SON Number: WPSON-12-04 **October 28, 2010**

Strategic Environmental Research and Development Program (SERDP)

FY 2012 STATEMENT OF NEED

Weapons Systems and Platforms (WP) Program Area

RELIABILITY OF TIN-WHISKER-MITIGATING CONFORMAL COATINGS

1. Objective of Proposed Work

The objective of this Statement of Need (SON) is to develop an understanding of the key mechanisms by which conformal coatings may provide long-term tin-whisker mitigation and nucleation/growth inhibition, and develop or identify conformal coatings that can provide long-term tin-whisker mitigation. Proposals are sought that either: (1) investigate only the fundamental mechanisms by which conformal coatings provide for mitigation or (2) investigate the fundamental mechanisms linked to the development of conformal coatings and application methods that provide for long-term mitigation.

Researchers should consider contributing factors influencing the formation and growth of tin whiskers. Consideration should be give to the diverse environmental conditions in which the Department of Defense (DoD) assemblies operate and the potential exposure to operational and maintenance fluids. Conformal coating application processes for both new and repair/rework assembly processes are of interest. A fundamental understanding of the key coating attributes as well as alternative methods of application will ensure effective whisker mitigation. The basic areas of interest include the interaction of conformal coatings with Pb-free surfaces and conformal coating properties. The study of the interaction of conformal coatings with surfaces may include consideration of topics such as (1) mechanisms for inhibition of whisker nucleation/growth (2) stress coupling between coating and tin finishes, or (3) micro-adhesion over non-homogenous Pb-free alloy and finish surfaces including the influence of micro-roughness and residual contamination from manufacturing processes.

Research on the conformal coating properties should consider one or more of the following topics: (1) diffusion of ionic species to the Pb-free surface (factors that might contribute to whisker growth), (2) understanding coating mechanical properties in DoD operational and storage environments (humidity, thermal aging, thermal cycling, altitude, vacuum, ozone, corrosive gases, salt fog, sulfur environments, etc.) and exposure to the various operational or maintenance fluids (hydraulic fluids, hydrocarbon fuels, deicing fluids, organic solvents, cleaners, etc.), (3) coating process considerations such as the initial application of coatings and rework as well as coating coverage of electronic assemblies including lead tips, vertical surfaces, corners and edges, (4) penetration and tunneling resistance of coatings by tin whiskers including the investigation of the coating creep under very low loading rates such as those encountered when slow growing whiskers are impinging on a conformal coated metal surface, and (5) development of an advanced film test methodology to measure film properties on a microscopic scale comparable to the dimensions of tin

whiskers, hillocks, and odd-shaped eruptions. Such methodology should be capable of measurement times on the order of 100-10,000 hours.

2. Expected Benefits of Proposed Work

The proposed research will result in a benefit to DoD by providing a scientific understanding of the key conformal coating properties and manufacturing parameters by which tin-whisker mitigation can be optimized and the identification or development of materials and application methods that provide long-term tin-whisker mitigation. This research area has the potential to mitigate the drastic impact on weapon systems reliability caused by the uncontrolled introduction of new Pb-free alloys and finishes into DoD's supply and manufacturing systems.

Gaining a scientific understanding of basic conformal properties in the context of tin-whisker growth and tin-whisker mitigation will help accelerate the removal of Pb from the supply chain. A fundamental understanding of the conformal coating behavior is expected to result in improved methods for verifying and quantifying the electrical and mechanical tin-whisker mitigation performance that can be used by both the coating manufacturer and the electronics assembler taking into account environmental and manufacturing variables.

3. Background

Historically, Pb has been mixed into electronic solder materials to improve manufacturing processing and reduce the growth of tin "whiskers". Recent legislation enacted by the European Union (EU) as well as several states has banned the presence of Pb in many applications. This change has caused a global change in the types of solders used in the consumer electronics sector causing a widespread shift to new "Pb-free" electronic finishes and solders. Because the DoD has such a small market share of electronic systems (less than 0.3%), weapon systems program managers are forced to shift away from Pb-containing alloy systems before the impact on weapon systems reliability is fully understood. The tin-rich Pb-free finishes used with these alloys no longer serve to mitigate the growth of whiskers which if left on their own can short out electronic circuits and cause mission critical systems to fail prematurely.

The recent directives and legislation have resulted in the majority of the lower tier component suppliers modifying their products to meet the primary market demands. Current high reliability systems place less than a 1% demand on the total market consumption of electronic components. With no "drop-in" replacement for Sn-Pb heritage solder alloys multiple Pb-free alternatives have emerged in the manufacturing industry as replacements; however, pure tin is by far the dominant component lead finish. The major concern with the Pb-free solders and finishes is the reemergence of tin whiskers.

While many aspects of the Pb-free transition cannot be controlled by DoD, the application of conformal coatings for the mitigation of tin-whisker risk is a key item that original equipment manufacturers (OEMs) can readily implement. Conformal coatings are already routinely applied in many, but not all, DoD applications to improve humidity performance and reduce corrosive effects. The presence of the coatings provides some level of default tin-whisker shorting risk mitigation, but the level of mitigation has not been quantified nor qualified. There are a broad range of acrylic,

polyurethane, silicone, epoxy and vacuum deposited conformal coating systems currently qualified for use. None of these coatings have been designed specifically for, nor comprehensively evaluated for, tin-whisker mitigation. In an effort to enhance the current DoD conformal coating materials, application and assembly qualification requirements need to include whisker mitigation attributes.

Current research with conformal coatings has been made with short term measurements of tin whiskers. This is accomplished using material combinations which knowingly are active sources of tin whiskers. These combinations are not representative of design/production processes utilized throughout industry. Observations of these conditions may not be applicable to combinations which are demonstrating essentially a long term phenomenon.

Complementary SERDP-funded Programs: SERDP has supported several projects related to Pb-free electronics. A brief description of these ongoing projects can be found at the SERDP web site (www.serdp-estcp.org/Program-Areas/Weapons-Systems-and-Platforms/Lead-Free-Electronics).

4. Cost and Duration of Proposed Work

The cost and time to meet the requirements of this SON are at the discretion of the proposer. Two options are available:

Standard Proposals: These proposals describe a complete research effort. The proposer should incorporate the appropriate time schedule and cost requirements to accomplish the scope of work proposed. SERDP projects normally run from two to five years in length and vary considerably in cost consistent with the scope of the effort. It is expected that most proposals will fall into this category.

Limited Scope Proposals: Proposers with innovative approaches to the SON that entail high technical risk or have minimal supporting data may submit a Limited Scope Proposal for funding up to $150,000 and approximately one year in duration. Such proposals are eligible for follow-on funding if they result in a successful initial project. The objective of these proposals should be to acquire the data necessary to demonstrate proof-of-concept or reduction of risk that will lead to development of a future Standard Proposal. Proposers should submit Limited Scope Proposals in accordance with the SERDP Core Solicitation instructions and deadlines.

5. Point of Contact

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For Core Proposal submission due dates, instructions, and addition solicitation information, visit the SERDP web site at www.serdp-estcp.org/Funding-Opportunities/SERDP-Solicitations.