

Pressure Measurement Applications in the Semiconductor Industry White Paper

Pressure Measurement in the Semiconductor Industry



As a provider of pressure testing and measurement solutions for our own MEMS processes, Druck fully understands the importance and complexity of semiconductor processes.

Druck is a world-renowned provider of pressure testing and measurement solutions, with more than 50 years of design and manufacturing history in pressure sensors, pressure controllers and calibration instruments. At the same time, Druck is also one of the few companies in the industry with silicon process capabilities – from wafer processing to final product delivery, every component of every Druck product is traceable. Druck is committed to making your pressure measurement worry-free in demanding application environments.





Semiconductor components are an integral part of many industries and applications. From consumer electronics, communications, transportation, to energy and medical care, semiconductor products are vital to all aspects of people's daily lives. In recent years, the semiconductor industry has maintained a vigorous development trend. Not only has the total industry output value continued to increase in the past few years, but we also have reason to believe that this strong growth trend will continue in the next few decades.

In the production of semiconductor devices, the measurement, calibration and control of pressure, a physical quantity, are key components of many processes. Druck is a well-known brand in the pressure measurement industry. After more than half a century of development and innovation, we have fully accumulated practical experience in many industries, including semiconductors. In this white paper, we will discuss how Druck technology solves the extremely challenging pressure testing and measurement requirements in various semiconductor processes.

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Overview

Overview

Druck's full range of pressure testing and measurement products can play an important role in the production and quality control of the semiconductor industry. In addition to the various pressure sensors, pressure controllers and calibration standard products shown in this manual, we can also customize products according to your unique application requirements.

The table in the selection guide lists the corresponding relationship between Druck products and various pressure testing and measurement applications in the semiconductor industry. On the next page, you can find the core indicators of these products. If you need to know more about product performance, please visit Druck's official website or WeChat public account, or contact Druck's local sales representative.

Product Selection

Selection Guide

Products and Applications		Lithography	Dry Etching / Chemical Vapor Deposition			Chemical Mechanical Polishing	Quality Control
		Light Source Protective Gas	Ultrapur Gas Application	MFC/PC	IGS	Air Chamber Pressure Measurement / Calibration	Pressure Calibration and Control
Pressure Sensor	TERPS	✓					✓
	UNIK5000-UHP		✓		✓		
	DPS 530D			✓			
	ADROIT 6,200					✓	
Pressure Core Body	PDCR 1,000			✓			
	PdP			✓			
Pressure Calibrator	DPI 620 GENii						★
	DPI 800					★	★
Pressure Controller	PACE		★	★	★	★	★

- ✓ Pressure measurement
- ★ Pressure calibration and control

Portfolio

Druck Product Series



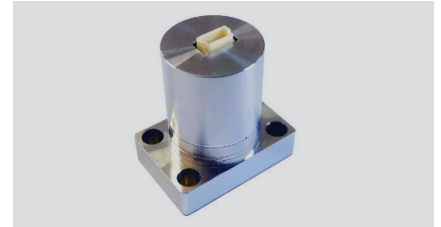
TERPS Series High Precision Pressure Sensor

- Pressure range: 1 to 200 bar
- Total accuracy: $\pm 0.01\%$ FS
- Compensation temperature range: -55°C to 125°C
- Stability: ± 100 ppm FS/year
- Output signal options: RS232, RS485, USB 2.0, CANBus, TTL



UNIK5000P-UHP Series Ultrapure Pressure Sensor

- Pressure range: Up to 5000 psi
- Accuracy: $\pm 0.2\%$ FS BSL
- Stability: $\pm 0.05\%$ FS (typical value)
- VCR compatible fitting and C-Seal available
- Compliant with SEMI standards, VIM/VAR available
- Hazardous area certification optional



DPS530D Series Digital Pressure Sensor

- Pressure range: 300 kPa absolute pressure, other ranges are optional
- Full temperature precision: $\pm 0.1\%$ FS ($0 - 70^{\circ}\text{C}$)
- Signal output: 1°C (response time 1ms)
- Annual stability: $\pm 0.05\%$ FS
- Temperature signal output
- 17.5 mm diameter



