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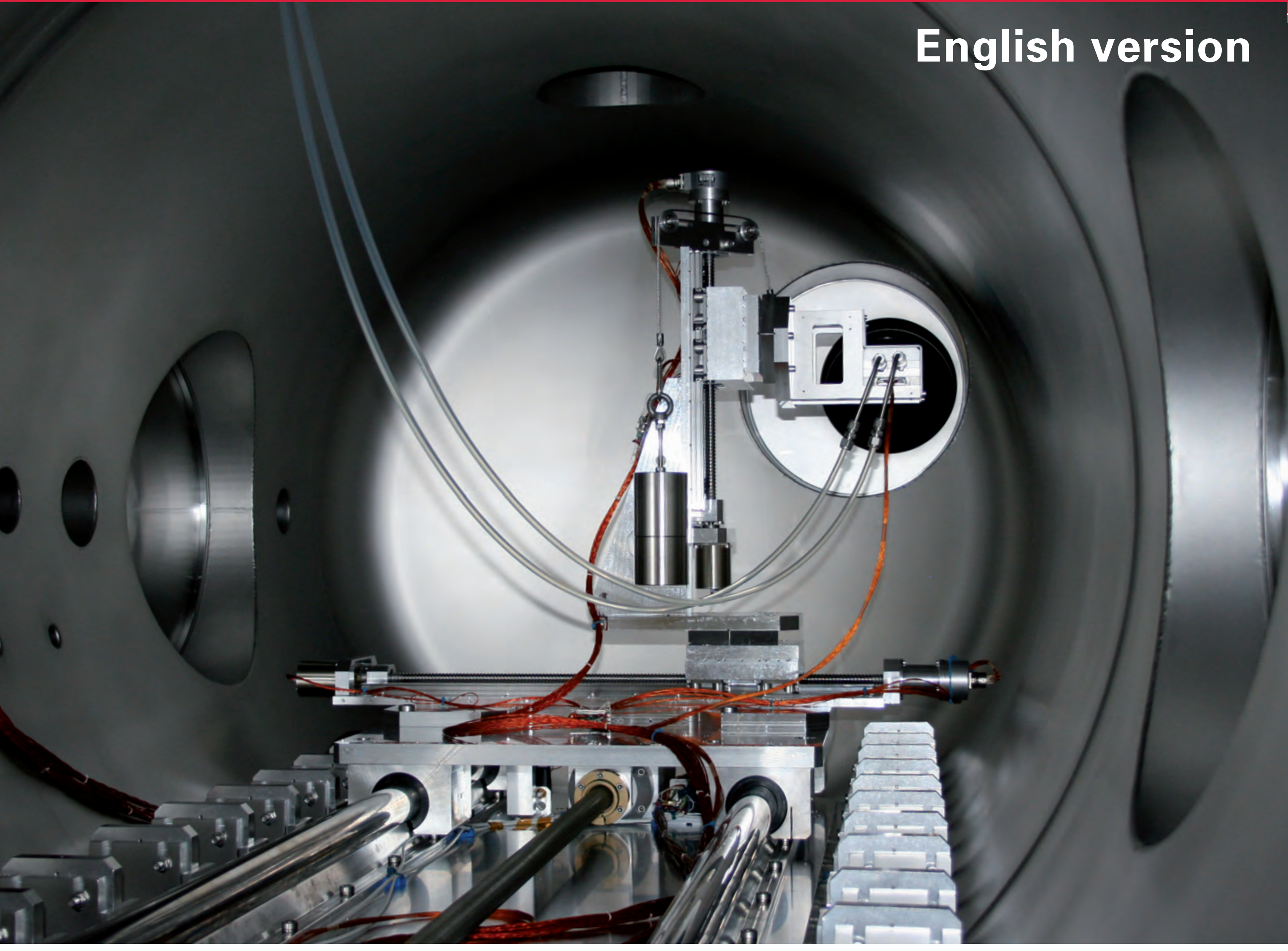

