

# Electron Microscopy

Vacuum Solution for Electron Microscopy

# Electron Microscopy

## Overview



### Introduction

Electron microscopy is a fascinating field of science that allows us to explore the world beyond the limits of visible light. Since its development, electron microscopy has played a revolutionary role in the study of materials, cells, and structures at the atomic and subatomic levels. This section of the brochure provides a comprehensive overview of the fundamentals, applications, and advances in electron microscopy.

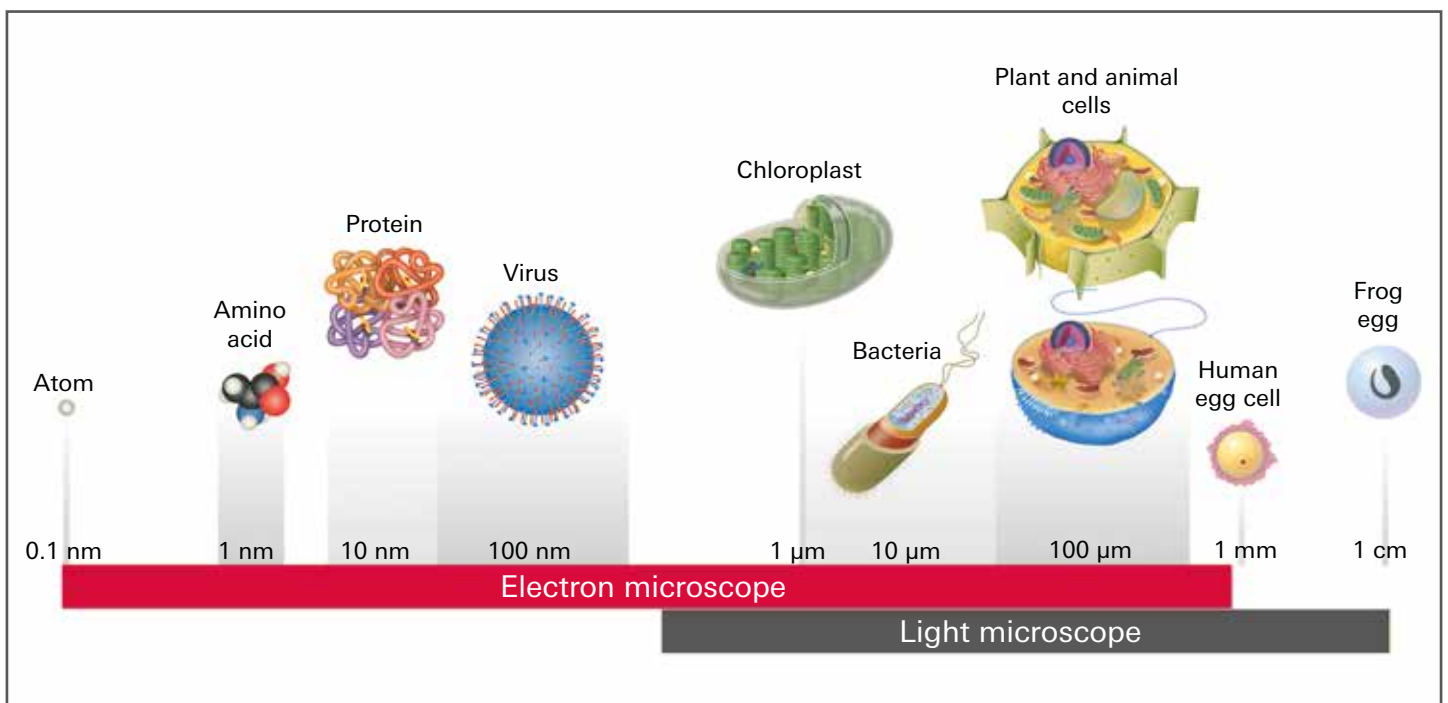
### History

The history of electron microscopy dates back to the 1930s when the first electron microscopes were developed. Ernst Ruska and Max Knoll are considered pioneers in this field. In 1931, they constructed the first transmission electron microscope (TEM), which enabled the generation of high-resolution images of samples. This development revolutionized microscopy as electrons have a much shorter wavelength than light, allowing for significantly higher resolution. In the subsequent decades, significant progress was made, including the development of the scanning electron microscope (SEM) in the 1960s and the scanning transmission electron microscope (STEM) in the 1970s.