D17.5/D12.5 Series Pressure Module

- Pressure range: 0.2 to 70 bar
- Combined hysteresis and repeatability $< 0.05\%$ FS, excellent long term stability
- High proof pressure, high sensitivity
- 17.5mm and 12.5mm diameter available
- Flush face pressure port, EP surface optional
- Hastelloy diaphragm and ring available



PDCR1000 Millivolt Pressure Sensor

- Pressure range: Up to 10 bar
- Accuracy: $\pm 0.25\%$ FS BSL
- Signal output: 100 mV
- 17.8 mm diameter
- Operating temperature: -20°C to 80°C
- Flush face pressure port



PdP Series Absolute Pressure / Differential Pressure Module

- Differential pressure range: 1, 3 and 5 psi
- Absolute pressure range: 50 psi
- Line pressure: Up to 150 psi
- Operating temperature: -20°C to 80°C
- Excellent repeatability and long-term stability
- Flush face pressure port for easy welding



ADROIT6200 High Accuracy Pressure Sensor

- Pressure range: 70 mbar to 350 bar
- Total accuracy: $\pm 0.1\%$ Span
- Room temperature accuracy: $\pm 0.02\%$ Span BSL
- Compensation temperature range: -40°C to 125°C
- 19 mm diameter



DPI802 Series Portable Pressure Calibrator

- Pressure range: 2.5 kPa to 70 MPa (including vacuum option)
- Precision: Up to $\pm 0.01\%$ FS
- Working temperature range: -10°C to 50°C
- Supports IDOS pressure modules
- Single or dual range configuration available



PACE Series Pressure Controller

- Pressure range: 0.35 to 3000 psi optional
- Control precision: Up to $\pm 0.001\%$ FS
- Control stability: Better than $\pm 0.001\%$ FS
- Single channel / dual channel optional
- High speed pressure control

Gas Supply System

Special Gas Supply System

Special Gas Supply System

Ultrapure pressure sensors used in special gas supply system

In semiconductor production lines, ultrapure pressure sensors are widely used in various types of equipment that require precise pressure measurement and flow control of ultrapure media. These types of equipment include special gas cabinets, flow distribution boxes (VDB), valve manifold boxes (VMB), gas pipelines, etc. In view of the high requirements of the semiconductor industry for gas-related applications, the pressure sensors used often need to meet the necessary ultra-pure, anti-corrosion, anti-leakage and other characteristics required by the system. At the same time, the other requirements also include degreasing and cleaning of the part of the pressure port that is in contact with the medium, vacuum packaging of the product, use of special pressure joints, etc.



UNIK Series Ultrapure Pressure Sensors

Druck Solution

Compliant with SEMI standards, high precision, and superior long-term stability

Druck's UNIK5000-UHP series are pressure sensor series specially developed for special gas applications in the semiconductor industry. These series meet semiconductor industry standards and have a maximum range of 5000 psi. Strict production standards are adopted, and they are packaged and delivered in a strictly controlled clean environment. Wetted parts comply with SEMI specifications, and 316L stainless steel or VAR/VIM materials are optional. In order to comply with the high-purity and ultra-high-purity requirements of the semiconductor industry, all products have passed the 1×10^{-10} mbar/s helium leak detection test.

The design of Druck's ultrapure pressure sensors is derived from the classic UNIK 5000 series products, which have long-term proven high reliability and stability. The UNIK5000-UHP, which combines high precision and high stability, have been recognized by many users.

Product Features

- Excellent long-term stability: $\pm 0.05\%$ FS / year
- High Overpressure: 4 times full-scale overpressure
- Wide temperature compensation range: -40 to 125 °C
- Use of Japan Daido stainless steel material, compatible with various special gases
- Compatible with VCR connector and C-Seal
- Wetted parts are EP polished to reach the RA5 ($0.13\mu\text{m}$) grade
- Fast delivery and global service

Lithography

Lithography

Lithography

High precision pressure measurement to avoid overheating

The lithography machine, also known as the mask alignment exposure machine, is one of the most complex and critical equipment in the semiconductor production process. It can be described as the core of the chip manufacturing process. It uses a technology similar to photo printing, which is to print the fine graphics on the mask onto the silicon wafer through light exposure.

