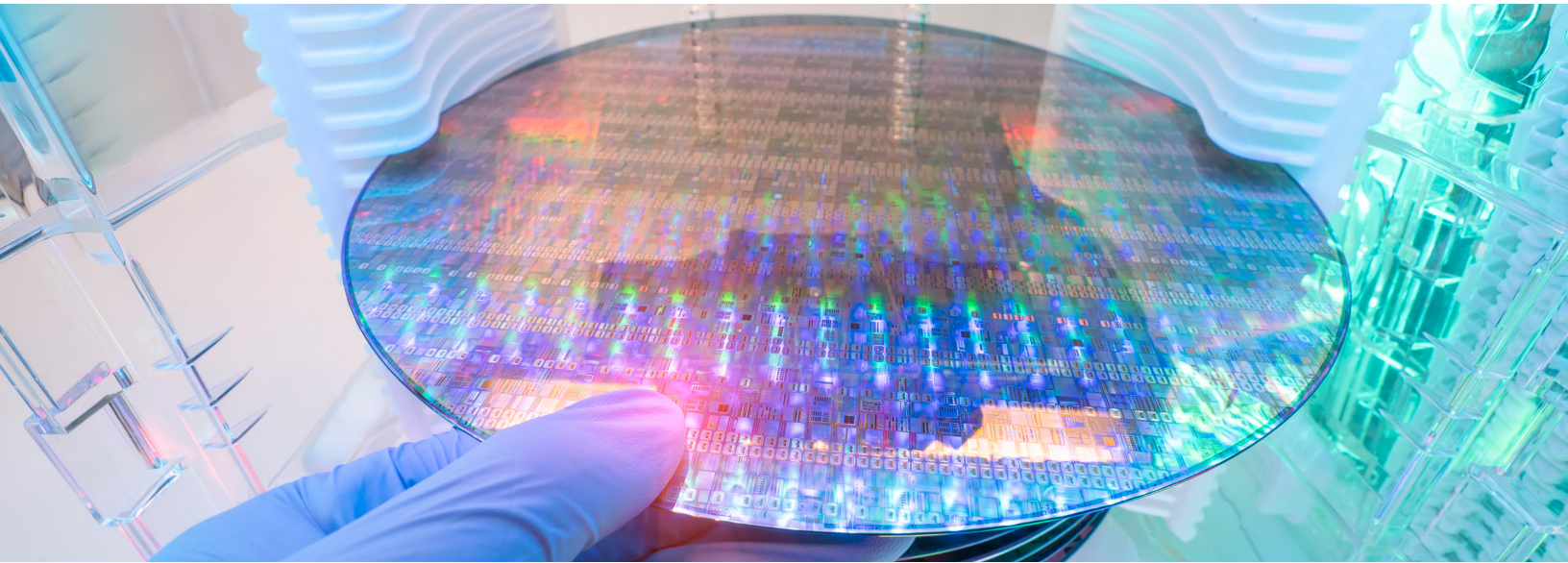
RENEWABLE ENERGY, INCLUDING SOLAR POWER,
REQUIRES SEMICONDUCTORS.



Temperature Control for
Semiconductor Chip Manufacturing

Application Overview

Semiconductors are materials with electrical conductivity properties that fall between conductors, which allow easy flow of electricity and insulators, which resist the flow of electricity. They are used to make electronic components such as transistors, diodes, and integrated circuits. Microchips are integrated circuits made up of electronic components, including semiconductors. So while semiconductors are a type of material used to make electronic components, microchips are a specific type of electronic component made using semiconductors.



PHOTOLITHOGRAPHY

Microchips are collections of interacting transistors that are controlled by external inputs. Microchips are commonly made out of silicon, a widely used semiconductor material, and formed into a wafer. The silicon used in microchip manufacturing is extremely pure to ensure consistent and reliable electronic performance. Creating microchips involves etching circuits onto a thin silicon layer/wafer using various techniques, such as photolithography.

