INTEGRATED THERMAL ANALYSIS SYSTEM

The Naval Research Laboratory (NRL), Washington, D.C. has a requirement for an integrated thermal characterization system. This integrated system will perform simultaneous differential scanning calorimetry (DSC), thermal gravimetry (TG), differential thermal analysis (DTA), mass spectrometry (MS), and dilatometry at temperatures up to +1550 degrees Celsius. The system must have a computer automated control and data acquisition capabilities. All offerors are expected to comply with installation, warranty, and documentation requirements as detailed in paragraph 2.0 below.

1.0 Integrated Thermal Analysis System

NRL has a requirement for a turnkey thermal analysis system capable of performing multiple functionalities simultaneously over a broad temperature range. The system will be used for characterizing the phase transformation, enthalpy change, weight change, thermal expansion coefficients, sintering parameters, linear thermal expansion, and gas evolution of a wide variety of materials. The system must be suitable for research and development of new advanced material systems and must have wide-ranging capabilities for user control over the test parameters (e.g., temperature ramp rate, atmosphere, etc.). The test system will be placed in a facility with multiple users and must provide ease of operation (suitable for use by multiple individuals with a range of experience in thermal analysis instruments) and safety to those in the facility.

The system must be capable of material testing during heating and cooling via computer software based on user-input parameters. The system must be capable of computer automated measurement and recording of the test signals. The system must also include data acquisition and analysis software for the determination of characteristic temperatures (e.g., the onset and peak of phase transformation, etc.) and key thermal properties (e.g., enthalpy, etc.). The system must include, at a minimum, the following major components:

1) Simultaneous thermal analysis module capable of differential scanning calorimetry, differential thermal analysis, and thermal gravimetry measurements.
2) Mass spectrometer that is directly coupled to the simultaneous thermal analysis module.
3) Cryogenic cooling module for the thermal analysis system.
4) Dilatometer module capable of determining sintering parameters, thermal expansion coefficients, and calculated DTA.
5) Computer software for automated testing, control, data acquisition, and data analysis.

Each component must meet or exceed the following minimum specifications:

1.1 Simultaneous Thermal Analysis Module (CLIN 0001)

The thermal analysis instrument must be a combined differential scanning calorimetry (DSC), differential thermal analysis (DTA) and thermal gravimetry (TG) measurement unit capable of performing these measurements simultaneously. The thermal analysis instrument must meet or exceed the following minimum specifications:

1.1.1 The instrument must be a vertical, top-loading furnace design to avoid condensation and to support natural gas flow. The furnace must have a motorized hoist with a separate safety button.

1.1.2 The furnace must have a temperature capability that equals or exceeds 1550 degrees Celsius. It also must be exchangeable with a cryogenic cooling module for measurement down to -150 degrees Celsius. The furnace must have forced air cooling.

1.1.3 The furnace must have a heating rate control capability equal to or lower than 0.1 degrees C/min. The furnace must have a safety feature to limit the heating rate to no more than 50 degrees C/min to avoid cracking in ceramic components.

1.1.4 The furnace must have a user-exchangeable protective tube to avoid cross-contamination of volatile species.

1.1.5 The system must be able to perform simultaneous TG-DSC/DTA measurement on one sample during one run to minimize sampling error. For low density materials, a user-exchangeable sample container for TG measurement with a capacity larger than 3 cubic centimeters shall be available.

1.1.6 The instrument must be able to perform measurement under oxidizing, reducing, and inert atmospheres, as well as under vacuum. It must have a vacuum tight design (equal to or better than 0.0001 mbar) to be used with a high vacuum pump system.

1.1.7 The balance must have a measurement range of 5 grams and a resolution of 0.1 micrograms over the entire range. Under isothermal conditions, the balance must have a stability better than 1 microgram/hr.

1.1.8 The instrument must be able to directly couple to a mass spectrometer and Fourier Transform Infrared Spectroscopy (FTIR) for simultaneous measurements.

1.2 Mass Spectrometer (CLIN 0002)

The mass spectrometer must be able to couple directly to the thermal analysis instrument (CLIN 0001) for simultaneous characterization of gas evolution analysis while a thermal analysis measurement is in progress.

1.2.1 The gas transfer line for coupling must have heating capability of 300 degrees C or higher.

1.2.2 The detection resolution must have a range of equal or greater than 300 amu.

1.2.3 The contractor shall provide the coupling adapter for the gas transfer line.

1.2.4 The contractor shall provide the temperature controller for the gas transfer line and the coupling adapter.

1.2.5 The mass spectrometer must also be able to operate independent of the thermal analysis instrument (CLIN 0001) for the analysis of other gas sources.

1.3 Dilatometer Module (CLIN 0003)

1.3.1 The furnace temperature capability must equal or exceed 1550 degrees Celsius.

1.3.2 LVDT displacement measurement with resolution equal or better than 1.25 nanometers/digit and a measuring range of equal to or greater than 5000 μm.