### Significance in Science

Electron microscopy has made a crucial contribution to scientific research. By providing the ability to generate high-resolution images of samples, it has allowed researchers to gain new insights at the atomic and subatomic levels. In the field of materials science, electron microscopy has contributed to a deeper understanding of the structure-property relationships of materials. It has enabled the exploration of nanostructures and nanomaterials, which is of great importance for the development of new materials and technologies. In the life sciences, electron microscopy has allowed the investigation of the ultrastructure of cells and tissues, providing insights into complex biological processes. In the field of geoscience and environmental research, electron microscopy has helped analyze the composition and structure of rock samples and the interactions between materials and the environment. Additionally, in the semiconductor and microelectronics industry, electron microscopy plays a crucial role in quality control and failure analysis of semiconductor devices.

Today, electron microscopy is an indispensable technique in many areas of science and industry. It allows researchers to explore the world at the smallest scale and gain new insights that can lead to groundbreaking discoveries and technological advancements.



# Electron Microscopy

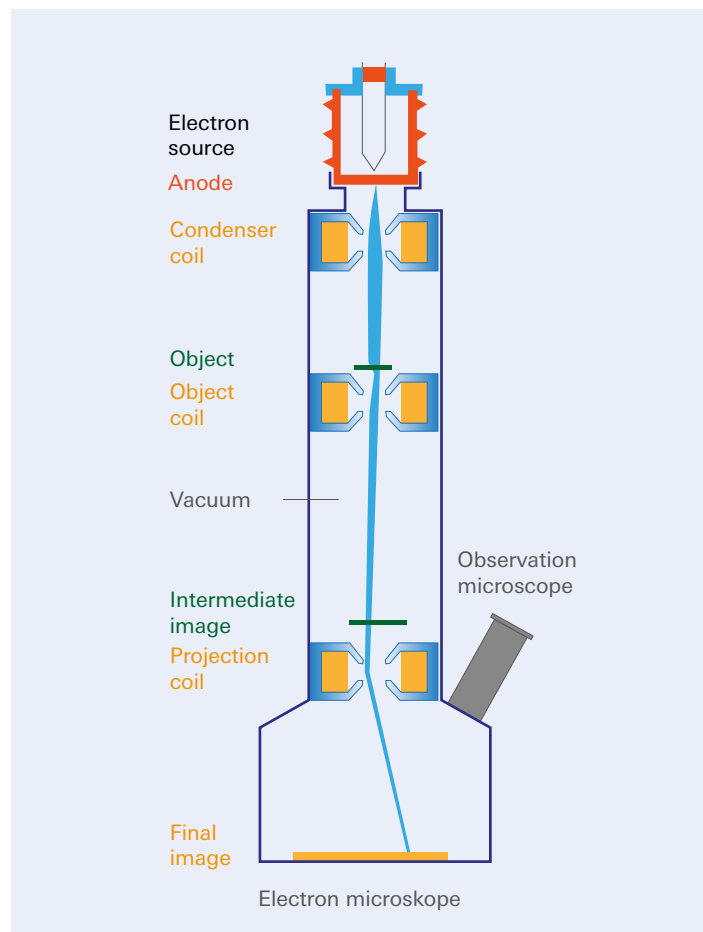
## Fundamentals

### Structure and Operation

An electron microscope consists of various main components that work together to produce high-resolution images. The basic components include an electron source that generates electrons and a system of electron lenses that focus and steer the electrons. The objective, also known as the condenser lens, is used to direct the electron beam onto the sample. After passing through the sample, the electrons are detected by various detectors to create the image. Signal processing is done using amplifiers and electronics to make the image visible and prepare it for further analysis.