Precise temperature control is critical in photolithography, which involves using light to transfer a pattern from a mask to a photosensitive material, called a photoresist on a silicon wafer. Temperature affects the photoresist's properties and the pattern transfer's accuracy. The temperature of the photoresist and the silicon wafer must be maintained within a precise range to ensure the correct chemical reaction between the photoresist and the light. Deviations from the optimal temperature can lead to under or overexposure, resulting in errors in the pattern transfer.

TEMPERATURE CONTROL IS ESSENTIAL FOR PATTERN
TRANSFER IN PHOTOLITHOGRAPHY.

Application Overview Cont.

SEMICONDUCTIVITY & DOPING

Silicon does not conduct electricity naturally; therefore, the silicon molecules must be doped with either boron or phosphorus to make the material electrically conductive. The doping process occurs at very high temperatures, and the resulting material needs to be precisely cooled to avoid damage to the sensitive product. Furthermore, the manufacturing process is highly sensitive to temperature changes, and any slight error can lead to malfunctions. Therefore, liquid temperature control products are important to semiconductor manufacturing, including JULABO's SemiChill product line, Ultra-Low chillers, and PRESTO line.



BORON, SILICON, AND PHOSPHOROUS ARE CLOSELY RELATED ON THE PERIODIC TABLE OF ELEMENTS.

SOLAR PANELS

Similar temperature-sensitive processes occur in manufacturing photovoltaic solar panels, using silicon as the semiconductor material. In producing solar panels, silicon is deposited onto a substrate and then processed to create photovoltaic cells that generate electricity. During the deposition of silicon onto the substrate, the temperature must be maintained at a precise level to ensure that the silicon adheres correctly and forms a uniform layer. If the temperature is too high or too low, it can lead to defects in the silicon layer, resulting in reduced solar panel efficiency.

JULABO's heaters, such as the Forte HT products, can be used on the production line to achieve temperatures around 300°C, ensuring high-quality solar panel manufacturing.