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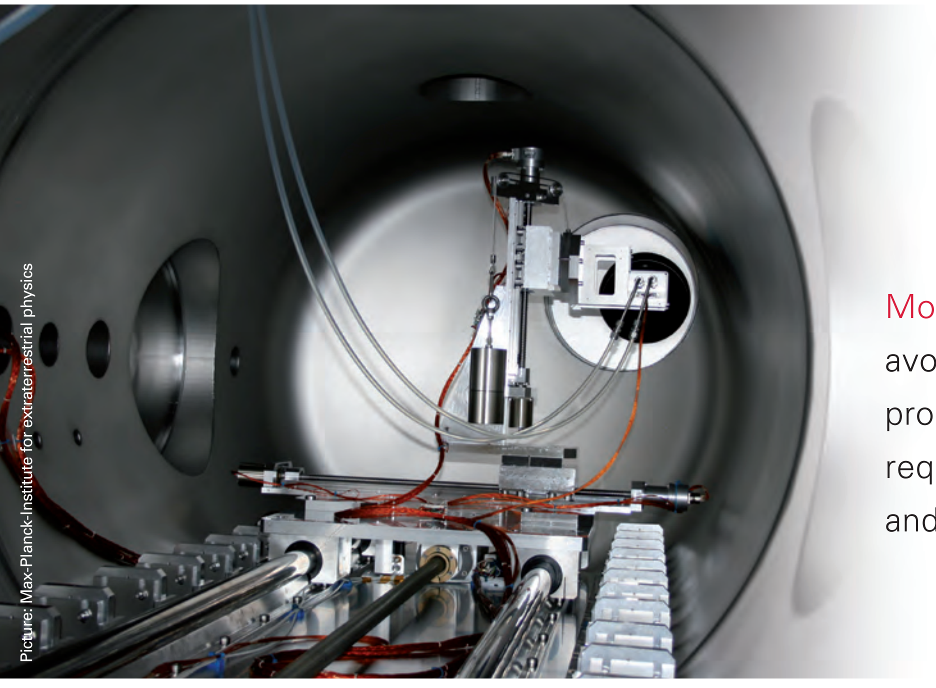

Motorised multi-axis mechanism inside an ultra high vacuum chamber.

Motors for in-vacuum use. How to avoid costly downtime in vacuum processes and master future requirements for process availability and quality.

Downtime in a high vacuum?

Modern factories e.g. for LEDs or OLEDs increasingly include vacuum chambers. While the wafer production facilities of the 1990's managed to avoid every speck of dust, today's production processes like sputtering (very thin and accurate coating of substrates with particles from a solid material) can be compromised by air contamination.

Why is it not possible to simply run standard motors directly in a vacuum chamber? Ordinary motors can contaminate the vacuum chamber with particles and molecular deposits. When organic substances such as lubricants, adhesives, insulation and board material are outgassed, they run the risk of contaminating workpieces or sensitive instruments within the chamber. The degree of degassing depends on the class and the operating temperature of the motor. While standard motors can occasionally be used in a medium vacuum environment, their use in high and ultra high vacuum environments is highly discouraged.

"A surgeon would never operate with dirty hands. Likewise, an engineer should consider using suitable materials and conditioning processes for in-vacuum usage. Not all motors that can survive vacuum are also suitable for vacuum conditions" says Alexander Hatzold, head of marketing and product strategy at Phytron GmbH.

Because of their unsuitability for use within the vacuum chambers, standard motors are installed outside the chamber. The mechanism is driven inside the chamber via axis feed-throughs. While this approach seems to save space inside the chamber, there are limitations in trying to automate multi-dimensional movements from outside the chamber. This is a rather expensive and space consuming approach as additional cumbersome mechanics are needed inside the chamber.

Working with standard motors and axis feed-throughs is not without risk. The feed through seal itself is a wear point. In a worst-case scenario, the vacuum could be uncontrollably disturbed, leading to the destruction of the entire batch of product. In this case, not only would it be necessary to replace the leaking implement, the vacuum in the chamber would also need to be rebuilt. Depending on the size of the vacuum chamber and vacuum class, repair time could range from hours to days, causing considerable production losses and wasted electricity costs.

Realise multi-axis mechanisms easily

"In order to analyse solid samples in mass spectrometry in vacuum, they have to be fed to a desorption laser one by one. For this purpose, a two-axis precision positioning stage is required. Moving seals, whether against vacuum or as a radial shaft seal on motors, have always been the Achilles heel for finding a lasting solution." explains Dr. Jens Höhndorf – Head of Development for Time-of-flight mass spectrometry at Bruker Daltonics GmbH, Bremen. While rubber-sealed feed-throughs may