### Difference

Compared to light microscopy, electron microscopy offers significant advantages. The electrons used have a much shorter wavelength than visible light, resulting in higher resolution. This allows for the visualization of smaller details in the sample. Electron microscopes also enable the examination of samples in a vacuum to minimize interactions with air molecules and ensure better image quality. In contrast, light microscopes operate in the air medium and have lower resolution due to the limited resolution limit of light.





### Types

There are different types of electron microscopes used for various applications. The scanning electron microscope (SEM) is commonly used to image the surface of samples. It produces high-resolution images by scanning the electron beam across the sample's surface and collecting information about its topography and composition. On the other hand, the transmission electron microscope (TEM) allows for the examination of the internal structure of samples. It generates images by transmitting the electron beam through the sample, providing information about its thickness, crystal structure, and chemical composition. The scanning transmission electron microscope (STEM) combines the advantages of both SEM and TEM by being able to produce both surface and transmission images.

### Detection and Imaging

The detection of electron signals is a crucial step in electron microscopy. Various detectors are used depending on the type of signal being detected. For example, secondary electron detectors can be used to obtain information about the sample's surface, while backscattered electron detectors provide information about its chemical composition. The acquired signals are then converted into an image that can be viewed on a screen or digitally stored. Modern electron microscopes often offer advanced imaging techniques such as energy-dispersive X-ray spectroscopy (EDX) and electron energy-loss spectroscopy (EELS) to obtain more detailed information about the samples.

Understanding the fundamentals of electron microscopy is crucial to better comprehend the operation and capabilities of this technique. A solid understanding of the fundamentals lays the groundwork for the successful application and interpretation of electron microscopy data.



# Electron Microscopy

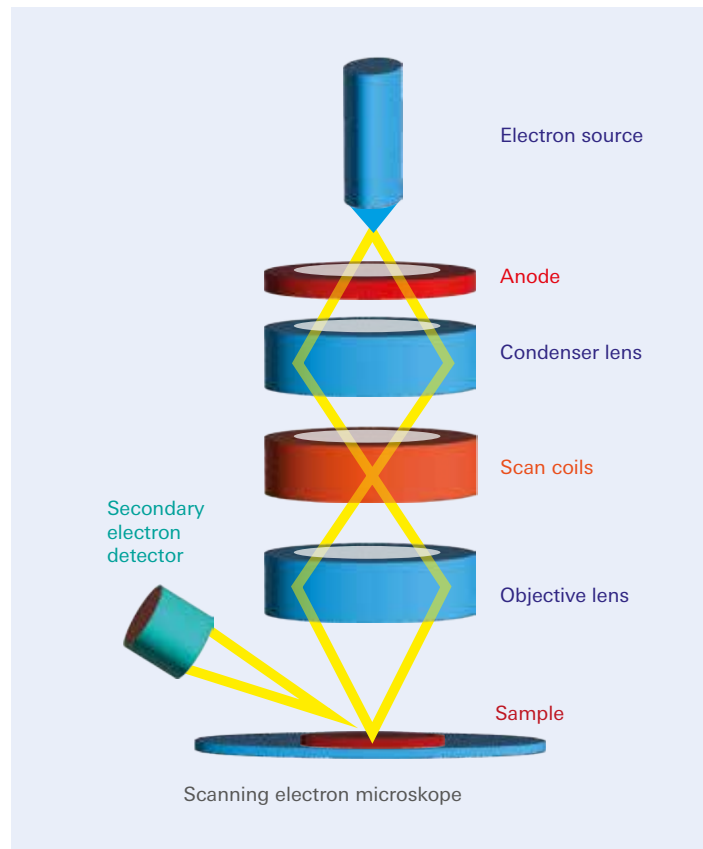
## Scanning electron microscopy (SEM)

### Introduction

Scanning electron microscopy (SEM) is an analytical method used in a wide range of applications. Scientists use it to learn more about microscopic organisms or crystalline structures. SEM is also used in industrial processes to examine the surface compositions of components and products. Applications range from the semiconductor industry, food monitoring, medical devices and microelectronics to general production monitoring.

