VARIABLE TEMPERATURE MICROPROBE SYSTEMS

THE WORLD'S RESOURCE FOR
VARIABLE TEMPERATURE
SOLID STATE CHARACTERIZATION
The Variable Temperature Microprobe System

The variable temperature microprobe system (VTMP) is designed to provide measurements of semiconductor materials such as gallium arsenide, amorphous silicon, mercury cadmium telluride or others across a wide temperature range as low as 70K to as high as 730K. The VTMP systems are precisely controlled temperature environment, free of vibration and microphonics. The Microprobe system may have between one (1) and seven (7) independently controlled probes. Each probe is capable of moving on three axes, with orthogonal travel, and with positioning accuracy of better than 50 microns to provide a unique platform capable of performing a wide variety of measurements and experiments, including electrical characterization of materials and deep level transient spectroscopy.

The patented Joule-Thomson temperature stages provide both a cryogenic cooling and heating system to provide automated and high precision control of the temperature of the sample stage over a wide range of temperatures. There are many options available with the VTMP system including top down optics, turbo pumps, a transmission (bottom) window, fiber optic probe manipulators, and vibration isolation tables. This is truly a system that provides any laboratory with a nearly unlimited range of experimental capabilities and opportunities.

A Typical Variable Temperature Microprobe System

A typical variable temperature microprobe system includes:

- High-purity high-pressure gas (typically nitrogen or argon, for Joule-Thomson Cooling only)
- A filter/dryer apparatus (Joule-Thomson thermal cooling stages only) with high-pressure gas lines
- Thermal stage for heating and/or cooling
- A temperature controller
- 4-Port or 7-Port Microprobe Vacuum Chamber
- Manipulators for the Vacuum Chamber
- Vacuum Pump Setup
- Optional Add-ons like optics, vibration isolation tables, turbo molecular pumps

In addition to the VTMP components, there will also be electronic devices that can be integrated into the SMA connectors on each manipulator for sample manipulation or measurement experiments. These are not sold by MMR Technologies - but the end user has complete flexibility to integrate any signal generating or measuring device to the manipulators that may be necessary to experimental requirements.

Available Temperature Ranges on Thermal Stages

When the vacuum chamber system is held under a vacuum pressure of at least 8 milliTorr, the following temperature ranges are available on the MMR Technologies’ instruments:

- Room Temperature
- 70K to 580K
- 80K to 580K
- 70K to 730K
80K to 730K
Room temperature to 730K

* Vacuum assist Joule-Thomson thermal stages require an auxiliary vacuum pump at the thermal stage gas exhaust. These thermal stages are not available on ultra high vacuum or scanning electron microscope systems. Hot stages do not require a filter/dryer setup or high vacuum assist.

When a thermal stage is used within an ambient pressure setup, with a well controlled atmosphere, the following temperature ranges are available using the appropriate thermal stage setup:

- -10 °C to 200 °C (using nitrogen gas) or -30 °C to 200 °C (using argon gas)
- -10 °C to 350 °C (using nitrogen gas) or -30 °C to 350 °C (using argon gas)
- Room temperature to 350 °C

** These are the maximum temperature ranges under ideal conditions like a glove box where there is no humidity and a dry, clean gas environment.

** MMR Technologies’ Unique Temperature Controller

MMR Technologies’ Unique Temperature Controller is exclusively intended for use with our patented cryogenic cooling and thermal stage systems. This controller provides accurate temperature measurement, precise and very stable temperature control and easy-to-use data acquisition functions over the temperature range from 70K to 730K. Controlled cycling, temperature ramping and changing temperature operation under software control gives the user a valuable tool for solid state characterization studies.

** The Circuit Breakout Box

The temperature controller and the unique temperature stages can work together with a Circuit Breakout Box - enabling direct electrical connections between the sample surface and extra pins available on the thermal stage. This gives an expanded flexibility to the system through up to 4 external BNC connections beyond any connections available through the probe manipulators.

