REPORT DOCUMENTATION PAGE

OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED (From – To)
1 Jun 07	Final Technical Report	1 Jun 07 14 Jun 08

4. TITLE AND SUBTITLE
Acquisition of thermal analysis instrumentation for the thermodynamic and mechanical analyses of advanced materials

5a. CONTRACT NUMBER

5b. GRANT NUMBER
FA9550-07-1-0496

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
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5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

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USAF/AFRL
AFOSR
875 North Randolph Street
Arlington VA 22203

10. SPONSOR/MONITOR'S ACRONYM(S)
AFOSR

11. SPONSORING/MONITORING AG... N...
AFRL-OSR-VA-TR-2013-0963

12. DISTRIBUTION AVAILABILITY STATEMENT

Distribution Statement A: Approved for public release. Distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT

The proposed work is of significant importance to the Air Force structural materials program and will result in fundamental understanding of materials properties at elevated temperatures.

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE	Unclassified	11	19b. TELEPONE NUMBER *(Include area code)*
Unclassified	Unclassified	Unclassified			(703)

Final Report

Acquisition of thermal analysis instrumentation for thermodynamic and mechanical analyses of advanced materials

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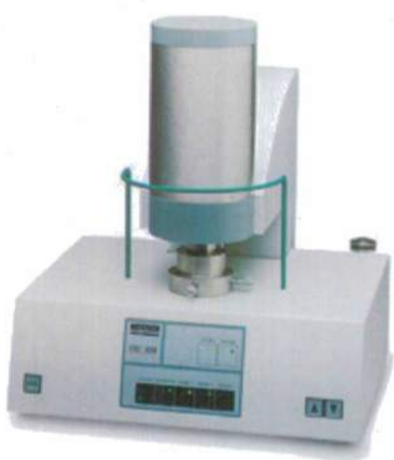
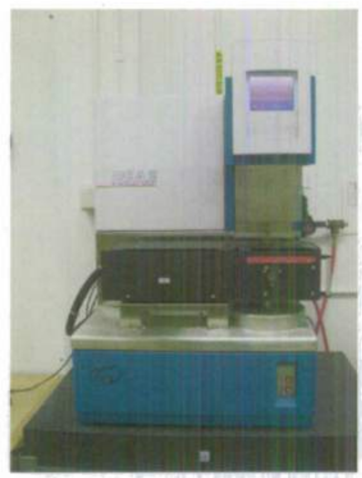
Types of Equipment:
Differential Scanning Calorimeter (DSC) and Dynamic Mechanical Analyzer (DMA)
Manufacturer: Netzsch Gmbh for DSC and TA Instruments, Inc. for DMA
Cost of Equipment: $74,851 for DSC and $95,149 for DMA and accessories



Netzsch 404C DSC



Thermal Analysis, Inc. RSA III DMA

Acquisition Summary:
With the funds provided by this grant Iowa State University acquired state-of-the-art differential scanning calorimeter (DSC) and dynamic mechanical analysis instruments in 2008. After soliciting bids from three different thermal analysis instrument manufacturers, the principal investigators selected a Netszch 404C DSC and a Thermal Analysis, Inc. RSA III DMA. The specific DSC instrument was chosen based on the high-temperature (T_{max} ~1500 °C) capabilities combined with excellent sensitivity for performing heat capacity measurements, which are essential for obtaining material properties to understand phase transformations and to develop data to compare with modeling predictions. Likewise the DMA instrument we obtained was selected because of the excellent temperature control provided by its unique force-gas convection furnace employing platinum-resistance thermistors. Moreover, this furnace design is easily modified to allow for a well-collimated X-ray beam to pass through its center and strike a

sample during dynamic mechanical testing (e.g., tension, compression or shear); diffracted X-rays may be collected using an area detector, thereby affording the capability to obtain structural data (e.g., lattice spacing or crystal structure) *in situ* during a broad array of complex loading conditions from ambient to 600 °C. The specialized *in situ* X-ray DMA experiments will be performed at synchrotron facilities (e.g., Advanced Photon Source at Argonne National Laboratory). As a consequence, the extremely large size of data files (i.e., > 2-3 giga bytes) requires parallel computing to efficiently process the large amount of data. Consequently, several processors were purchased from Dell to support this specialized effort.

Instrument Capabilties:

The DSC instrument has the following capabilities:

- 1500 °C temperature capability with operation in air, inert gas and high vacuum
- heat capacity sensitivity of +/- 1.0%

The DMA instrument has the following capabilities:

- 25-600 °C temperature capability with forced-air convection (inert gases may be used instead of air to reduce oxidation of sensitive materials)
- maximum force of 40 N
- loading configurations include tension, compression and 3-point bending
- dynamic loading at frequencies from 0.01 to 100 Hz; amplitudes depend on elastic properties of test materials
- transient loading for creep, stress relaxation and controlled strain-rate tests
- a second furnace was purchased and modified for use at synchrotron beam lines to perform *in situ* experiments for collecting structural data in parallel to mechanical responses to dynamic and transient loading

Current Status of Instruments:

The Netzsch 404C DSC was installed and became operative in June 2008. The system is currently being used to study phase transformations and heat capacity of Pt-modified Ni-Al alloys for use in gas turbine engines and heat shield for hyper-sonic vehicles.

The Thermal Analysis, Inc. RSA III DMA was installed and became operative in April 2008. It is being used, in part, to examine the martensitic phase transformations in Pt-modified Beta Ni-Al alloys. Moreover, a second furnace was purchased and modified in June 2008 to allow for *in situ* synchrotron X-ray experiments where we will collect high-precision structure data along with changes in elastic behavior as a function of temperature. A proposal for beam time at the Advanced Photon Source at Argonne National Laboratory was granted access beginning July 30, 2008.