In order to ensure the high precision of the light source subsystem, several high precision pressure sensors need to be deployed in it, including for nitrogen supply control, overheating protection, atmospheric pressure measurement and other measurement points. The Druck TERPS series (DPS8100) is a pressure sensor based on MEMS technology. Its high precision and high stability are very suitable for integration into the lithography equipment.

Product Features

- High precision
- Excellent long-term stability
- Flexible configuration options
- Customizable



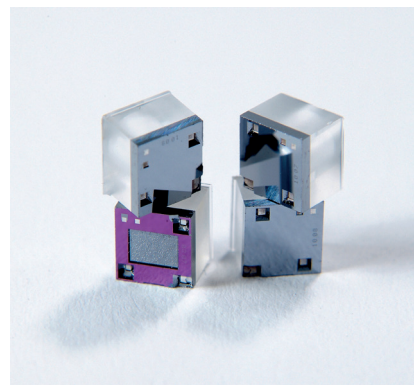
TERPS High Precision Pressure Sensor

Druck Solution

High precision and high long-term stability

TERPS is the abbreviation of trench etched resonant pressure sensor. It is the flagship product in Druck's pressure sensor product series. TERPS can achieve a full temperature precision of $\pm 0.01\%$ FS and an annual long-term stability of $\pm 0.01\%$ FS. In addition, this product offers many different configurations to meet the product indicator requirements of your different applications.

Based on the high precision and long-term stability characteristics of TERPS, this product is also suitable for other applications in the semiconductor industry that have more stringent performance requirements, such as the calibration of pressure-related equipment (see page 11).



TERPS Silicon Wafers

Mass Flow / Pressure Controller

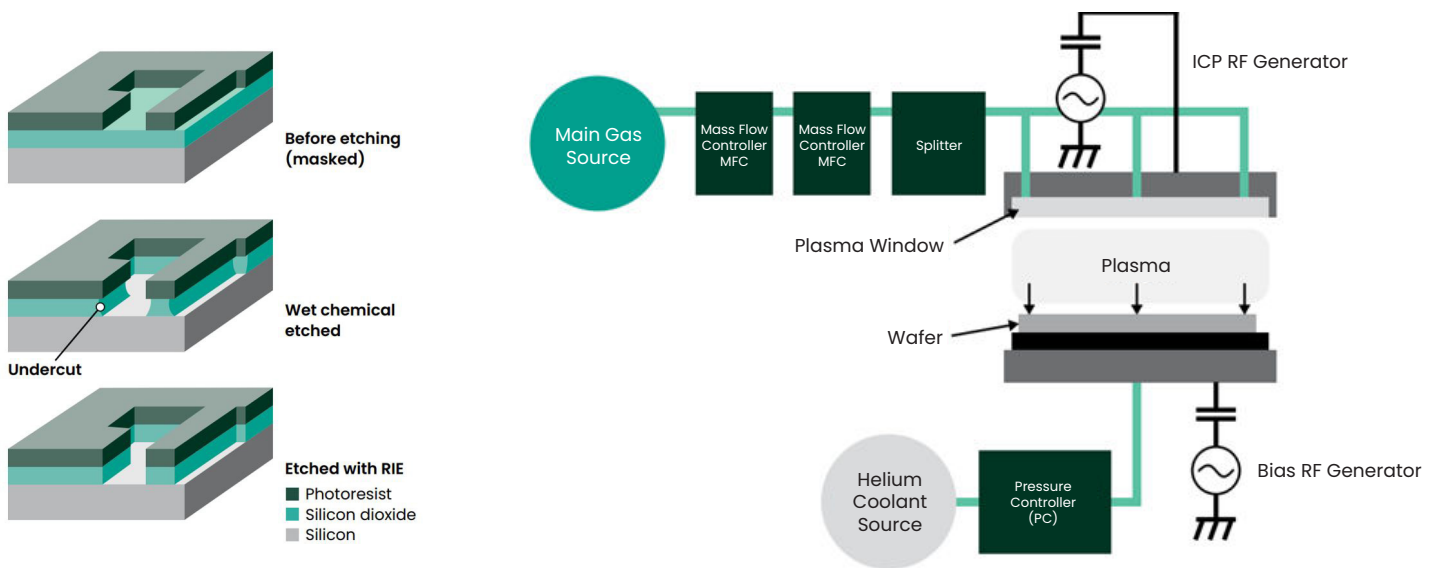
Mass Flow Controller / Pressure Controller

