



## HELIUM LEAK DETECTION IN SEMICONDUCTOR FACTORIES

Smartphone, tablet, games console, navigation system, flatscreen – those and many other hightech products only exist thanks to the semiconductor industry. Without it, the memory chips and processors used in modern communication media could not be produced.

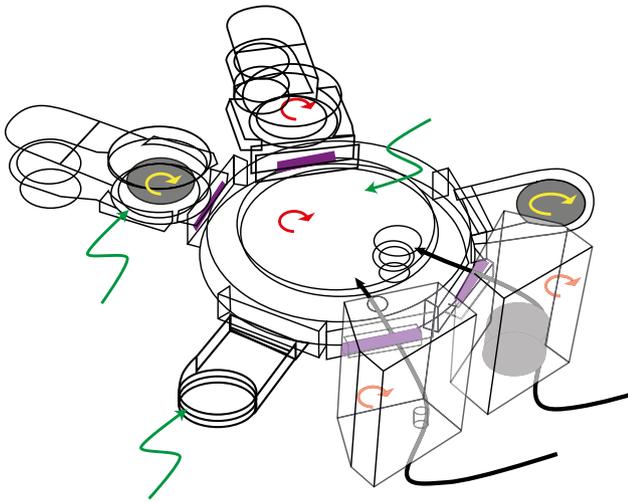
For their manufacture, extremely clean vacuum conditions are needed, which have to be monitored precisely. For example, a leak test is conducted in form of a measurement of pressure rise after having maintained a semiconductor production facility – known as “fab”. Only if the tightness of the system is approved, the process is being released. If the pressure rise is larger than a defined threshold value, the fab is closed and the leak detection started to localize a leak and repair it. With its broad service portfolio, Pfeiffer Vacuum provides optimal support by experts – even for on-site leak detection.

Take a glance at a typical on-site service of one of our service engineers:

### **Helium leak detection for testing the production environment**

“More than 5 milliTorr, I am going to get the leak detector!” Eyck Schwarz is a service engineer at Pfeiffer Vacuum. He supports the operators of a large semiconductor provider with vacuum equipment and leak detection on-site. Today, a system for the dry etching of polycrystalline silicone has to be restarted after a standard maintenance.

“Before restarting, a measurement of the pressure decay is carried out” he explains. “The pressure rise consists of many different gas sources in the system. This can either be the



**Caption**

→	Wafer transport L/L
↻	Wafer degassing
↻	Chamber inner surface, degassing
→	Leak
—	Seals— outgassing and permeation

Figure 1: Pump down curve of a 100-liter chamber with a rotary vane pump Duo 65

degassing of the inner surface, permeation – i.e. the emission of gas through a sealing – as well as one or more leaks. If the pressure rise is above our threshold value, the leak is too big. It would thus disturb the process. Then, the leak must be detected and sealed.”

The measurement results show a pressure rise of 10 milli Torr. It is thus twice as high as the allowed threshold value. If the chamber volume is known, it can be estimated in which scale the display of the leak detector is going to be.

The pressure rise and the helium leakage rates have to be converted into comparable units to get a feeling for the values displayed on the helium leak detector.



Leak rates are mostly displayed in mbar l/s. The measurement of the pressure rise shows a pressure change per time. For conversion, the system’s chamber volume has to be known. Then, the pressure rise is converted from the unit “mTorr” to the unit “mbar” while minutes are converted into seconds. Thereby, Pfeiffer Vacuum’s unit converter in the mobile eVacuum app ([https://www.pfeiffer-vacuum.com/en/downloads/evacuum-app/?request\\_locale=en\\_US](https://www.pfeiffer-vacuum.com/en/downloads/evacuum-app/?request_locale=en_US)) is at hand for support. In the actual example, 10 mTorr correspond to 0.013 mbar or  $1.3 \cdot 10^{-2}$  mbar l/s. Five minutes correspond to 300 seconds. The chamber volume is 5 litres. This thus results in a leak rate of  $2.2 \cdot 10^{-4}$  mbar l/s.