### How does it work?

In this type of electron microscope, the electron beam scans the sample in a raster pattern. Initially electrons are generated at the top of the column by the electron source. They are then accelerated and attracted by the positively charged anode. The entire electron beam needs to be under vacuum in order to achieve the highest image quality. The high lateral resolution requires an excellent insulation against vibration and noise. Furthermore, high vacuum increases the collection efficiency of electrons by the detectors that are in the column.



**Product portfolio**

Due to the low vibration level required, the HiPace Plus line is the best solution for electron microscopes. The vibration level of the HiPace Plus is significantly lower than that of standard turbopumps. Pfeiffer Vacuum can also offer you a specially developed vibration isolator to reduce the vibration level even further. Since a backing pump is required, Pfeiffer Vacuum offers various dry solutions, including dry membrane pumps, multi-stage Roots pumps or even our newly developed scroll pumps. A variety of gauges can also be installed in order to provide you with a customized vacuum solution.

In addition to standard pumps, we offer customized solutions and we also do the vacuum design and calculation for you.



**HiPace 80 Neo**

Turbopump



- Patented laser balancing technology
- High performance lubricant
- Compact size
- Minimal vibrations
- Long service life and low operating costs
- Complete series from 10 m<sup>3</sup>/h to 2.300 m<sup>3</sup>/h

**Customized SplitFlow**

Turbopump



- Compact desing makes for mimimum footprint
- High pumping speed and maximum compression for all gases
- Customized pumps from 10 m<sup>3</sup>/h to 700 m<sup>3</sup>/h

**MVP 010**

Diaphragm pump



- Completely dry and oil-free vacuum
- Long diaphragm service life
- Low noise and vibrations levels
- Excellent operational reliability
- Maintenance-friendly

**HiScroll 6**

Scroll pump



- Oil-free vacuum pump
- High comfort and low vibration
- Sustainable and energy efficient
- Extremely quiet: <47 dB[A]
- Very good final pressure: <math>1 \cdot 10^{-2}</math> hPa

# Electron Microscopy

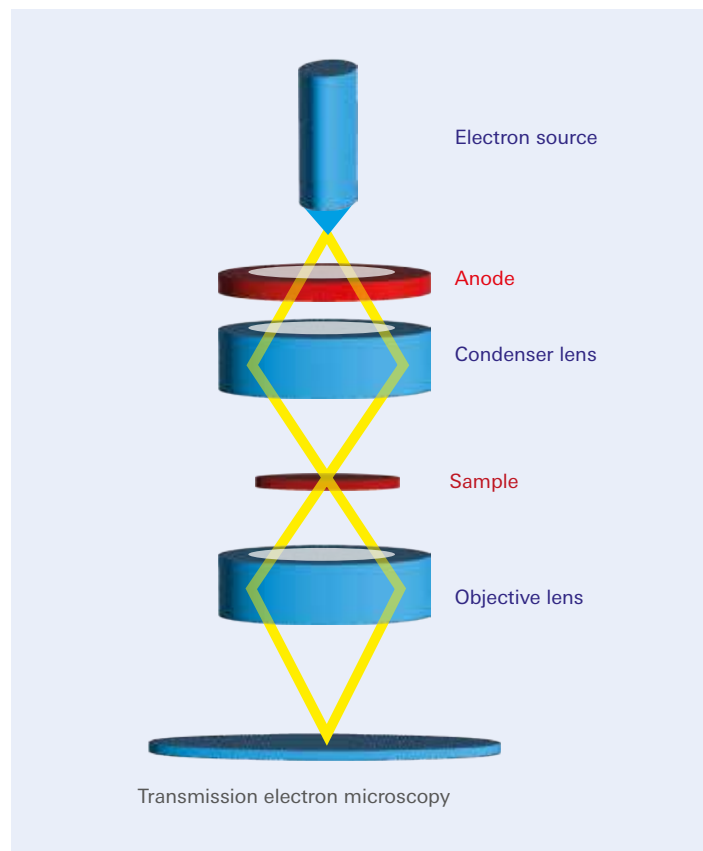
## Transmission electron microscopy (TEM)

### Introduction

Transmission electron microscopy (TEM) is used in various fields of application such as medical biology, life sciences, materials research, metallurgy and industry. TEM can provide information about the structure and texture of the object under investigation. It can be used in the semiconductor market to analyze the production and fabrication of computer and silicon chips. It is also useful in industrial applications to examine crystals and metals. They examine the manufactured objects to identify defects, fractures and damages in the micro range.