Development and Refined Control of MFC/PC

Technology evolution of flow and pressure in semiconductor chemical vapor deposition / dry etching processes

Dry etching and chemical vapor deposition (CVD) are key processes to form the multi-layer overall structure of silicon wafers. Dry etching is used to form trenches of the target structure for the CVD deposition material in the next process by using gases such as halogenated compounds, oxygen, ozone, helium, hydrogen, hydrocarbons, and nitrogen oxides to form a plasma, selectively reacting physically and chemically with the wafer materials (such as silicon dioxide, etc.) exposed to the plasma through the masking layer window opened by lithography, and removing the materials.

Nowadays, a 300 mm (12-inch) diameter wafer has become the mainstream choice for current manufacturing processes, but corresponding challenges have also come with it. Compared to a 200 mm diameter wafer, it is more difficult to apply plasma uniformly throughout the wafer. To this end, dry etching equipment manufacturers need to control the air supply in the vacuum reaction chamber with higher precision. This places higher requirements on the precision of the mass flow controller (MFC) used on the main gas supply system to control the flow rate of gas injected into the vacuum chamber. Similarly, the precision requirements for the pressure controller (PC) in the helium coolant supply system have also been further increased. The schematic diagram of typical dry etching equipment and its pressure control is shown below.



Schematic Diagram of Dry Etching Principle

Dry Etching Equipment and its Pressure Control

Measuring, calibrating and controlling pressure

Druck Solution

Special pressure sensor for pressure controller (PC) of dry etching system

Druck's PDCR1000 series is a small-sized analog output piezoresistive pressure sensor. It is specially designed for the pressure controllers of the dry etching system and is one of the core devices. It is used to precisely measure pressure and temperature in order to control the helium flow. With its high precision, high long-term stability and high reliability, it has been chosen by many users related to dry etching processes.

It is worth mentioning that this product can work in a wide pressure range from vacuum to pressurized states, providing reliable pressure and temperature signals for the control of high speed valves in the PC.



Druck PDCR1000 Series
Pressure Sensor

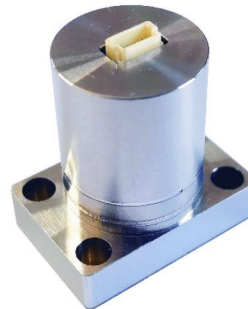
Druck Solution

Special digital pressure sensor for the next generation of MFCs

In order to meet the control requirements of more uniform air supply and more stable temperature in the new generation of 300 mm wafer manufacturing process, Druck has developed and applied innovative digital technology and launched the digital high precision pressure sensor DPS530D specially designed for the next generation of MFCs. Its characteristics include:

1. High speed I²C interface with 1ms response time
2. Digital compensation to achieve $\pm 0.1\%$ FS accuracy over compensation temperature range
3. Full range calibrated pressure and temperature signal outputs

Compared with traditional analog sensors, digital interface can significantly simplify circuit and system design for MFC manufacturers, and can configure the required pressure and temperature data and perform calibration through instruction codes. The fast response time is more suitable for the control of high speed valves. At the same time, compared with the previous generation of MFC pressure sensors, the DPS530D itself integrates temperature signal output and temperature compensation for high accuracy pressure output, so that MFC manufacturers no longer need to perform calibration and compensation by themselves during the production process. With these new features, MFC manufacturers can reduce the total cost of their product and greatly improve the MFC performance and production efficiency.