1.3.3 The instrument must be able to perform measurement under oxidizing, reducing, and inert atmospheres, as well as under vacuum level lower than or equal to 0.4 mbar.

1.3.4 The contact force applied by the pushrod must not exceed 0.5 newtons.

1.3.5 The dilatometer must have the capability of performing measurements on powder, paste, and metal melt materials (with appropriate sample containers).

1.3.6 Capable of performing a calculated differential thermal analysis to identify exothermal or endothermal events while a dilatometry measurement is in progress.

1.3.7 Must be integrated with the simultaneous thermal analysis module through a central computer that controls the entire system.

1.4 Cryogenic Cooling Module (CLIN 0004)

The cryogenic cooling module must be comprised of two components: 1) a low temperature furnace that is exchangeable with the high temperature furnace of CLIN0001 and 2) a liquid nitrogen-based cooling unit that provides the cooling capability to the low temperature furnace. The cooling module must or exceed the following minimum specifications:

1.4.1 The low temperature furnace is equipped with shielded heating elements and a cooling shell for the cooling agent.

1.4.2 The liquid nitrogen cooling unit must have a content level indicator.

1.4.3 The cryogenic cooling module must have a temperature capability of -150 to 650 degrees Celsius.

1.5 High Vacuum Pump System (CLIN 0005)

The contractor shall provide a turbo-molecular pump with the driving electronics and a vacuum capability of equal or lower than 0.0001 mbar. The contractor will also provide a two-stage vane rotary pump for rough vacuum. All mounting hardware and gauges must be included.

1.6 Low Temperature Sample Holder (CLIN 0006)

The contractor shall provide a sample holder capable of temperature range of -150 to +700 degrees Celsius. A type E thermocouple should be included.

1.7 High Temperature Sample Holders for TG and DTA (CLIN 0007)

The contractor shall provide one sample holder for the simultaneous TG and DTA measurements. The temperature capability must be from +25 to +1650 degrees Celsius or better.

1.8 High Temperature Sample Holder for TG and DSC (CLIN 0008)

The contractor shall provide one sample holder for the simultaneous TG and DSC measurements in the temperature range of +25 to +1650 degrees Celsius.

1.9 Spare Heating Elements (CLIN 0009)

The contractor shall provide one set of spare heating elements and the mounting hardware.

1.10 Spare Protective Tubes (CLIN 0010)

The contractor shall provide two spare protective tubes and the mounting hardware.

1.11 Spare Sample Containers for Dilatometer Module (CLIN 0011)

The contractor shall provide one sample container for measurements on powder and paste materials and one sample container for metal melts.

1.12 Computer Software (CLIN 0012)

The test system must include computer hardware and Windows XP compatible software for control of the integrated system and concurrent data acquisition. All necessary electrical hardware/cabling between the individual components, controllers, and computer must be provided. Additional requirements include:

1.12.1 The software must provide system control, data acquisition and storage, data analysis, etc. for standard test methods.

1.12.2 The software must include the capability to customize the data acquisition and storage process (e.g., data acquisition rate, etc.).

1.12.3 The software must provide a means for real-time monitoring and testing through user-selectable digital display meters and auto-scaling graphics.

1.12.4 The software must be able to correct enthalpy values for weight changes during the measurement run.

1.12.5 The software must include calibration routines and baseline correction capability.

1.12.6 The software must be able to be used for the control, data acquisition, and data analysis of the Dilatometer Module.

1.12.7 The software must be able to calculate the differential thermal analysis behavior of the data obtained from the dilatometer module.

1.13 Acceptance Criteria

The contractor shall demonstrate the system's capability and functions at time of installation. The contractor shall demonstrate use of the materials test system using NRL-DC supplied test coupons including: oxide ceramics and magnetic materials.

1.14 Installation and Training

The contractor shall deliver and install the materials test system at the Naval Research Laboratory, Washington DC 20375, at the location specified by the authorized government representative. The contractor shall install the components (CLIN 0001 to CLIN 0012) in their final integrated configuration and then calibrate the integrated system. The contractor shall deliver at least traceable standards to allow calibration of temperature and DSC/DTA by the user. The contractor shall provide a minimum of 2

days of training for up to six people at NRL-DC. The training shall be conducted immediately following contractor installation and calibration of the system. The topics to be covered in the training session shall include: test system functionality, operation, procedures, maintenance, and software.

2.0 General Requirements

The following information/requirements apply to all instruments which make up the thermal characterization facility:

2.1 Used Equipment

Offers of used equipment will not be accepted.

2.2 Installation Site.

The contractor shall deliver and install the materials test system 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 materials test system. 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., bench depth, maintenance access, etc.); environment (e.g. temperature, vibration, air flow, etc.); procedures for receiving the equipment and placing it in its laboratory location; and communication hook-ups (e.g. Ethernet). The materials test system shall be ready for immediate use following installation/set-up by the contractor.

2.3 Warranty

The contractor shall offer the Government at least the same warranty terms, 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.

2.4 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.