

PURPOSE

The LDM-4872 Quantum Cascade Laser Mount is designed to meet the unique requirements of quantum cascade lasers, including operation at low temperatures and under vacuum. Vacuum operation is desirable in order to reach low operating temperatures while preventing water condensation on the laser. This technical note provides recommendations on vacuum system components and setup, discusses different pumping strategies, provides pressure guidelines to avoid condensation, and describes typical vacuum performance of a sealed mount over time.

VACUUM SETUP

The LDM-4872 is designed to operate in the medium vacuum range, which encompasses pressures from 0.001 Torr to 25 Torr (1.3×10^{-1} Pa to 3.3×10^3 Pa). There are two approaches to operating the LDM-4872 under vacuum. The first is to attach the mount to a vacuum pump and run the pump continuously. This will provide the best vacuum performance (lowest pressures) but can be costly since the pump is constantly consuming energy. The second approach is to locate a valve inline between the mount and pump. Once the mount is pumped down to an acceptable pressure, the valve is closed and the pump is turned off. Some vacuum losses are inevitable over time, so periodic re-pumping may be necessary depending on length of test and pressure requirements.

The LDM-4872 contains two vacuum ports. The ports are $\frac{1}{8}$ " NPT and are fitted at ILX with compression fittings compatible with $\frac{1}{4}$ " OD stainless steel tubing. Only one port is required for vacuum operation. The second port can be plugged with the supplied cap, or can be fitted with

a pressure gauge. A typical vacuum setup is shown in figure 1.

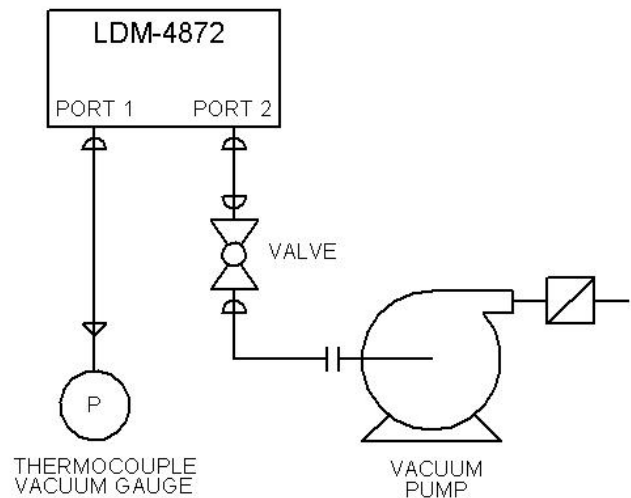


Figure 1. Diagram of a typical vacuum setup

A dual-stage rotary vane vacuum pump, commonly referred to as a “roughing pump” is well suited for use with the LDM-4872. These pumps are relatively affordable and are commonly used in many laboratories. A required feature in any pump is a check valve that prevents backwards flow that could introduce oil from the pump into the mount.

ILX Lightwave recommends always using a vacuum gauge to monitor pressure when operation of the laser depends on maintaining vacuum. A thermocouple vacuum gauge works well for the medium vacuum range.

There are several choices for fittings in a medium vacuum system including KF flange fittings, compression tubing fittings, and NPT threaded fittings.

KF flange fittings use heavy construction and an o-ring seal. They are very reliable and provide easy connection and disconnection, but are bulky and expensive. Compression fittings, such as Swagelok®, are convenient and easy to use. They rely on a metal-to-metal interface, and thus are better suited for applications where frequent assembly and disassembly are not required. Stainless steel is the recommended material choice for Swagelok® fittings in vacuum service. Swagelok® also produces a vacuum-specific compression fitting, the Ultra-Torr, which uses a superior o-ring seal, but is approximately twice the cost of a regular Swagelok® fitting.

Threaded NPT fittings are common and inexpensive, but are more prone to leaks than other options and therefore should be avoided where possible in vacuum systems. If NPT fittings are to be used, careful application of thread sealant and proper tightening are critical for success. Teflon tape can be used to seal threads, but is very sensitive to proper assembly technique, and is not recommended. A semi-permanent thread adhesive, such as Loctite® 212 works well for NPT fittings under vacuum. In all cases, fittings should be hand tightened, and then tightened ½ additional turn. Over-tightening will not improve performance and will likely damage threads.