Druck DPS530D Series Digital
Pressure Sensor

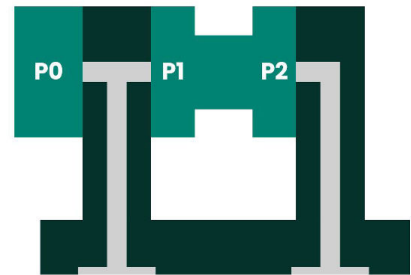
Druck Solution

Special pressure module for miniaturized differential pressure MFCs

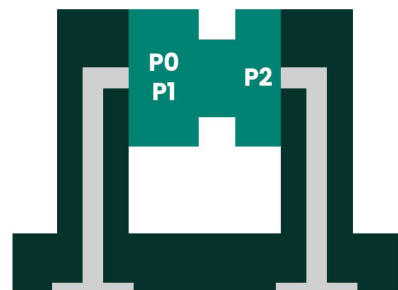
In some pressure based mass flow controllers, it is often necessary to measure the inlet pressure P0 and the difference between the pressures P1 and P2 on both sides of the flow restrictor to calculate and control the flow rate. However, more sensor elements make the structural design and assembly of the MFC system more complicated. Druck has developed a special absolute pressure / differential pressure dual output sensor module PdP for the new generation of miniaturized differential pressure MFCs. Its characteristics include:

1. Integrated differential pressure sensitive component to eliminate consistency errors
2. Integrated inlet static pressure sensitive component
3. Low differential pressure range and high static pressure tolerance
4. Excellent repeatability and long-term stability

Compared with traditional MFCs with complex structures, the PdP sensor module is highly integrated with P0, P1, and P2. With the help of these innovative functions, it not only improves the precision of differential pressure measurement to a new level, but it also greatly reduces the number of parts inside this type of MFC and simplifies the welding process, thereby significantly reducing the cost of the product. In addition, the repeatability and stability of Druck silicon piezoresistive pressure sensing components make it easier for MFC manufacturers to perform subsequent welding and compensation. While the structure is more compact, the performance of MFC products is further improved.



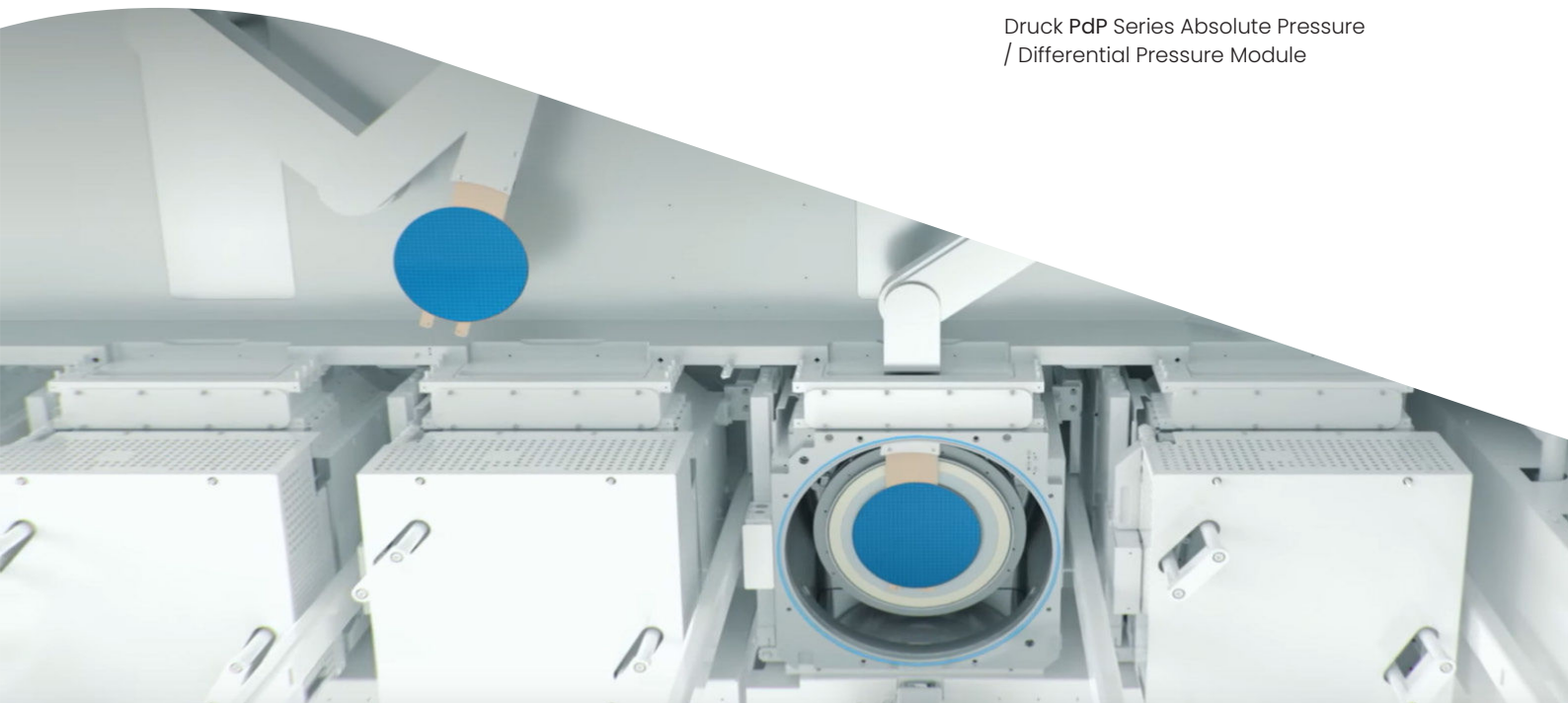
Schematic Diagram of Traditional Differential Pressure MFC Structure