** The Filter/Dryer Setup

A filter-dryer system is necessary to remove both the water and the other condensable contaminants to ensure optimal performance of the Joule Thompson refrigerators. Failure to use one of these systems in conjunction with your cooling system will ultimately result in a loss of cooling capacity, reduction in the temperature range the microminiature refrigerator can obtain, clogging in the channels of the glass refrigerator, and ultimately damage to these channels that may not be repairable.

There are two types of filter/dryer systems available from MMR Technologies: Model F2115 and Model F2105. These systems are designed to work with the company’s line of microminiature Joule-Thomson refrigerators.

There are a number of applications for the filter-dryers from MMR Technologies, including:

- Suitable for drying argon, nitrogen, hydrogen, helium, and many
other gases to a Dew Point below -75 °C.

♦ Use of this dryer with the MMR line of microminiature refrigerators allows continuous operation of the refrigerators for up to hundreds of hours without clogging.
♦ The dryer may be used to provide point-of-use, dry gas at a purity level, previously attainable only with dryers of much greater cost.

*** For more detailed information on the two types of filter dryer systems, please refer to the data sheets or the technical support bulletin TSB003. These are available by contacting sales@mmr-tech.com.

The Vacuum Chamber and Manipulators

There are two sizes of vacuum chamber available for the Microprobe system. The first is a four-port chamber that may have anywhere from 1 to 4 manipulators installed. The second size chamber is the seven-port chamber that may be configured with up to 7 manipulators.

The vacuum chambers are designed to have frost free operation while under vacuum.

The optical viewing window is typically fused silica though a variety of other windows may be substituted upon request as a customization to your specific needs. The Four-Port chamber has a top window with a diameter of 1 inch (25 mm). The Seven-Port chamber has a top window with a diameter of 2.5 inches (64 mm). The Microprobe systems also come with a window port plug that allows measurements to be performed in the dark when materials are light sensitive. There is an optional bottom window available for transmission optical studies.

The Microprobe vacuum chambers can be integrated with the MMR Technologies Vacuum Accessory kit to give easy vent and purge within the Microprobe Chamber. The Microprobe chamber can then be operated with the full temperature range of the thermal stage under vacuum or on a more limited temperature range under a positive pressure of an inert gas environment.

Manipulators are completely independent of one another electrically and mechanically. They may be easily removed from the Microprobe vacuum chamber and replaced with a blanking port if fewer manipulators are required or the manipulators can be exchanged if a special version of manipulator is required. There are two types of manipulators available on the Microprobe System. The standard manipulator has an SMA connector where the outer shield is insulated from the vacuum chamber and a mini-coax connects the SMA to the tungsten probe tip. The tungsten probe that is standard with the Microprobe system has an end tip radius of 0.5 micron. Optional tips with a smaller (0.1 micron) end tip radius are available. Fiber optic probe manipulators are available as a custom option. These manipulators are readily exchangeable with the standard manipulators and come with either UV-Vis range or IR Range fiber optic probes.
and couplers in lieu of the SMA connectors and tungsten probes. The fiber optic probes can be coupled to either bring light of a specific wavelength near to the sample or to collect light emitted from the sample, thereby allowing for a wide range of optical and optoelectric experiments.

* For more information on the vacuum accessory kit, please contact sales@mmr.com and request TSB 012.

** Triax connectors are available on the Four-Port vacuum chamber upon request as a customization to meet your experiment requirements.

The vacuum chamber comes with a small digital camera microscope that can be placed over the top window viewing port, allowing you to export the signal out through a USB cable to the computer. This allows you to measure your specimens and capture images and video of your samples and experiments.

**Options Available on the Microprobe System**

**Vibration Isolation Table**

The VT1000 Custom Vibration Isolation table was designed for the Microprobe system, and specifically to be used when a turbo molecular pump is integrated into the instrumentation setup. A 6-inch diameter hole is set to one side of the table so the turbo pump can interface with the bottom plate of the microprobe chamber. The table has an optical bench integrated into the surface for the simple integration of the Microprobe system into any desired optical setup.