### How does it work?

At the top are two electrodes, an anode and a cathode. The anode is positively charged and the cathode negative. As a cathode, a thin wire/filament is used that emits electrons. When a voltage is applied to the Filament, electrons are emitted which are pulled to the anode. The anode is a disc with a little void in the middle through which the electrons can pass. The voltage is between 70kV and 120kV. Thereby the electrons can pass the TEM hitch less, inside the microscope needs to be a vacuum. Magnetic fields regulate the electron beam inside the TEM. Several coils produce the magnetic fields. The coils also focus the electron beam, so that the high impact is concentrated on the sample. To regulate the intensity of the electron beam, a blind is used.









There you can change the luminosity of the passing electrons. After the electrons pass the specimen, the quantity can be reduced with another blind, before they were focused again with additional coils. This is necessary, because some electrons are distracted after they pass the specimen. Afterwards the electrons pass the projection lenses. There the electron beam will be expanded, so that the specimen can be imaged sharper.

**Product portfolio**

Because of the low vibration level required, the HiPace Plus line from Pfeiffer Vacuum is the best solution for electron microscopes. The vibration level of the HiPace Plus is significantly lower than that of standard turbopumps. Pfeiffer Vacuum can also offer you a specially developed vibration isolator to reduce the vibration level even further. For a backing pump we can offer various dry solutions. You can choose between our dry membrane pumps, multi-stage Roots pumps or even our newly developed scroll pumps. We can also offer different gauges in order to provide you with a customized vacuum solution.

HiPace 80 Neo Turbopump	Customized SplitFlow Turbopump	MVP 010 Diaphragm pump	HiScroll 6 Scroll pump
			
<ul style="list-style-type: none"> <li>■ Patented laser balancing technology</li> <li>■ High performance lubricant</li> <li>■ Compact size</li> <li>■ Minimal vibrations</li> <li>■ Long service life and low operating costs</li> <li>■ Complete series from 10 m<sup>3</sup>/h to 2.300 m<sup>3</sup>/h</li> </ul>	<ul style="list-style-type: none"> <li>■ Compact desing makes for mimimum footprint</li> <li>■ High pumping speed and maximum compression for all gases</li> <li>■ Customized pumps from 10 m<sup>3</sup>/h to 700 m<sup>3</sup>/h</li> </ul>	<ul style="list-style-type: none"> <li>■ Completely dry and oil-free vacuum</li> <li>■ Long diaphragm service life</li> <li>■ Low noise and vibrations levels</li> <li>■ Excellent operational reliability</li> <li>■ Maintenance-friendly</li> </ul>	<ul style="list-style-type: none"> <li>■ Oil-free vacuum pump</li> <li>■ High comfort and low vibration</li> <li>■ Sustainable and energy efficient</li> <li>■ Extremely quiet: &lt;47 dB[A]</li> <li>■ Very good final pressure: &lt;math&gt;1 \cdot 10^{-2}&lt;/math&gt; hPa</li> </ul>

# Electron Microscopy

## Products

Pfeiffer Vacuum is a renowned manufacturer of vacuum pumps and vacuum solutions that are used in a wide range of analytical applications. The company offers a broad range of products which are specifically designed for analytical applications.

### HiPace

The HiPace 300 Plus vacuum pump from Pfeiffer Vacuum is a high-performance turbomolecular pump optimized for high-vacuum applications. With the help of patented Laser Balancing Technology and high-performance lubricant, the turbo pump is very low in vibrations. With its innovative and reliable technology, the HiPace 300 is ideal for electron microscopy, gas chromatographs, and other analytical instruments that require stable and precise vacuum conditions.





### HiScroll

The HiScroll 12 dry pump is an oil-free vacuum pump designed for use in analytical applications. The Scroll pump combines the points of high comfort, low noise level and low vibration. Additionally, the pump is sustainable and energy efficient. The HiScroll 12 is well-suited for applications such as ion implantation, scanning electron microscopy, and surface analysis, where clean and stable rough vacuum is crucial.



