MOCVD – Run/Vent switch

What is a Run/Vent switch?

As is shown in ***Fig***.1, the Run/Vent switch connects the outlet of the MO bubbler to either the run line (which goes to the reactor chamber) or the vent line (which goes to the exhaust). A Run/Vent switch is provided for each precursor source. To avoid a pressure difference when switching between run line and vent line, the pressure in both of them is the same as the pressure in the reactor chamber. The following two states are possible:

Run The process gas flows to the ***run*** line. The vent line is not connected to the process gas. Simultaneously, an equal flow of carrier gas passes through the vent line.

Vent The process gas flows to the ***vent*** line and bypasses the reactor. Simultaneously, an equal flow of carrier gas passes through the run line.

Note that the flow in the run line is a constant and does not change with time.

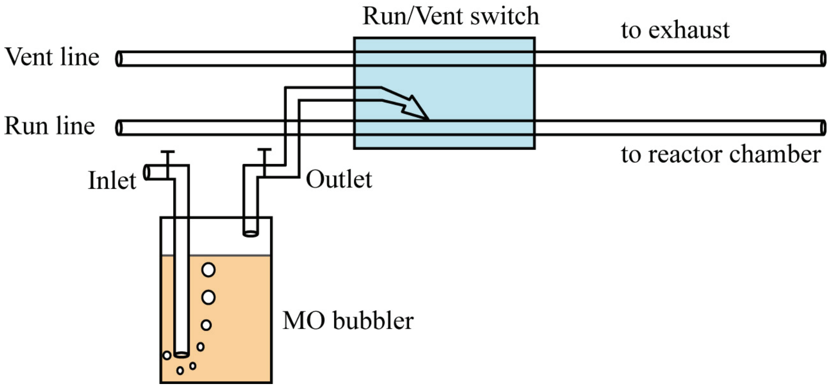

Figure 1: Schematic diagram of a Run/Vent switch.

Why is the Run/Vent switch needed?

The purpose of the Run/Vent switch is to reduce the transient "start-up effects", *e.g.*, the transient of the vapor pressure inside the bubbler. One can find its advantages by comparing the designs with and without the Run/Vent switches, which we will discuss next.

Designs without Run/Vent switches

In the old design of MOCVD systems there were no such Run/Vent switches. The carrier gas flowed into the bubbler, mixed with the vaporized MO precursor, and then flowed directly into the reactor chamber. This design led to a problem when switching among different precursors during the growth. For example, during the growth of a GaN/AlGaN multiple quantum well (MQW) structure, one needs to rapidly switch the bubbler that contains TMAl precursor "on" (for AlGaN barrier) or "off" (for GaN well). Because a quantum well is very thin (only several nanometers), a fast switching time is required. However, switching the bubbler "on" or "off" will change the gas flow and vapor pressure inside the bubbler. It takes a much longer time for the vapor pressure inside the bubbler to stabilize. When the TMAl bubbler is switched "on" to grow the thin AlGaN barrier of the MQW, the vapor pressure inside the TMAl bubbler has not yet stabilized. It is still in the transient “start-up” stage. That may affect the concentration of the vaporized TMAl precursor in the process gas that flows into the reactor chamber. Thus the quality of the AlGaN barrier may be affected.

Newer designs with Run/Vent switches

The transient “start-up effects” problem can be solved by the newer design which incorporates Run/Vent switches. When growing the thin AlGaN barrier, the Run/Vent switch will connect the outlet of the TMAl bubbler to the run line, so that TMAl precursor can flow into the reactor chamber. On the contrary, when growing the GaN well, no TMAl precursor is needed for this layer. The Run/Vent switch will connect the outlet of the TMAl bubbler to the vent line, so that TMAl precursor bypasses the reactor chamber and directly flows to the exhaust. In both of these two situations (switch to run line or vent line), the TMAl bubbler is always kept at the “on” status (*i.e.* carrier gas is flowing through the bubbler). The gas flow inside the TMAl bubbler does not change, so that the vapor pressure inside the bubbler is always kept at its stabilized value. Furthermore, the Run/Vent switch responds fast enough so that very thin MQW structure can be grown.

Note that the total gas flow into the reactor chamber is always kept constant to prevent pressure fluctuations in the reactor chamber during the growth. This is done by having two complementary working Run/Vent switches. The working sequences of the process-gas and carrier-gas (dummy) Run/Vent switches are as follows:

	Growth	**No growth**
Process-gas Run/Vent switch	Run	Vent
Carrier-gas (dummy) Run/Vent switch	Vent	Run

How long does it take for the vapor pressure inside the bubbler to stabilize?

The period to stabilize the vapor pressure inside the bubbler depends on different precursor sources, the carrier gas flow rate and the bath temperature of the bubbler. Solid-state precursor sources, *e.g.*, TMIn and Cp_2Mg need longer time to stabilize compared to liquid-state precursor sources, *e.g.*, TMGa, TEGa and TMAl. A lower gas flow rate or a lower bath temperature will also result in a longer time to stabilize. Usually it will take several minutes for the vapor pressure inside the bubbler to stabilize. The drawback of using long stabilization times is a high source-material usage.

- We use 2.5 minutes for stabilizing TMGa
- We use 2.5 minutes for stabilizing TEGa
- We use 3 minutes for stabilizing TMAl
- We use 4.5 minutes for stabilizing TMIn
- We use 200 minutes for stabilizing Cp_2Mg