By: Adam Freyler, VP of Sales and Marketing (Americas) on January 8th, 2024

How do I select a pressure transducer for Semiconductor UHP Gas applications.

PRESSURE TRANSDUCERS | SEMICONDUCTOR INDUSTRY

If you work in semiconductor manufacturing, you understand that the process requires highly specialized equipment and instruments that can handle harsh applications involving corrosive gases and chemicals. Transducers, for example, are critical for measuring pressure throughout the production process to control the flow and distribution of ultra-high purity (UHP) gases safely and effectively. However, not all transducers can handle such challenging conditions. That's why selecting the right one for your operation is a critical step in ensuring the successful creation of your product.

Ashcroft and our parent company Nagano Keiki Co. LTD, have a long and proven track record of supplying pressure and temperature instrumentation to semiconductor manufacturing customers worldwide. This article will share our insights into semiconductor UHP gas processes and the unique challenges for pressure measurement instrumentation used in semiconductor applications. It will also review the best types of pressure transducers that are designed for these complex processes.

The complexities of semiconductor manufacturing.

Semiconductor manufacturing requires highly complex equipment along numerous stages to transform a blank silicon wafer into a microelectronic device. The process chambers within these pieces of equipment perform the removal or layering of materials onto the wafer and ultimately form the pathways and junctions enabling the flow and storage of electronic signals.

For this process to run smoothly, precision measurements are needed to manage pressure, temperature, flow and other variables. For example, the instrument you use to monitor and control gas pressure in these applications (like the ZT12 Pressure Transducer) must offer highly accurate and repeatable measurements while ensuring absolute cleanliness inside the system.

For the greatest success, your instruments need to be:

Designed to fit.

Careful design is essential for systems used to deliver UHP gases from the source (i.e., a cylinder) to the process chamber where the wafers are located. It involves injecting UHP gases at relatively high pressure (compressed) and often reducing pressure to near or below atmospheric pressure in the process chamber.

Physical size can be one of the most important factors in the selection of any instrument in Semiconductor Equipment applications and bigger is generally NOT better. Space is always at a premium when a designing a process tool and the surrounding support equipment.

A process tool chamber may require 15 or more different gas supply / vacuum lines packed alongside thousands of wire harnesses, sight glasses, openings, heaters and a multitude of other devices. In gas boxes, where the different process gasses are routed into the process tool chamber, pressure transducers are paired with combinations of valves, gauges, regulators, mass flow controllers and other devices often in high density arrangements.

It is important to consider that pressure transducers need to be connected to both the gas and electrical systems as well while needing to remain accessible in order to calibrate or adjust the output signal. In this case, minimizing the height and the diameter of transducers help make the transducer easier to install AND service.

Utilizing the right sensing technology and the right materials.

Factors that may impact the accuracy of pressure transducers in these applications include the sensor technology used within the device, the materials of construction, and its resistance to environmental impacts. In addition to purity, precision and corrosion resistance, resistance to hydrogen can be a critical factor.

Hydrogen is used in a variety of different semiconductor applications. For instance, it is used as an effective “scavenger gas” to remove oxygen in a crystal growth process called Epitaxy2. But hydrogen also has a unique challenge: it is known to cause embrittlement in certain metals.

Embrittlement is a phenomenon that causes loss of ductility and, consequently, brittleness in a material. In a pressure transducer that utilizes a diaphragm to consistently flex like a spring, embrittlement can have a very negative impact on the repeatability and stability of the device. 316L Stainless steel is commonly employed due to its combination of broad resistance to corrosion as well as its proven resistance to hydrogen embrittlement.

Hydrogen is also known permeate through materials including metals. Certain technologies use extremely thin isolation diaphragms and oil backfilling to sense pressure. For example, Isolated Piezo-resistive sensing elements can have diaphragm thicknesses under 0.001”/0.03mm (thinner than typical human hair) which can allow hydrogen ions to pass though the diaphragm and dissolving into the oil backfill which may create serious problems with measurement accuracy drift due to what is sometimes called the “Jiffy Pop” effect.

In addition to having no oil fill, Thin film sensing elements such as the CVD technology utilized in the ZT12 and ZT16 use a robust diaphragm which are generally 10-30x thicker and do far better in mitigation of hydrogen permeation.

Compatible and Resistant to Electromagnetic Interference (EMC/EMI).

