

LN₂ circulation for MBE systems

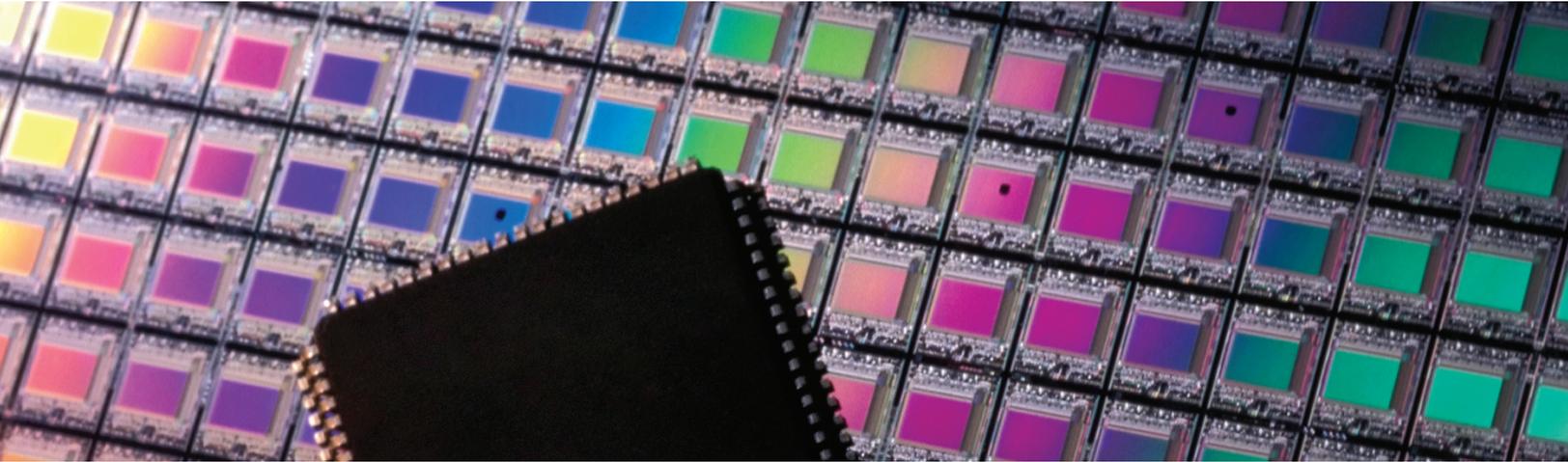


Molecular beam epitaxy (MBE) is an epitaxial deposition technique which consists of growing layers of atomically thin materials onto a substrate. The MBE process takes place inside an ultra-high vacuum chamber in order to make materials with high purity and precision. To achieve such low pressures, liquid nitrogen (LN₂) cryoshrouds are used to pump out residual gases.

The MBE technique was first developed in the early 1970's. At that time, a typical LN₂ piping system consisted of foam-insulated copper tubing fed by a portable Dewar tank placed as close to the MBE tool as possible. This method proved to be highly inefficient, and caused erratic vacuum levels within the chamber because of two-phase nitrogen flow. In an attempt to address these shortcomings, vacuum-jacketed piping was used in place of insulated copper tube. Although efficiency was increased, vacuum-jacketed piping alone did not completely eliminate the two-phase flow of nitrogen inherent to such a system. To solve this problem, Vacuum Barrier Corporation developed a LN₂ circulation system specifically designed to deliver single-phase LN₂.

VBC LN₂ CIRCULATION SYSTEM

The VBC LN₂ circulation system is fully automated and maintains completely wetted surfaces within the MBE cryoshrouds. A typical system consists of vacuum-jacketed piping running from a pressurized LN₂ bulk source to a liquid/vapor phase separator. Interconnecting feed and vent piping run between the phase separator and the MBE shroud(s). Flow is automatically regulated to the phase separator by a modulating inlet valve controlled by a differential pressure level-control system. The phase separator reservoir allows for gas to be vented to atmosphere leaving a volume of gas-free, low pressure liquid at -320°F (-196°C).



LN₂ is gravity fed from the phase separator through a triaxial feedline. Because of the hydrostatic head pressure created at the lower end of this feed pipe, a column of liquid is slightly sub-cooled as it enters the MBE. As the LN₂ flows into the cryoshroud, it picks-up heat which lowers the density of the liquid and facilitates a natural, passive circulation. The lighter liquid (along with any evolved gases) is returned to the phase separator above the liquid level through a coaxial return pipe. Gas is vented to atmosphere, and the recovered liquid can be reused. As heat levels change within the MBE, this circulation provides an automatic, self-compensating effect. The modulating style inlet valve of the VBC phase separator, coupled with frost free connections

to the MBE, maintain consistent LN₂ temperature and pressure resulting in low, constant vacuum levels within the chamber.

As the industry leader, Vacuum Barrier Corporation continues to develop new products for the MBE community. Flexible, modular piping components are available in both static and dynamic vacuum to allow users a wide range of options. VBC fabricates piping to a variety of internal diameters to accommodate the LN₂ flow rates of small research MBE's to large, high-use production tools. Years of experience as cryogenic experts has allowed VBC to continually advance both the form and function of LN₂ circulation systems for MBE.