Schematic Diagram of Differential Pressure MFC Using PdP



Druck PdP Series Absolute Pressure / Differential Pressure Module



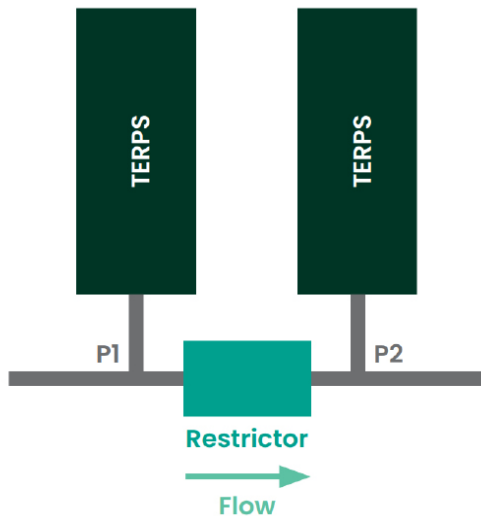
Mass Flow Calibration

Mass Flow Controller Calibration

Mass Flow Controller (MFC) Calibration

Pressure-based working standards

MFC is an instrument used to precisely measure and control the mass flow of fluids. It is widely used in multiple processes in the semiconductor production process. Its factory standards have high-level quality control standards and traceability requirements. Therefore, many manufacturers hope to establish a MFC differential pressure calibration system that complies with the working standards and is traceable, in order to ensure the factory quality of their MFC products during mass production and provide standards for onsite maintenance and calibration during subsequent use.



Principle of Pressure-Based Mass Flow Calibration System



USB Output TERPS Pressure Sensor

Druck Solution

High precision, superior long-term stability, and multiple port options

In order to realize the function of the standard instrument, this differential pressure mass flow calibration system puts forward extremely high precision, long-term stability, range and reliability requirements for the pressure sensor used. Druck's silicon resonant pressure sensor TERPS is an ideal choice. Its principle is shown in the figure on the left. By measuring the inlet pressure P1 and outlet pressure P2 at both ends of the flow restrictor, the mass flow rate Q can be calculated by using the following formula, thereby achieving calibration of the mass flow rate. Where kT is the constant value of the restrictor at temperature T.

$$Q = kT (P1^2 - P2^2)$$

Druck's TERPS series pressure sensors provide a calibration system that meets the working standards and is traceable for MFC calibration. In addition, it is worth mentioning that we can also provide silicon piezoresistive pressure sensors and pressure modules for differential pressure MFC manufacturers.

