Tutorial 3 - MOCVD - bubblers (©Rensselaer Polytechnic Institute)

A bubbler is a container filled with a metal-organic (MO) precursor. For the growth of III-V nitride semiconductors, there are usually five types of MO precursors, which are trimethylgallium (TMGa), trimethylindium (TMIn), trimethylaluminum (TMAl), triethylgallium (TEGa), and bis-cyclopentadienylmagnesium (Cp2Mg).

As is shown in Fig. 1, the MO precursor is contained in the bubbler. The carrier gas (N2 or H2) flows into the bubbler, dissolves the MO precursor to form a saturated gas solution, and flows out of the bubbler.

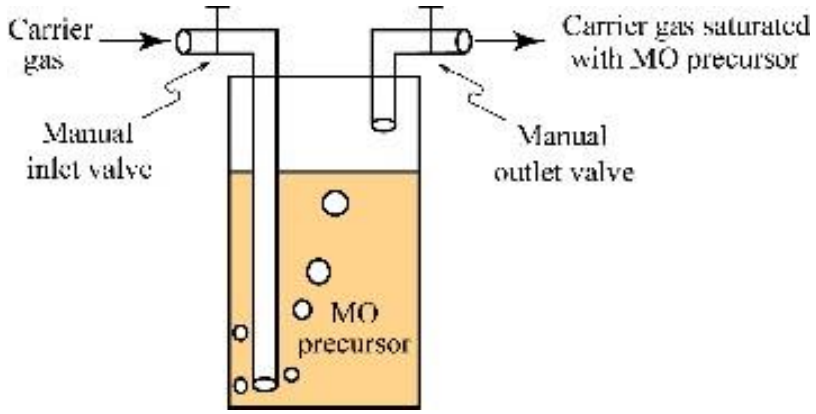

Figure 1: Schematic diagram of a bubbler.

When installing a new bubbler or deactivating an old bubbler, the sequence for opening/closing the inlet and outlet valve is very important. When opening the valves, the outlet valve should be opened first, so that the gas pressure inside the bubbler can be released through the outlet. If the inlet valve is opened first by mistake, the gas pressure inside the bubbler may push the liquid MO precursor out of the bubbler through the inlet. This must never happen. When closing the valves, the inlet valve should be closed first before closing the outlet valve, so that the gas pressure inside the bubbler can be released through the outlet.

The vapor pressure of a MO precursor depends on the temperature. In order to keep a constant vapor pressure inside the bubbler, the bubbler is placed in a bath whose temperature is precisely controlled by a thermostat. The accuracy of the temperature control is usually 0.1°C.

Here are some additional facts:

- When installing a new bubbler, wait until the temperature of bubbler has stabilized.
- The bubbler housing is usually made from stainless steel. The interior is electro-polished to provide passivation so that it does not react with the MO precursor.
- Typical bath temperatures for MO precursors are:

Name	TGMa	TEGa	TMA1	TMIn	Cp2Mg
Temperature (°C)	0	17	17	17	17

- When installing a new bubbler, wait until the temperature of bubbler has stabilized. The bath in which the bubbler is placed is 50% water mixed with 50% coolant (we use automotive antifreeze). The coolant is added to prevent metal corrosion and freezing for bubblers kept at 0°C.
- TMGa, TEGa and TMAl are liquids, while TMIn and Cp2Mg are solids at the typical bath temperature.
- MO precursors are usually flammable and toxic.
- Typical MO mass of a bubbler is 50g, 100g, or 250g.
- MO precursors are expensive. Typical list prices for 100g MO are:

Name	TGMa	TEGa	TMA1	TMIn	Cp2Mg
Price ($)	1800	2700	2300	6400	2800

Manufacturers and suppliers of MO precursors are:

Air Products and Chemicals, Inc.	http://www.airproducts.com/compound
Akzo Nobel High Purity Metalorganics	http://www.akzonobel-hpmo.com
Applied Optoelectronics, Inc.	http://www.ao-inc.com
EMF Ltd.	http://www.emf.co.uk
Sigma Aldrich Fine Chemical (SAFC)	http://www.safc.com
Praxair	http://www.praxair.com/
Dow Electronic Materials	http://www.metalorganics.com
Sichuan Western Minmetals Co.,Ltd.	http://www.swmc-metal.com
Strem Chemical	http://www.strem.com

- As soon as the carrier-gas/MO-precursor solution leaves the bubbler, it is strongly diluted by adding additional carrier gas. This is to prevent precipitation and possible deposition of the MO precursor on the inside wall of the gas lines.

- The definitions of solute, solvent, and solution are as follows:

Solute: A substance dissolved in another substance, usually the component of a solution present in the lesser amount. Examples: salt in water, where salt is the solute.

Solvent: The component of a solution that is present in the greatest amount. It is the substance in which the solute is dissolved. Examples: The solvent for sea water is water. The solvent for a MO precursor is nitrogen or hydrogen.

Solution: A homogeneous mixture of two or more substances, which may be solids, liquids, gases, or a combination of them. Examples: saltwater (water plus salt) and air (dry air plus water).