Phase I Project Summary

Firm: MicroXact, Inc.
Contract Number: NNX10CD42P
Project Title: Temperature Sensing Solution for Cryogenic Space Engines

---

Identification and Significance of Innovation:

Cryogenic systems, heavily used in rocket ground testing, space station operations, shuttle launch systems, etc, require a number of temperature sensors for system management and control. Currently available temperature sensors cannot offer simultaneously sufficient reliability in highly corrosive environments of LOx and LH2 flows and sufficient temperature resolution. Development of new type of cryogenic temperature sensing solutions is needed to meet reliability and sensitivity requirements simultaneously and thus to provide NASA with more efficient, reliable solution for ground testing and flight missions. MicroXact Inc. proposes to develop highly sensitive, reliable sensing solution to address NASA needs that will offer ease of calibration and installation. In Phase I the feasibility of the solution was experimentally demonstrated. In Phase II, sensors and system will continue to be refined and will undergo extensive testing and validation. By the end of Phase II, the proposed sensing solution will reach TRL 5. In Phase III, MicroXact will commercialize the developed sensors.

Technical Objectives and Work Plan:

Phase I project objectives were:
Objective 1: Develop the CuO/epoxy nanocomposite coating.
Objective 2: Demonstrate nanocomposite fiber coating.
Objective 3: Design the temperature measurement solution for NASA applications.
Objective 4: Enhance commercialization and transition to manufacturing strategies, develop Phase II plans.
Objective 4: Develop strategies for product commercialization and transition to manufacturing.

Work proceeded through the following tasks:
Task 1: Develop CuO/epoxy nanocomposite.
Task 2: Demonstrate elastic properties of nanocomposite at cryogenic temperatures.
Task 3: Develop nanocomposite fiber coating.
Task 4: Demonstrate performance of single-point fiber optic sensor at cryogenic temperatures.
Task 5: Design the temperature measurement solution for NASA applications.
Task 6: Develop the concept of Phase II, commercialization strategy, and transition to manufacturing.

Technical Accomplishments:

During Phase I project, MicroXact developed CuO nanoparticle synthesis process resulted in high level of CuO nanoparticle monodispercity, and developed ball milling process to induce oxygen vacancies in the nanoparticles, necessary to provide large negative coefficient of thermal expansion (CTE) at cryogenic temperatures. Significant progress has been made on development of CuO nanoparticles/epoxy nanocomposite coating; however, the best results were achieved with Combustion-Driven Compaction (CDC) of CuO nanoparticles, where large negative CTE was demonstrated in CuO nanogranular ceramic sample. MicroXact Inc. developed the process of Fiber Bragg Grating sensor coating with CuO/epoxy nanocomposite and demonstrated (with the assistance of, Lake Shore Cryotronics Inc.) large sensitivity of the sensor at cryogenic temperatures. MicroXact also designed the fiber optic temperature sensors for NASA applications, conceptually developed the calibration procedures, selected the LOx protective coating and developed the process of coating its sensors. Also during the project, MicroXact identified

both the near term and long term applications, and developed a preliminary concept of a commercialization plan for the cryogenic fiber optic temperature sensors under the development on this project. This provides a solid foundation for Phase II development, optimization and demonstration of fiber optic temperature sensors for cryogenic temperatures.

NASA Application(s):

The proposed solution when properly developed will find applications in NASA test facilities as well as potentially in space missions utilizing cryogenic space engines. Applications include but not limited to LOx and LN2 pipeline temperature monitoring, and LOx and LN2 liquid level sensing in cryogenic tanks. Not only it promises the improvement of reliability and useful lifetime of temperature sensors, but it also promises significant cost savings due to multiplexibility and low weight of the solution. This, in turn, will cause a significant impact on the cost, safety and reliability of future NASA missions.

Non-NASA Commercial Application(s):

In addition to NASA applications the proposed solution will find applications in such applications as temperature measurements in superconducting RF cavities (used in accelerators), superconducting magnets (for MRI imaging as general research), temperature mapping of superconducting power lines and many more.

Name and Address of Principal Investigator: Dr. Vladimir Kochergin, MicroXact, Inc., 2000 Kraft Drive, Suite 1207, Blacksburg, VA, 24060-6373

Name and Address of Offeror: MicroXact, Inc., 2000 Kraft Drive, Suite 1207, Blacksburg, VA, 24060-6373