Product Features

- ±0.01% FS full temperature precision and ±100 ppm annual stability can ensure calibration accuracy and extend maintenance cycles
- Resolution up to 10 ppm
- Pressure measurement data in ASCII code format can be directly output through the RS-232/RS-485 serial port or USB interface to simplify the system design.
- Multiple ranges, pressure ports, etc. are optional

Chemical Mechanical Polishing

Chemical Mechanical Polishing (CMP)

High reliability pressure measurement and calibration

The purpose of chemical mechanical polishing is to achieve the highest possible global planarization of the silicon wafer surface and occupies a key position in large-scale integrated circuit manufacturing. Before and after this process, its planarization degree or non-uniformity (MRR, Material Removal Rate) can be characterized by the Preston equation:

$$MRR = k \cdot P \cdot V$$

Where P is the external pressure exerted on the surface of the silicon wafer. The smaller the MRR value, the higher the degree of planarization and the higher the precision of the polishing process. With the development and advancement of CMP processes, the precision and reliability requirements for pressure sensors deployed in wafer carriers are also increasing. At the same time, in order to ensure the consistency of its precision during long-term use, the importance of daily calibration is also increasing.

Druck Solution

Multiple product options and customizable

Druck's DPI 800 series portable pressure and electrical signal calibrator is an excellent choice for daily calibration tasks of pressure sensors in CMP equipment. This product can calibrate the pressure value of the pressure chamber of the wafer carrier to ensure the consistency of equipment indicators.

In addition, Druck's ADROIT 6200 and UNIK5000 series pressure sensors are also very suitable for OEM applications in CMP equipment. The pressure medium in many measuring points contains various chemical compositions, and these two series of pressure sensors have good media compatibility. When our shelf products cannot meet your OEM needs, we can also provide you with customized services for pressure sensors.



DPI 800 Series Portable
Calibrator



ADROIT6200 Series High Precision
Pressure Sensor

[Druck helps ensure accuracy and reliability in Semiconductor plants across the world]

Quality Control

Quality Control

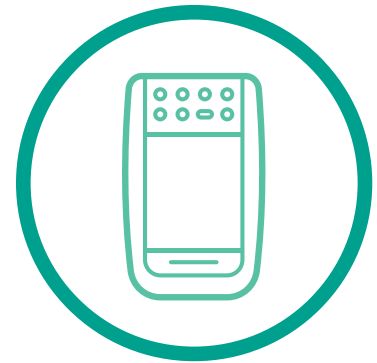
Druck Portable Calibrator

Druck's portable calibrator products are committed to making your daily calibration work more convenient and efficient. During the rigorous design, research and development stage, we fully considered your daily use experience – whether it is connection, reading, or interactive experience, all are unique.

Druck PACE Series Pressure Controller

Druck's PACE series pneumatic pressure controller integrates Druck's patented pressure control algorithm and high precision pressure measurement technology, providing an outstanding and cost-effective solution for pressure control in production, testing and calibration. In order to improve the control stability and speed, it adopts full digital control. The digital compensation pressure sensor used inside ensures the quality and stability of the PACE series products, while improving the bandwidth and precision.

As a pressure controller product known for its control speed in the industry, Druck's PACE series products are fully compatible with Druck's 4Sight2 calibration management software, providing you with an integrated, paperless calibration solution. You can manage the pressure control system with one click, greatly reducing calibration time and machine maintenance downtime.



GENii High-Performance Modular Calibration System

Druck's DPI 620 Genii is a convenient and easy-to-use three-in-one multifunctional all-in-one calibrator that integrates functions such as calibration, detection and HART/Foundation Fieldbus communicator, and can provide high-precision calibration functions for pressure, electrical signals, temperature and frequency. Combined with the PV 624 series of portable automatic pressure controllers newly released by Druck in 2023, the GENii modular calibration system can provide users with high-performance, modular and portable solutions for pressure control and pressure calibration applications.



