

Bridgman Single Crystal Growth Furnace (CLIN 0001)

The Naval Research Laboratory (NRL), Washington, DC has a requirement for a front loading, vacuum/inert atmosphere Bridgman single crystal growth furnace capable of high temperature operation (up to a maximum of 2200°C). This system will be used for the synthesis of single crystals of a wide variety of materials. The system will be used for research and development of novel advanced materials and must allow flexibility for control parameters during growth (e.g. growth rates, temperature range, atmospheric control). The growth system will be placed in a facility with multiple users and must provide ease of operation for personnel with varying degrees of expertise in crystal growth. The growth system must also provide safety measures to both the individuals using the system (i.e. prevent personnel injury) and to the facility itself (i.e. prevent damage of equipment). The system must be capable of growing single crystals of a wide range of materials (e.g. metals, intermetallics, semiconductors, etc.). The crystal growth control parameters must include but are not limited to: temperature, atmospheric environment (i.e. vacuum or inert gas), and crystal translation rate. The system must have a computer interface for control of temperature and sample draw systems. The chamber must include a port near the sample hot zone for viewing the sample during growth. The single crystal growth furnace must have overload protection, electrical isolators, a lockable main power circuit breaker, and automatic shutdown features designed to protect both the operator and the equipment from harm. The furnace chamber must have a water-cooling system to cool both the sample chamber housing and the sample pedestal.

The system shall include (at a minimum) the following major components:

- 1) A resistive element furnace capable of operating up to a maximum of 2200 °C
- 2) An atmosphere control system with both positive pressure and high vacuum crystal growth environment capabilities
- 3) A crystal translation system, including a sample draw mechanism with linear travel readout
- 4) A water cooling system
- 5) Computer hardware and software for automated monitoring of the crystal growth of time-stamped sample processing conditions. This will include a programmable controller and/or computer control for gas and vacuum systems, temperature control, and draw mechanism.

The major system components must meet or exceed the following minimum specifications:

1.0 Furnace

The furnace must be capable of operating at temperature up to a maximum of 2200 °C within an enclosed double walled stainless steel chamber. The furnace must be capable of operating under an inert atmosphere from high vacuum (10^{-6} torr) to positive chamber pressure (100 PSIG) conditions. The furnace must be capable of heating at a rate up to a maximum of 20°C/min. Programmable temperature controllers and thermocouple temperature measurement must be used to control the temperature during operation. The temperature of the furnace hot zone shall not deviate by more than $\pm 10^{\circ}\text{C}$ from the set point over a region 1.25" in diameter and 6" in height. The furnace must have utility ports available to extend the capabilities of the crystal growth furnace should future modifications be deemed necessary. Access to the chamber shall be provided through a full opening, hinged door with an anti roll back feature. The chamber must also have a shutterable quartz port window aligned with the centerline of the heat zone. A safety mechanism must be implemented that prevents power to the furnace elements when a preset temperature has been exceeded.

2.0 High Temperature Control System

The furnace must have a high temperature control system with a retractable thermocouple for temperatures below 1400°C and an optical pyrometer for the 1400 to 2200°C temperature range. A pneumatic operated retractor mechanism must be used for retraction of the thermocouple at high temperatures. Seamless transition from thermocouple to pyrometer control is a required.

3.0 Atmosphere Control System

The crystal growth furnace must have both inert gas and high vacuum operation capabilities. The pressure range for operation must range from 100 PSIG to 10^{-6} torr. The vacuum system must include both roughing and turbo pumps to achieve the low-pressure requirement. Ports must be available into the furnace for inert gases and the vacuum pumping system. Gauges to monitor the vacuum performance must include ionization, thermocouple, and compound pressure-vacuum gauges. As a safety feature of the atmosphere control system, the crystal growth furnace must include a pressure relief valve. A safety mechanism must be implemented that prevents power to the furnace elements when 1) the pressure exceeds a preset threshold or 2) either vacuum pump experiences overload or exceeds a preset temperature(necessary for high vacuum operation mode only).

4.0 Gas Purification Furnace

The atmosphere control system must include a gas purification furnace to improve the furnace heating element service time. The gas purification furnace must reduce the oxygen content of the inert gas to better than 10^{-6} ppm. The gas purification furnace must be fully self-contained.