O-RING MAINTENANCE

The LDM-4872 can be ordered with either an XYZ stage cover with collimating optics, or a simpler ZnSe window cover. Both covers are installed to

the mount housing with four screws. A viton o-ring is used to seal the cover to the housing (AS568A Dash Number 153). Proper maintenance of the o-ring is crucial to prevent leaks. Before each assembly, the o-ring should be wiped clean with a lint free cloth and carefully inspected for cuts, abrasions, or other damage. The o-ring gland (groove) should be cleaned as well with a lint-free wipe, first with acetone and then with alcohol. Apply a light film of vacuum grease (Dow Corning® High Vacuum Grease or equivalent) to the entire surface of the o-ring and wipe away excess. The prepared o-ring should be visibly shiny but free of excess grease. Carefully place the o-ring into the gland. Install the XYZ or window assembly, ensuring that the o-ring stays in place and is not pinched. Alternately tighten the screws until metal to metal contact between the cover and housing is achieved.

INITIAL PUMP DOWN

Moisture, oils, and other contaminants can enter the mount anytime the cover is removed and the inside of the 4872 is exposed to atmosphere. If using a valve and periodic pumping, these contaminants can outgas and increase pressure within the mount, creating “virtual leaks.” Usually, allowing the pump to evacuate the mount for 3 to 4 hours is sufficient to remove trace vapors and prevent virtual leaks. A longer initial pumping period of 12 to 24 hours can be useful when the mount is brand new or when very low pressures are desired.

PREVENTING CONDENSATION

One of the reasons for evacuating the mount is to prevent moisture from condensing on the laser at low temperatures. Condensation occurs on a surface when the temperature of a surface is lower than the dew point of the surrounding air. One

way to suppress dew point is to reduce pressure. It is helpful to know the relationship between ambient temperature, humidity, and the pressure required to suppress dew point sufficiently. The following graph in figure 2 shows the minimum pressure required to prevent condensation at -35°C for different ambient temperatures and humidities.

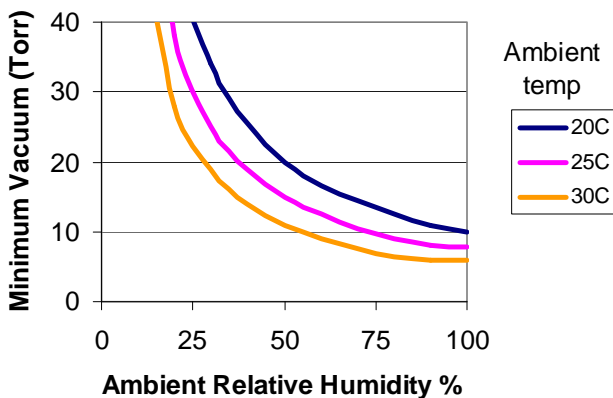


Figure 2. Minimum pressure required to prevent condensation at -35°C

VACUUM LOSSES OVER TIME

When the inline valve between the pump and mount is closed, some increase in pressure will occur over time. These small vacuum losses could be due to small leaks or porosity in the mount, valve, and fittings or slow outgassing of materials. Figure 3 shows a typical increase in pressure over a 125 hour period observed in a LDM-4872. Much more rapid pressure increases could be symptoms of a leak. If rapid leakage rates are observed (>500 mTorr per hour pressure increase) the mount and all connections should be inspected for leaks.

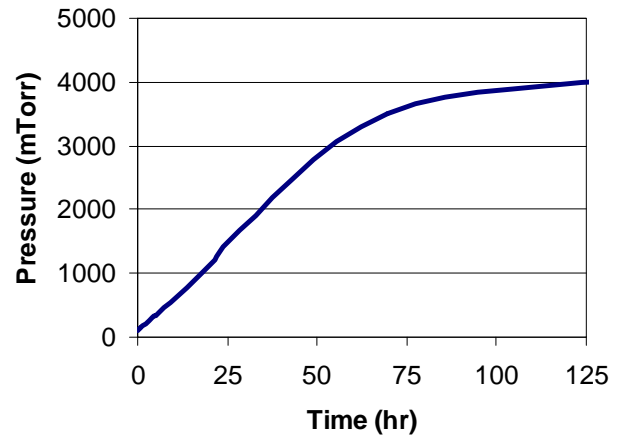


Figure 3. Typical vacuum losses over time, LDM-4872

CONCLUSIONS

The LDM-4872 mount allows the operation of quantum cascade lasers under vacuum. The mount can be operated under continuous vacuum pumping, or with an inline valve that allows the pump to be turned off after initial pump down. A common dual-stage rotary vane roughing pump is well suited for use with the LDM-4872. A thermocouple vacuum gauge should be used to monitor pressure whenever a laser is being operated. KF flange fittings and Swagelok® compression fittings are good choices for vacuum setups. When the mounted is sealed with an inline valve, some vacuum losses will occur over time. In order to prevent condensation at mount control temperatures of -35°C and typical ambient conditions ($<30^{\circ}\text{C}$, $<50\%$ humidity), pressures of less than 10 Torr should be maintained while operating a laser.