Handheld Calibrator

From Druck's DPI 800 series of handheld high precision pressure calibrators to the DPI 610E series of portable pressure calibrators newly released in 2022, you can get an accurate, fast, convenient and easy-to-use pressure calibration experience on site. The DPI 800 series has many commonly used onsite calibration and maintenance functions, and supports the Druck IDOS module. It is an ideal choice for onsite pressure testing and maintenance, transmitter calibration, loop setup and diagnosis, switch calibration and other applications. The DPI 610E has stronger and more convenient pressure generating capabilities, and supports external sensor access to extend the range and achieve temperature measurement. The new industrial design and human-machine interaction make operation more convenient.



PACE Series Pressure Controller

The modular high precision PACE series pressure controller based on Druck's TERPS technology is specially designed for pressure calibration and automated testing applications in laboratories, test benches, desktops and racks. The TERPS technology ensures the high precision and long-term stability of the built-in pressure sensing unit, and obtains high control stability, control speed and load capacity through a digital control algorithm with excellent performance. The modular design can enhance user flexibility when using the instrument, reduce downtime and lower overall cost of ownership.

The PACE 1000 precision pressure indicator / barometer incorporates Druck's patented TERPS technology. We welcome you to scan the QR code on the back cover for more information.

Excellent Company in Global Manufacturing

Our pressure testing and measurement solutions are manufactured in the UK, China and Norway, allowing us to be even closer to our customers. Each factory is ISO9001 certified, UKAS and Aerospace AS9100 certified, and operates under the strict quality control process of Baker Hughes. Our continued investment in advanced manufacturing technologies and processes keeps us at the forefront of product quality and efficiency.

Pressure Measurement and Sensing

Founded as a start-up company in Leicester, UK in 1972, it has now developed into a world-renowned pressure testing and measurement company and a well-known brand for manufacturing high quality and high precision piezoresistive and resonant pressure sensing and measurement solutions. We have customers in more than 70 countries around the world, serving a variety of industry applications, including semiconductor, aerospace, deep sea oil recovery, testing, calibration, and industrial applications. This can be partly attributed to our complete silicon processing technology. Over the past 50 years, we have accumulated an enriched industry experience in producing pressure sensing equipment with high performance, high stability, high response speed and high reliability.

Smart Factory

Druck's factory in Leicester, UK, is named a smart factory within the Baker Hughes Group. The data connectivity across the entire factory allows us to continuously improve and optimize our manufacturing processes.

In addition, for Chinese users, Druck's Changzhou factory can provide you with excellent localized rapid prototyping, localized rapid service and localized OEM production.

Advanced Silicon Processing Clean Room

One of Druck's core technologies is silicon pressure sensing components. Druck's UK factory has an advanced clean room and complete silicon processing capabilities. We completed its comprehensive upgrade in 2015 and now have the process capability to handle more than 260 types of silicon wafers 24/7. The advanced robotic technology has more than tripled the efficiency of silicon processing, thereby greatly improving quality and yield. Druck's global research and development center in Niskayuna, New York, USA, is the second source of silicon wafer supply. This allows us to serve the needs of our customers and provide a strong, reliable supply chain.

Innovation

Druck is a technology innovator in the areas of pressure sensing and calibration. We continue to drive the development of new technologies and continue to raise the performance standards of the pressure sensing industry. Decades ago, we launched the trench etched resonant pressure sensor (TERPS) technology, which raised the performance standard in pressure sensing areas –especially measurement precision and long-term stability – to a new standard.





We are a technology-driven global multinational company dedicated to designing, researching, developing and manufacturing high-quality, accurate and reliable pressure sensing equipment, instruments, software and services. We continue to innovate and make continuous progress to ensure excellent quality, enabling customers to successfully build and operate systems, monitor and control critical assets in demanding application environments, and satisfying challenging application requirements around the world.

We meet customer needs through tailor-made solutions. Combining an in-depth understanding of customer application areas, we provide innovative and high-performance pressure sensing equipment, instruments, software and services, and complete manufacturing with high safety, quality and delivery standards.

We are Druck, giving you peace of mind in demanding application environments.

Contact Us

For more information, please contact your local Druck representative, or visit:

druck.com/cn

We welcome you to scan the QR code to follow Druck's WeChat public account