**Turbo molecular Pump**

The turbo molecular pump option allows the pressure within the Microprobe vacuum chamber to reach pressures of $10^{-6}$ to $10^{-7}$ Torr through an interface on the bottom of the vacuum chamber. When the turbo pump is interfaced, a hole of approximately 6 inches in diameter is required in the table or counter where the Microprobe chamber is setup - making this an ideal integration with the VT1000 vibration isolation table. MMR Technologies offers two different turbo molecular pump options depending on the level of vacuum required for experiments. These pumps have the advantage of being reliable and compact. High-pumping speeds and low vibration levels enable vibration sensitive optical experiments to be carried out in the versatile Microprobe setup.

**High Frequency Operation System**

The MMR Technologies Microprobe system was designed originally as a probe station for Deep Level Transient Spectroscopy (DLTS), where capacitance determination was made using a 1 MHz probe frequency. The need for higher frequency operation has surfaced in recent years leading to the VTMP-MHF (High Frequency Variable Temperature Microprobe System). In this high frequency Microprobe setup the SMA connectors are bonded directly to the vacuum chamber providing a common ground for input and output as well as shielding for the interior of the chamber. The grounding along with some additional modifications result in a relatively flat response up to 400 MHz and extends the pulse capability to about 0.6 nanoseconds rise time. *

* For further information, please contact sales@mmr-tech.com and request the product technical bulletin on the VTMP-MHF system.
There are three basic measurements taken with respect to the performance specifications for the Microprobe system.

**Leakage Current**

With an SMA connector installed on the manipulator and the connector outer shield isolated from the vacuum chamber and a mini-coax connection between the SMA connector and the probe tip, the typical leakage current can be seen in the figure below, ranging less than a picoAmp over a wide range of applied voltages.

**Outgassing Rate**

The Microprobe chamber is meant for stable use for vacuum pressures up to the $10^{-7}$ Torr range. As long as a vacuum pump is operating, the vacuum pressure within the chamber will remain very stable at the pressure set by the pump integrated with the system. Once the vacuum pump is turned off, the vacuum leakage or outgassing rate for the chamber can be described as ranging from 46.8 mTorr cc/sec for a Seven-Port Chamber with four manipulators installed to 34 mTorr cc/second for a Four-Port Chamber with four manipulators installed. These results are similar for the various configurations of the Four-Port and Seven-Port chambers with varying numbers of manipulators installed.

**Frequency Response**

DLTS measurements with the Microprobe called for a floating ground for the SMA connectors that was separate from that of the vacuum chamber. The performance data seen in the middle graph is not characteristic of the Microprobe itself, but rather characteristic of the particular shielding arrangement used. The location of the resonance near 110MHz is sensitive to the length of cable and grounding arrangements of the SMA; and the amount of shielding needed severely limits the use of the Microprobe in high frequency measurements.

On the other hand, with some care in shielding, consistent results can be obtained up to about 40 MHz, permitting pulse operation for rise times up to about 4 nS, with reasonable fidelity. Results
of high frequency operation can be seen in the bottom graph on page 6. When there is an experimental need for High Frequency Operation, MMR Technologies offers the MHF-Microprobe systems.