5.0 Crystal translation system

The sample draw mechanism must be capable of a minimum ten-inch (10") stroke and rated for 100 PSIG operation. The sample translation speed must be greater than or equal to the variable speed range of 0.5 to 10 mm/hr and must incorporate a fast 'jog' mode for sample positioning. The work support connected to the sample draw mechanism must be water cooled during furnace operation. The position sensor for the draw mechanism must have a travel capability of 9.5" with a repeatability of 0.005% for proper repositioning of the sample.

6.0 Water Cooling System

The water cooling system for the furnace must have a solid state flow switch with controlled master water circuit protection. The cooling system must also include individual, manually operated ball valve controls for each water circuit. The cooling system must include an in-line strainer or filtering system. A safety mechanism must be in place to prevent power to the furnace when there is inadequate cooling water flow through the furnace and/or through any cooling circuit.

7.0 Computer Hardware and Software

The crystal growth furnace must include a computer control system capable of controlling the furnace temperature and monitoring the pressure, sample draw mechanism, and vacuum gauges. All necessary electrical hardware and cabling between the temperature controller and the computer must be provided. The computer hardware and software shall meet or exceed the following minimum specifications:

7.1 The hardware must include a PC with Windows XP operating system and the following minimum configuration: Pentium 4 2 GHz processor, 512 MB RAM, 40 GB hard drive, floppy drive, DVD/CD-RW Drive, and a Color Display..

7.2 The software must provide temperature control and system monitoring capabilities which allow the computer to communicate with the vacuum and temperature sensors and control the furnace temperature. The software must also provide a time-stamped data log of the pressure and temperatures measured during growth. The data log must be in a form that can be readily exported and analyzed using spreadsheet/graphing software.

7.3 The software must include the capability to customize the data acquisition and storage process to monitor the temperature, pressure, and sample draw mechanism.

7.4 The software must include a means to monitor the sample growth conditions in real time through the Color Display.

8.0 Option Items

8.1 Solid State Flow Switches (CLIN 0002)

The water cooling system must have solid state flow switches for each cooling circuit to protect against loss of cooling water. The flow switches must have warning indicator lights for low flow conditions and be adjustable for proper flow rate.

8.2 Replacement Heating Elements (CLIN 0003)

The single crystal growth furnace must be accompanied by two replacement sets of heating elements.

9.0 GENERAL REQUIREMENTS

9.1 Used Equipment

Offers of used equipment will not be accepted.

9.2 Installation Site, Installation, and Training.

The contractor shall deliver and install the Bridgman crystal growth furnace to the Naval Research Laboratory, Washington DC 20375, at the location specified by the authorized government representative. NRL will be responsible for providing the necessary facilities and utility hook-ups at that location for proper installation and operation of the crystal growth furnace. The contractor shall provide a pre-installation guide with its proposal submitted in response to the solicitation. The pre-installation guide shall indicate, in detail, all of the site requirements including, but not limited to: utility hook-ups (e.g. electrical, air, water, vacuum,

etc.); required space (e.g., doorway passage, floor space, operating space, maintenance access space, etc.); required ambient environment (e.g. temperature, vibration, air flow, etc.); procedures for receiving the equipment and placing it in its laboratory location for use and communication hook-ups. (e.g. Ethernet, portable media connections for data retrieval) The Bridgman crystal growth system shall be ready for immediate use following installation/set-up by the contractor. The contractor shall provide a minimum of three days of setup/training for up to three people at NRL-DC following the installation and set up of the crystal growth furnace.

9.3 Warranty

The contractor shall offer the Government at least the same warranty terms, including offers of extended warranties, offered to the general public in customary commercial practice. These warranty terms must be included in the system price. The period of the warranty shall begin upon contractor installation and calibration of the test system.

9.4 Documentation

Written documentation customarily provided to the public with a commercial item shall be provided. This shall include user manual(s) or equivalent as well as copies of any software, and any manuals for the software included with the system, if customarily provided. This documentation must be received at NRL with the system hardware, unless other arrangements are agreed to by the authorized Government representative. This documentation shall also include all documentation, drawings and schematics for full site preparation, operation, troubleshooting, servicing and repair of the system and its components.