

# **SBIR Phase II Partnership:**

## **Quantifying Mitigation Strategies for Vibration and Shock of Pb-free Assemblies**

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DfR Solutions is currently offering membership in our Phase II SBIR Partnership. This effort will for the first time quantify, from a cost-benefit perspective, the value of various mitigation techniques that may be needed to make a successful transition to Pb-free in severe environments. This collaborative effect will allow your investment to go a lot farther in answering the most important question: What is the most cost-effective remediation technique that will allow my Pb-free assembly to last as long as it did with SnPb solder?

Partners will have the opportunity to influence the experimental design of the mitigation assessment activity, have full access to results from the largest research project on Vibration and Mechanical Shock of Pb-free Assemblies, and use of DfR Solutions' revolutionary design analysis tool, Sherlock.

### Introduction / History

In March 2009, DfR Solutions was awarded a Phase I Small Business Innovative Research (SBIR) grant from the Naval Air Systems Command (NAVAIR) to investigate the performance of Pb-free assemblies when subjected to Vibration and Mechanical Shock. Specifically, DfR subjected test coupons with 208 I/O 0.8mm pitch Ball Grid Array (BGA) components to a range of harmonic vibration and mechanical shock loads. Time to failure data and mechanical simulation were then used to derive a time to failure model for Pb-free assemblies when subjected to vibration.

To supplement this important investigation, DfR created a unique Phase I SBIR Partnership, where participants could guide testing on additional components, solderability plating, and test parameters (see table below) and have unrivaled access to the results of the Phase SBIR activity.

Package	Size (mm)	I/O	Pitch (mm)	Precondition	Test
Ball Grid Array (BGA)	15x15	208	0.8	None	Vibe / Shock
Land Grid Array (LGA)	15x15	208	0.8	None	Vibration
Ball Grid Array (BGA)	12x12	228	0.5	None	Mech Shock
Ball Grid Array (BGA)	12x12	228	0.5	Staking	Mech Shock
Ball Grid Array (BGA)	35x35	1156	1.0	None	Vibration
Ball Grid Array (BGA)	35x35	1156	1.0	Thermal Cycling	Vibration
Ball Grid Array (BGA)	35x35	1156	1.0	Iso-Thermal	Vibration
Ball Grid Array (BGA)	35x35	1156	1.0	Iso-Thermal	Vibration
Quad Flat No-Lead (QFN)	10x10	124	0.4	None	Vibration
Multiple	Multiple	Multiple	Multiple	None	Vibration
Multiple	Multiple	Multiple	Multiple	None	Vibe / Shock

## **SBIR Phase II Partnership: Outline**

At the request of numerous participants in the SBIR Phase I Partnership, DfR Solutions is launching a SBIR Phase II Partnership. The Phase II Partnership will build upon the knowledge developed in Phase I, which indicated that the reliability of SAC305 under vibration and mechanical shock may not be adequate for certain applications. Since Pb-free is not going away, there is significant importance and interest in the accurately capturing the effectiveness and cost of various mitigation techniques.

In the Phase II Partnership, the effectiveness of five mitigation techniques will be assessed. They include

- 1) Corner dot staking - a drop of staking compound is applied to the corner of the BGA connecting it to the board.
- 2) Corner "L" staking - staking compound is applied at the corner and wraps around the corners along the edges.
- 3) Underfill - epoxy compound is fills the space under a device and mechanically connects it to the board
- 4) Corner ball removal - the circuit is designed in such a way that the corner ball is an unnecessary I/O and may even be removed.
- 5) Board notching - The PCB has slots cut near the corners of the BGA to reduce board level stiffness in that area.

The effectiveness of these techniques will be assessed under a variety of conditions, including vibration, mechanical shock, and temperature cycling (with assistance from Rockwell Collins). Different staking compounds will likely excel in different conditions. Some materials may offer improved resilience under shock but not vibration. The cost-benefit curve will change with the volume and process of staking material (an on-going cost) or requirements to redesign the PCB (a one-time expenditure). As with Phase I, participants will opportunity to influence the final design of experiments, including selection of materials, possible preconditioning, component packages, and test parameters.

## **SBIR Phase II Partnership: Additional Benefits**

In addition to capturing the risks and benefits of various mitigation techniques, the partners would also gain full access to SBIR Phase II results. This research activity has the potential to be the largest study on Pb-free and vibration and mechanical shock ever conducted, with a breadth approximately an order of magnitude larger than the Phase I of our SBIR. The investigation is expected to include a broad variety of component packages (BGA, QFN, TSOP, QFP, CSP), solder alloys (SnPb, SAC305, SAC105, SN100C), and test conditions (mechanical shock at low and high temperatures, vibration at low and high temperatures, thermal cycling).

Participants would also receive a six-month trial license to Sherlock, DfR Solutions' new automated design analysis tool. The full results from the Phase I SBIR and Partnership activity already form the basis for some of the calculators included in the current version and the Phase II results would rapidly be incorporated into new software modules.

The value of the combined offering of test results and analysis tool can not be underestimated. Instead of attempting to hunt through reports and presentations associated with this activity for models and S-N plots, the implications to your assembly will be readily accessible in one streamlined application.

**Timeline**

The SBIR Phase II Partnership will launch January 3<sup>rd</sup>, 2011 and is expected to last 12 months.

**Value**

The value of a SBIR Phase II Partnership is \$27.5K. Organizations that provide a purchase order by October 15<sup>th</sup>, 2010 will receive a 20% discount. Requests for partnership will not be accepted after December 17<sup>th</sup>, 2010.

Companies that are joining the SBIR Phase II Partnership and were not a part of the SBIR Phase I Partnership can receive the SBIR Phase I Partnership Report for an additional \$10K.