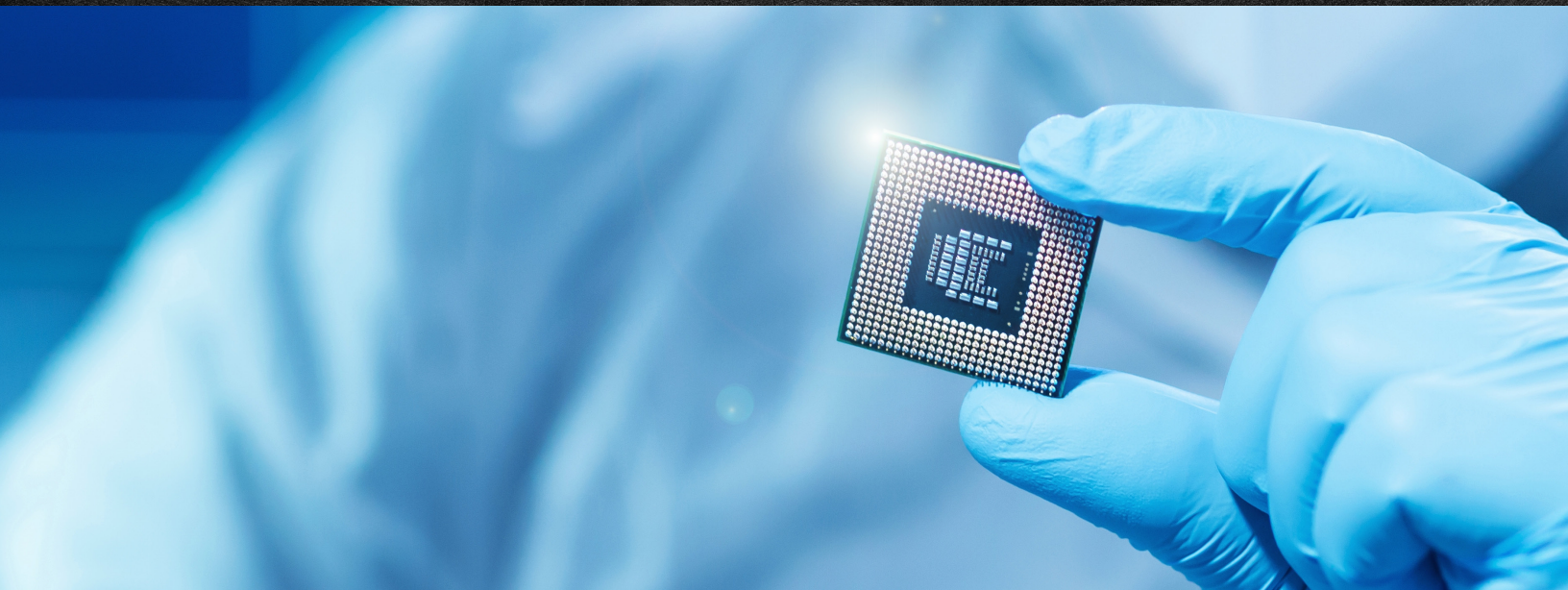


Challenges & Considerations

CLEANLINESS

The semiconductor manufacturing process requires clean room facilities, and any impurities can compromise the functionality of the wafer. JULABO's liquid temperature control units are placed outside the manufacturing room to avoid dust from ventilation, ensuring the highest cleanliness levels. Air-cooled units can be placed outside clean rooms and operated remotely. Water-cooled models, which don't disturb air flow, can be placed inside the clean room.

TEMPERATURE CONTROL UNITS WITH REMOTE OPERATIONS ARE
CRITICAL FOR CLEAN ROOM OPERATIONS.



THERMAL FLUIDS

The liquid temperature control units must circulate thermal fluids into the application, which must be silicon-free to avoid detrimental interactions with the wafer. Therefore, polyfluorinated polymers such as Fluorinert™ and Galden™ are used. The highly volatile and dielectric (nonconductive) fluids are a huge advantage for leaks and spills as they will evaporate without residue, which can compromise the wafer's functionality. However, the liquid cycle must be kept leak-tight, which can cause challenges. JULABO's PRESTO product line ensures leak-free operations.

SILICONE-BASED FLUIDS CAN NOT BE USED IN THE
MANUFACTURING OF WAFERS AND CHIPS.



Explore Temperature Control Solutions for Semiconductor Chip Manufacturing

Our SemiChill and PRESTO models are ideal for chip manufacturing, however, we have a full portfolio of temperature control products and would be glad to help you find the perfect solution for your application needs.

SEMICHILL RECIRCULATING CHILLER
FOR SEMICONDUCTIVITY AND DOPING.



SC5000w

PRESTO W56, PRESTO W56X, PRESTO W91, PRESTO W91X, PRESTO W92, AND PRESTO W92X

Our Highly Dynamic Temperature Control Systems are ideal for clean rooms, leak-free operations, and silicon-free fluids.



PRESTO W56



PRESTO W91



PRESTO W92

FROM -92°C TO $+250^{\circ}\text{C}$ WITH CENTRIFUGAL
OR GEAR PUMPS.








Conclusion

The semiconductor industry requires precise liquid temperature control to achieve the physical and chemical characteristics necessary for high-quality products. Temperature control is crucial in semiconductor manufacturing, as even slight errors can lead to malfunctions. JULABO provides liquid temperature control solutions that ensure high precision, cleanliness, and environmental sustainability in semiconductor and microchip manufacturing.



Next Steps

We have in-depth experience consulting with semiconductor manufacturers to find the best temperature control solutions for their application needs. If you need expert consultation, contact us directly.

-  Convenient shipping and delivery
-  2-year warranty with optional extended coverage
-  Virtual and in-person training and support
-  Extended service hours, web chats, installations, and training
-  In-house service technicians and additional service providers across North America
-  NRTL, UL/CSA marked units
-  German-engineered products

For personalized product recommendations and application assistance, please reach out to JULABO USA directly:



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