**Specifications for the Variable Temperature Microprobe Systems**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
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<tbody>
<tr>
<td>Operating Temperature Range</td>
<td>Available between 70K and 730K (Joule-Thomson Thermal Stage)*</td>
</tr>
<tr>
<td>Dimensions of Vacuum Chamber</td>
<td>Four-Port with 4 Manipulators installed: 16.68 in wide x 16.68 in long x 3.25 to 3.75 in high 42.40 cm wide x 42.40 cm long x 8.25 to 9.53 cm high Seven-Port with 7 Manipulators installed: 20.20 in wide x 20.20 in long x 3.25 to 3.75 in high 51.31 cm wide x 51.31 cm long x 20.20” x 3.25” cm high</td>
</tr>
<tr>
<td>Sample Mounting Surface Size</td>
<td>10 mm x 12 mm</td>
</tr>
<tr>
<td>Maximum Sample Weight Allowed</td>
<td>No more than 5 grams</td>
</tr>
<tr>
<td>Working Distance</td>
<td>29 mm</td>
</tr>
<tr>
<td>X and Y Travel Range for Manipulator</td>
<td>1 inch x 1 inch (25 mm x 25 mm)</td>
</tr>
<tr>
<td>Z Travel Range for Manipulator</td>
<td>6 mm</td>
</tr>
<tr>
<td>Positioning Accuracy of Probes</td>
<td>Better than 50 microns</td>
</tr>
<tr>
<td>Electrical Connections</td>
<td>SMA connectors with outer shield insulated from vacuum chamber. Mini-coax connects SMA to probe. Triax available on Four-Port Chamber only as custom request.</td>
</tr>
<tr>
<td>Leakage Current on SMA Connectors</td>
<td>Ranges from ‘-/ 1 pA in the range of applied voltages from ‘/- 30V **</td>
</tr>
<tr>
<td>Temperature Controller Requirements</td>
<td>MMR’s Programmable Temperature Controller</td>
</tr>
<tr>
<td>Temperature Accuracy</td>
<td>&lt; 0.5K at 80K; ‘/- 0.5K between 80K and 400K; &lt; 1.5K from 400K to 730K</td>
</tr>
<tr>
<td>Temperature Stability</td>
<td>‘/- 0.5K</td>
</tr>
<tr>
<td>Temperature Resolution</td>
<td>0.1 K</td>
</tr>
<tr>
<td>Filter/Dryer Requirements</td>
<td>Either the standard filter dryer or the reversible filter dryer system if operation below room temperature is required.</td>
</tr>
<tr>
<td>Vacuum Requirement</td>
<td>For operation outside of room temperature, 8 milliTorr of vacuum pressure is a minimum requirement. Better vacuum can be achieved with a turbo pump setup.</td>
</tr>
<tr>
<td>Outgassing Rate</td>
<td>46 mTorr cc/sec (0.6 x 10^-4 atm cc/sec) ***</td>
</tr>
<tr>
<td>(based on a Seven-Port Chamber with Four Manipulators starting at 4 milliTorr)</td>
<td></td>
</tr>
<tr>
<td>Optical Viewing</td>
<td>USB Powered Digital Microscope mounts over top window port 2 MP Digital Camera for capturing images and video 10x to 40x magnification (up to 150x on some monitors) 6 LED ring illuminator</td>
</tr>
</tbody>
</table>

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* For more information, please refer to the product data sheets for the Joule-Thomson thermal stages and for the Helium Cryostat.

**For more detailed information on the Leakage Current, please contact sales@mmr-tech.com.
Features and Benefits

The variable temperature microprobe systems are noted for their unique benefits and features, making these systems easy to use and inexpensive additions to research facilities:

♦ Modular - you can build the systems up over time to meet your budget and experimental needs.
♦ Bench-top Configuration: small and compact in size
♦ Excellent temperature setability, stability, and reproducibility.
♦ Absence of mechanical, acoustic, or electrical noise.
♦ Fast cool down and warm up times, with frost free operation.
♦ Wide range of operation: 70K to 730K
♦ Non-magnetic electrical feedthroughs facilitate electrical connections directly to samples on the thermal stage.
♦ Low cost of operation: $0.50/hour
♦ On the Joule-Thomson stages there are no liquid cryogens to handle.
♦ Very low power consumption - less than 12 watts on any stage.
♦ Designed for stereo zoom microscope integration - providing easy observation of probe placement and operation.

Applications

MMR Technologies Variable Temperature Microprobe system is one of the more flexible instruments for solid state characterization. There are many possible applications for these systems, including but not limited to:

♦ Optical Experiments
♦ Deep Level Transient Spectroscopy Studies
♦ Micromanipulation
♦ Electrical Measurements
♦ Fiber Optic Probe Illumination and Optical Studies
♦ Material studies
♦ IC Testing
♦ Testing of IR detectors
♦ MEMS
♦ Environmental Control Chamber Studies

These systems are flexible, modular, and highly adaptable to integrate with a wide variety of experiments through SMA or triaxial connectors on each manipulator.