### UnoLine

The Uno 6 rotary vane vacuum pump is a robust and reliable solution for basic vacuum applications in analytics. With its compact design, easy operation, and quiet performance, the Uno 6 is an ideal choice for small laboratories and applications such as vacuum filtration, vacuum drying, and sample preparation. It delivers stable performance and enables efficient evacuation of vacuum chambers.

Pfeiffer Vacuum's products offer high-quality vacuum pumps and vacuum solutions specifically designed for analytical applications. They are characterized by their high performance, reliability, and precision, meeting the demanding requirements of analytical instrumentation. With its extensive product portfolio and years of experience, Pfeiffer Vacuum is a trusted partner for laboratories and companies in the analytical industry.

Thanks to its innovative technologies and continuous research and development, Pfeiffer Vacuum remains at the forefront of vacuum pumps for analytical applications. The products from Pfeiffer Vacuum contribute to achieving precise and reliable analytical results, enabling advanced research, quality control, and product development in various industries such as pharmaceuticals, biotechnology, environmental analysis, and material research.

In addition to standard pumps, we offer customized solutions and we also do the vacuum design and calculation for you.



# Electron Microscopy

## Products and applications

Application	HiPace – turbomolecular pumps	SplitFlow – customized solution	HiCube – turbomolecular pumping stations	HiPace – MagLev series	MVP – dry diaphragm pumps	HiScroll – dry scroll pumps	Smartvane – single stage rotary vane pumps	Duo /Uno – rotary vane pumps	Measurement and Analysis	ASM – Leak detection and measurement	Valves, Chambers and Components
<b>Mass Spectrometry</b>											
GCMS	■	■	■		■	■		■	■	■	■
LCMS	■	■	■			■	■	■	■	■	■
ICPMS	■	■				■	■	■	■	■	■
HLD	■	■			■			■	■	■	■
MALDI	■	■				■		■	■	■	■
RGA	■	■	■		■	■		■	■	■	■
<b>Surface Science</b>											
STM	■	■	■			■			■	■	■
AFM	■	■	■			■			■	■	■
SPM	■	■	■			■			■	■	■
TEM	■	■		■	■	■		■	■	■	■
SEM	■	■		■	■	■		■	■	■	■
EPMA									■	■	■
<b>Sample preparation</b>	■	■	■			■		■	■	■	■
<b>Material Characterisation</b>											
XRD	■	■	■			■		■	■	■	■
XRF	■	■	■			■		■	■	■	■
OES	■	■	■		■	■			■	■	■
FT-IR		■				■			■	■	■
<b>Thermal</b>	■	■	■		■	■		■	■	■	■
<b>Sorption</b>	■	■	■		■	■		■	■	■	■
<b>Leak detection</b>	■	■	■		■	■	■	■	■	■	■

# We drive sustainable solutions

Sustainability is playing an increasingly important role in today's society, including the products we use. This also applies to Electron Microscopy and the associated instruments and equipment, such as those manufactured by Pfeiffer Vacuum.

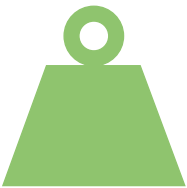
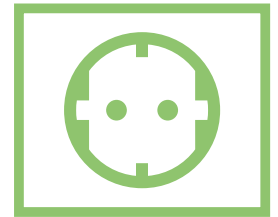
Pfeiffer Vacuum is aware of the importance of sustainability and actively strives to offer environmentally friendly solutions. An important aspect is the energy efficiency of the devices. By using energy-efficient components and innovative technologies, Pfeiffer Vacuum's products can reduce energy consumption and contribute to reducing CO<sub>2</sub> emissions.

Another goal is the longevity and recyclability of the products. Pfeiffer Vacuum designs its devices to have a long service life and be easy to maintain. Sustainable material selection is also prioritized to improve recyclability and minimize the use of environmentally harmful substances.