### Different gas sources inside systems

Leaks are not the only gas source inside systems that cause a pressure rise. Additionally, outgassing from inner surfaces and permeation through seals have to be especially observed. Which gas source has the greatest impact depends on the particular system and must thus be identified individually. Eyck Schwarz forces himself inside the system and connects the oil-free, high-performance leak detector ASM 380 by Pfeiffer Vacuum. Therefore, he mounts the leak detector to a shut-off valve which is located between the turbopump and the process pump in the basement lines.

The system operators, who are watching him, are surprised: “There is a flange at the chamber of this system which can be accessed easily. This is where we normally connect the leak detector. Why don’t you do this as well instead of crawling into the system so that you can access the flange inside? This means much more effort and is thus time-consuming!”

“This might be right”, the service engineer answers, “But it is worth the effort. If the leak detector is connected between the turbopump and the dry pump, the leak signal is much higher and the reaction time shorter. Therewith, the leak can be found and localized faster. So in the end, you even saved time!”

The flange at the fore vacuum line in the basement is indeed the optimal connection. Here, the leak detector does not have to compete with the running turbopump.

The effective pumping speed of the leak detector is smaller compared to the pumping speed of the turbopump. Thus only a mere fraction of the leak rate display of  $2.2 \cdot 10^{-4}$  mbar l/s from the pressure rise measurement has to be expected. With a turbo pumping speed of about 1000 l/s, the leak rate value will sink to under  $10^{-6}$  mbar l/s.

If the leak detector is connected between the turbopump and the backing pump, it still runs in partial current to the backing pump but the process pump has a significantly lower helium pumping speed than the turbopump. If the leak detector is connected to the fore vacuum line, a leak signal of around  $1.1 \cdot 10^{-6}$  mbar l/s can be expected at the leak detector instead of the  $2.2 \cdot 10^{-4}$  mbar l/s from the measurement of the pressure rise. The leak that caused the pressure rise must thus be in this scale.

In leak detection, the time constant depends on the volume of the process chamber and the effective pumping speed for helium. It is determined when the leak rate signal has reached 63 % of its maximum intensity.

If the leak detector is only connected to the chamber, the time constant in the actual example is approximately 1.4 seconds. If the leak detector is connected behind the turbopump, the time constant is 4 milliseconds and thus significantly shorter than the reaction time of the leak detector. In our example, the reaction time is not important. But the pumping speed gets more important for the reaction time the bigger the volume is.

### Special demands of semi-fabs

Eyck Schwarz opens the pressure regulator at the helium bottle. He adjusts the helium spray gun so that he can only feel the slightest breeze of the test gas at his tongue. This is absolutely sufficient to detect even tiniest leaks. Furthermore, it prevents a helium load in the close environment. Slowly, methodically and patiently, he sprays the parts of the system that are suspected to leak from bottom to top.

“If you start at the bottom, the light gas helium rises to the top. There, leaks are pretended that do not really exist!” one of the operators interjects. “Correct, this is often stated at leak detection training classes. But it is only true if the air is absolutely calm and the helium spreads equally into the environment. In a cleanroom like this, there is always a laminar flow from the ceiling to the floor. It tears down the test gas with it. In this case, the test thus has to be conducted against the flow – from bottom to top.”

Suddenly, the leak detector reacts. Eyck Schwarz sprayed a chamber sealing. But he is not yet content. “The displayed value is way too small to explain this pressure rise.”

He marks the leak and proceeds. The measurement device reacts a second time. The leak seems to be found. Nevertheless, he also checks the rest of the system so that he does not oversee any leakage. It takes only a few minutes but prevents another test procedure with shutting down and restarting the system that would be necessary if any leak had not been detected. Finally, the measurement values are stored on the



Figure 2: The ASM 380 of the leak detection portfolio of Pfeiffer Vacuum is optimal for the mobile use in large systems

integrated SD card in the ASM 380 leak detector. This allows for the documentation of the detected leak in the report.

The two defect seals can easily be replaced. The system is restarted. The new pressure rise measurement now states: “READY FOR PROCESS”.

### Convincing leak detection solutions by Pfeiffer Vacuum

With its broad leak detection portfolio, Pfeiffer Vacuum offers the optimal solution for the leak detection on semiconductor production systems. This offer includes portable, universal, and high-performance leak detectors. All models convince with their high degree of reliability and sensitivity: They can be operated easily and are individually adjustable to the specific requirements of the particular application.

Are you looking for an optimal leak detection solution? Contact us!

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