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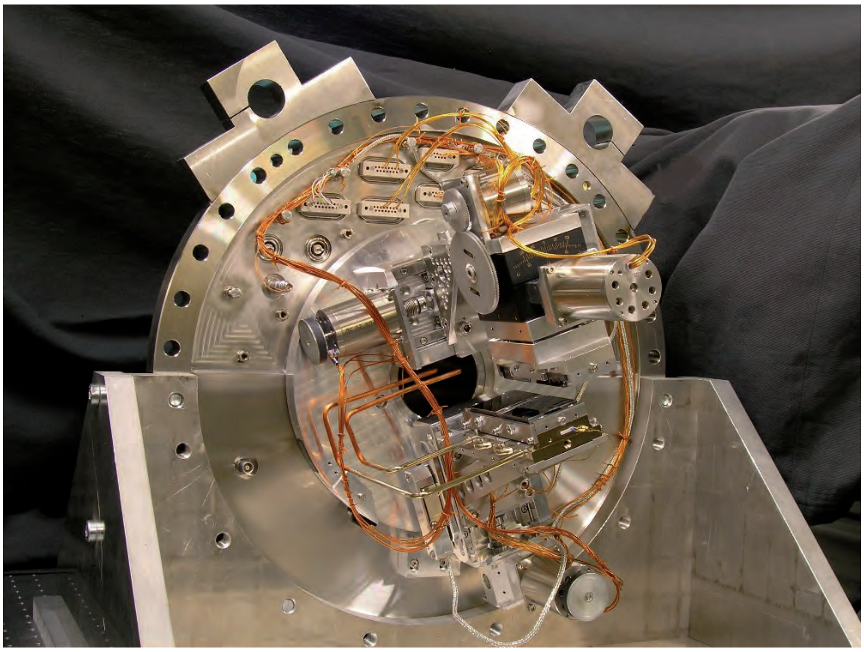

Picture: Desy

Complete mechanism before being built into the vacuum chamber.

seem less expensive at first glance, they are unable to withstand a detailed analysis in terms of cost, reliability and durability. This is exactly why in-vacuum motors are used in the large vacuum facility at the Max Planck Institute for Extraterrestrial Physics. There is no production, but the tight schedule of the research facility enforces the use of fail-safe solutions. With in-vacuum motors, even complex multi-axis mechanisms are easily implemented, e.g. for use in electron microscopes for x,y,z-adjustment of the samples.

According to Dr. Höhndorf, complex transmissions such as magnetic couplings or bellows do not only require more space, they also need additional power transmission in the vacuum. Below the line these approaches are usually considerably more expensive. “Vacuum motors installed directly at the point where the torque is needed provide a more elegant, simple and reliable solution. We have had very positive experiences using Phytron’s vacuum motors,” says Dr. Höhndorf.

The use of motors directly in the vacuum comes with benefits, but creates additional requirements for the motor:
The motors should be vacuum baked, robust and highly accurate. Therefore, especially high-resolution stepper motors in stainless steel housings are suitable. They position accurately and dynamically without the need for outgassing feedback electronics. They are also ideally prepared for duty in extreme environments. To ensure a long lifetime and to avoid outgassing, high-quality insulation materials and special lubricants should be used. Depending on the vacuum class and the planned duty cycle, optimised conditioning processes are applied.

Temperature management in a vacuum – a hot issue

Special attention should be given to the temperature management in a vacuum. Due to the lack of air circulation, heat can only be removed by radiation and heat-flow through the material. To avoid overheating of the motor, the motor configuration should include safety margins depending on the duty-cycle. In addition, a temperature sensor can be integrated directly into the winding to monitor the motor. By these means, a longer lifetime of the system can be ensured.

When in doubt play it safe

The key advantage to using in-vacuum motors is to minimise the risk of losing the vacuum. Process stability and reliability is significant, especially in industrial processes. The use of high quality in-vacuum motors pays off: Depending on the intensity of use, there should always be the option to have the bearings replaced by the manufacturer. With proper care, there is practically no limit to the potential life span of the high-quality motor.

For controlling the motor from outside the vacuum chamber, it is worth considering the necessary additional functions such as temperature monitoring from the start. Controllers with integrated power stages close to the chamber allow a low-disturbance monitoring of the temperature sensors and the direct connection of the motor cable. For large systems in particular, it should be ensured that the automation of the in-vacuum actuators can be seamlessly integrated into the existing PLC-world despite the special requirements. In the 1980’s, the Max Planck Institute began using the freely programmable IXE system with integrated power amplifiers. Today, they use the follow-up product, the modular controller phyMOTION. The integrated amplifiers are each equipped with optional temperature control and encoder evaluation. The integrated fieldbus interface allows for control by not only a PLC system, but also for operation via the supplied software, LabView interface or touch terminal.

Ready to use in-vacuum motors are priced starting from a few hundred Euros – depending on size, options (gear, resolver) and required vacuum class.

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