Pfeiffer Vacuum also places great emphasis on sustainability in production. By employing modern manufacturing technologies and optimizing processes, resource consumption is reduced and waste is avoided.

Furthermore, Pfeiffer Vacuum is committed to developing environmentally friendly packaging and using renewable energy sources in its facilities.

Through these sustainable measures, Pfeiffer Vacuum is contributing to making Electron Microscopy, as an important technology for scientific research and industrial development, more environmentally friendly and making a positive contribution to sustainability.



# Electron Microscopy

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## Applications

Electron microscopy finds application in a wide range of fields, allowing researchers to gain new insights and knowledge. In this section of the brochure, we will introduce some of the key application areas of electron microscopy.

### **Material Science and Nanotechnology**

In materials science, electron microscopy plays a crucial role in the characterization of materials at the atomic level. It enables the investigation of crystal structure, defects, and chemical composition of material samples. Through detailed analysis of material properties, researchers can develop and optimize new materials with improved properties. Electron microscopy is also of great significance in nanotechnology, where it enables the visualization and manipulation of nanoparticles, nanowires, and other nanostructures.

### **Life Science and Medicine**

In the life sciences, electron microscopy has contributed to a better understanding of the structure and function of biological systems. It allows for the examination of cells, tissues, and organelles at the subcellular level. With electron microscopy, researchers can investigate the ultrastructural features of cells, the organization of proteins, and the interactions between cells and viruses or bacteria. This contributes to elucidating disease mechanisms and developing new therapeutic approaches. Electron microscopy has revolutionized structural biology and biochemistry by enabling high-resolution imaging of biomolecular complexes. With advanced techniques such as cryo-electron microscopy (cryo-EM), researchers can analyze the structures of proteins, enzymes, and other biomolecular complexes in their natural states. This has led to significant advancements in drug research and therapy development.

### **Geoscience and Environmental Research**

In geosciences, electron microscopy is used to investigate the mineralogy, petrology, and geochemistry of rock samples. It enables the characterization of mineral grains, identification of trace elements, and analysis of mineral reactions.

In environmental research, electron microscopy contributes to the examination of environmental samples such as pollutant particles, aerosols, and sediments to gain information about their composition and their impacts on the environment.



### **Semiconductor and Microelectronics Industry**

Electron microscopy is of great importance in the semiconductor and microelectronics industry. It enables the characterization of components, investigation of causes of failures, optimization of manufacturing processes, and evaluation of advanced materials.

Through electron microscopy, semiconductor devices can be analyzed and characterized. Defects and irregularities can be identified to improve quality and performance. Failure analysis also plays a crucial role. Electron microscopy techniques help determine the cause of malfunctions and identify defects.

Electron microscopy has played a crucial role in many scientific and industrial fields, and it continues to offer enormous potential for new discoveries and applications.



# Pfeiffer Vacuum Service

## Our services – your advantages








Each customer places its own particular demands on its products, and these may also be influenced by application-specific parameters. Our flexible service concept, with a focus on preventive services, offers just the right solution for you.

## Preventive maintenance – avoid downtimes

With our preventive service concept, we can recommend service intervals tailored to each product. The aim is to avoid failures and to carry out planned and predictable servicing.

**Maintenance level 1** includes fluid changes and contributes significantly to the good working order of the product.

**Maintenance level 2** also includes replacement of all wear and tear parts. In **maintenance level 3**, all wear and tear parts of the product are replaced and the product is overhauled. In order to keep downtimes to a minimum, we offer temporary replacements for many of our products for the duration of maintenance. We provide an equivalent **replacement product** that our customers can start using immediately.