EMC/EMI are the unwanted electromagnetic disturbances that can interfere with the functioning of electronic devices or systems. In practice, these interferences can be generated from typical equipment sources found in industrial environments such as from motors, pumps and drives. EMI can also be generated from the many unique high voltage/high power processes used in Semiconductor applications that create plasma, ions and RF fields. These sources may release large amounts of static discharge or create large electromagnetic fields that can impact instrumentation like pressure transducers.

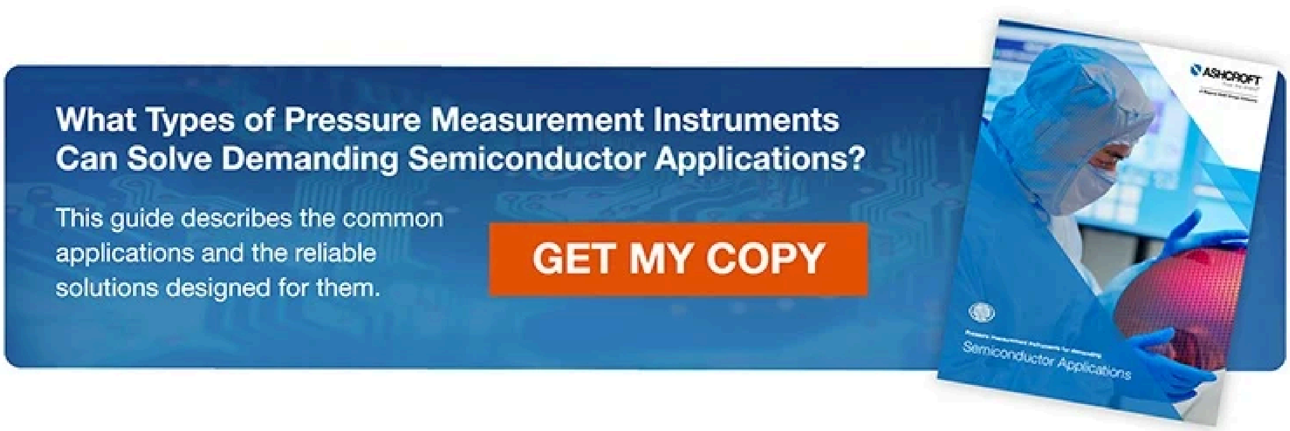
EMI can create several undesired effects with instruments like pressure transducers that can impact the accuracy of a signal temporarily, cause long-term drift, reduce the lifespan, or even destroy a device altogether. A standard from the SEMI industry association was created (SEMI E176-1017) to manage and mitigate EMI within semiconductor processes, but it may be impossible to fully eliminate it. It is, therefore, very important to select products that meet EMC/EMI standards and fully test them in the applications.

Changes to semiconductor processes are inevitable.

With a better understanding of the challenges in semiconductor UHP gas processes and the pressure measurement solutions designed to meet those challenges, you can be sure of one thing: change is coming. The global semiconductor industry is expected to continue robust growth over the next few years, so semiconductor suppliers face the challenge of improving supply to meet demand. This includes increasing transistor density, improving reliability, and, of course, reducing production and purchasing costs. This is especially true for materials in emerging technologies such as Artificial Intelligence (AI), The Internet of Things (IoT), and numerous others.

Stay informed of the latest trends and innovations in this ever-changing industry and the products that best support its stringent requirements. Visit Ashcroft.com to learn more.

In the meantime, if you would like more information on selecting a pressure transducer for your semiconductor application, download our free guide or contact one of our product experts with any questions you have.



1 NIST Fluid Metrology Group Index of Semiconductor Processes Gases

2 Epitaxy - Physical Principles and Technical Implementation ISBN 978-3-642-08737-0

About Adam Freyler, VP of Sales and Marketing (Americas)

Adam has been our Vice President of Sales and Marketing for the Americas since 2014, leading the company's sales and marketing teams in the Americas and is responsible for product strategy and driving sales growth in this market. Prior to joining the executive team, Adam was responsible for the sales and marketing of our electronic products. His previous experience includes 10 years in the industrial sensor business including roles in sales management, marketing and engineering at GE Druck and Gems Sensors. Adam earned his B.S. in Physics from the University of Maryland. Adam is an enthusiastic football fan and enjoys fishing, kayaking and spending time outdoors with his family.