	 <b>Maintenance</b>						
<b>Inspektion</b> Health Check zur Definition weiterer Maßnahmen	Preventive exchange of relevant wear parts – depending on product specific application conditions. Individual modules, adjusted to your requirements.		<b>Working Exchange</b>	<b>Calibration</b>	<b>Repair</b>	<b>Standard Exchange</b>	<b>Individual Services</b>
	Level 3	Premium	Fast solution to reduce downtime  Alternative to maintenance level 3	Professional calibration of vacuum gauges and test leaks according to international standards	Product related reconditioning to restore the functionality	Fastest solution to reduce downtime  Alternative to Repair	Contracts and maintenance plans, Warranty extension, Commissioning, decontamination (remote) support, etc.
	Level 2	Expert					
	Level 1	Essential					

## Services at a glance

- User training and product training
- Pfeiffer Vacuum original spare parts and tools
- Troubleshooting and advice from our technical support team
- Comprehensive on-site service by our service technicians
- Maintenance and repair in our service centers worldwide
- Individual service agreements
- Replacement products
- Calibration service for measuring devices and helium test leaks

### **Spare parts – original parts increase life expectancy**

Pfeiffer Vacuum's spare parts and tools are defined early in the product development stage to ensure their proper fit and quality.

Every improvement to our serial products is also transferred to our spare parts. This means products are brought up to state of the art status after undergoing maintenance level 3 or a repair.



### **Advice – to assist you with any questions you may have**

In addition to our individual concepts and the quality of our replacement parts, it is our employees and personal contact that give our service its special touch.

### **Technical support – competent advice from the experts**

Since not everything about our products is self-explanatory and questions can arise both before and after purchase, Pfeiffer Vacuum's Technical Support is available to assist our customers.

Each member of our team specializes in a specific area of our portfolio to enable them to assist our customers competently with technical questions relating to our products. Our team also works closely with our developers and application experts.

### **Field service technicians on site**

From commissioning new vacuum components and systems to troubleshooting, and from maintenance to repairs, we offer our customers a comprehensive range of on-site services. Our service locations ensure customer proximity and short-term assistance in emergencies.

### **Service agreements – individually tailored to your project**

We offer project-specific service agreements so that our customers can plan maintenance or service interventions over a long term. These agreements can be made at a later date or as early as during the project planning stage. In order to take our customers' differing needs into account, agreements may include all or just some of the services we offer.

# Components and valves

The connection in your vacuum system



A vacuum system is made up of a variety of individual parts which are combined to form a single unit. Pfeiffer Vacuum offers standard solutions, but also component modifications or a customized solution to fit your needs perfectly.

## Your advantages and benefits

- A direct contact for you and your projects
- Proactive support and competent advice
- Convenient ordering
- Short delivery times
- High delivery reliability
- High security of supply
- More than half a million parts in stock
- High uptime
- Cost saving- no keeping stock necessary

## [www.vacuum-shop.com](http://www.vacuum-shop.com)

- Convenient online vacuum component ordering any time
- Information about your prices, delivery times and terms



Components



Valves



Feedthroughs



Manipulators

## Individually designed chambers for your vacuum applications

Due to our many years of experience, we can provide professional guidance for system specifications, design and engineering.

Our physicists, designers, project managers and production specialists have extensive experience in many applications from all market segments. The tasks are based on your requirements: our starting point on the path to a finished product can range from a rough sketch to a complete set of blueprints.

### High vacuum chambers



#### Advantages

- Preconfigured design
- Proven, tough design
- Customized ports

#### Benefits

- Cost and time savings due to lower design expenses
- Reliable and safe
- Individual adaptation to your processes

### High vacuum chambers



#### Advantages

- Preconfigured design
- Proven, tough design
- Customized ports

#### Benefits

- Cost and time savings due to lower design expenses
- Reliable and safe
- Individual adaptation to your processes

### High vacuum chambers



#### Advantages

- Preconfigured design
- Modularly expandable
- Customized ports

#### Benefits

- Cost and time savings due to lower design expenses
- Maximum flexibility at all times
- Adaptable individually to your application

### High vacuum chambers



#### Advantages

- Individual design
- High quality materials
- Robust design
- Project engineering and construction by qualified and experienced project managers

#### Benefits

- Can be adapted optimally to your process
- Best quality and long life
- Reliable and safe
- Time saving

## Your Success. Our Passion.

We give our best for you every day –  
worldwide!

Are you looking for your  
optimized vacuum solution?  
Please contact us:

**Pfeiffer Vacuum GmbH**  
Germany  
T +49 6441 802-0



All information is subject to change without prior notice. PI 0541 PEN (January 2024/PoD)

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