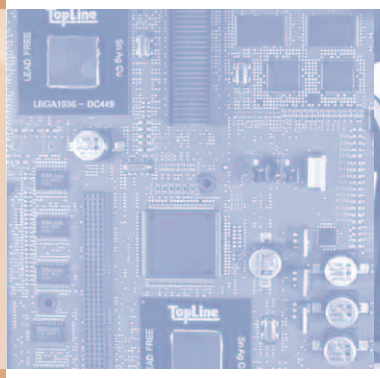
RESEARCH



Getting the Lead Out of Electronics

The New England Lead-Free Electronics Consortium

"The experience we gained building the lead-free test vehicles gives us a competitive advantage. By working together with the Consortium members, we gained intricate knowledge, credibility, and access to University and company resources that's helping us meet or exceed our customer requirements."

Robert Farrell, Principal Engineer
Benchmark Electronics

TURI
TOXICS USE REDUCTION INSTITUTE
University of Massachusetts Lowell

A Success Story: How industry, academia and gove address the lead-free electronics challenge.

To help the electronics industry find alternatives to lead, the Toxics Use Reduction Institute (TURI) and the University of Massachusetts Lowell launched the **New England Lead-Free Electronics Consortium** — a collaboration of industry, government, and academia.

Lead Works. Why Change?

Although lead is a well-established human and environmental hazard, it is still used in many products such as batteries, cables, ammunition, fishing sinkers, wheel weights and electronics products.

In electronics, lead has remained the selection of choice on printed circuit boards for the past 60 years because it is proven to work. The toxic substance has been commonly used on the boards in three areas — the board surface finish, the finish of electronics components, and the solder that joins the components to the board.

"Getting the toxics out of electronics is no easy task. But this Consortium's groundbreaking model of mining the depth of technical knowledge from industry and academia with support from TURI and EPA was very successful."

Linda Darveau
Environmental Scientist
Environmental Protection Agency

Manufacturers are moving away from using lead in electronics for two main reasons — regulatory and market drivers. An initial regulatory driver was the 2006 European Union RoHS Directive that restricts the use of lead in consumer electronic products. Although it affects companies who sell products in Europe, many major corporations have transformed their entire consumer product lines to avoid higher costs for maintaining two production lines — lead-free for European markets, and lead for other markets.

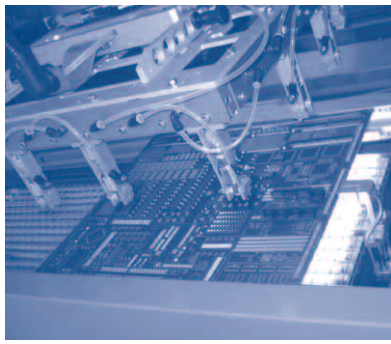
Progressive companies that are exempt from RoHS because they manufacture mission critical applications such as for the defense, medical, and aerospace industries, are requiring suppliers to provide environmentally friendly products. This market demand cascades throughout the entire supply chain that now needs to provide materials, components, and assemblies that are lead-free or risk losing the business of the progressive companies.

Mobilizing to Address the Challenge

Switching from the proven substance to non-lead alternatives presents a colossal challenge for the entire electronics supply chain industry — from small assembly shops to large original equipment manufacturers.

A major challenge with the new lead-free solder materials is higher melting temperatures which require reflow ovens and other processing equipment to operate at higher temperatures. This elevated temperature generates additional thermal stress and can damage components and circuit boards.

With a narrower "processing window," which means much tighter manufacturing controls and standards, there is also a greater risk of mistakes that could be amplified throughout the supply chain.



Robotic soldering of lead-free printed circuit boards at Benchmark Electronics in Hudson, NH.

rnment in New England worked together to

How the Consortium Works

Consortium members designed and executed comprehensive research experiments to evaluate various lead-free materials and manufacturing processes. The lead-free conversion parameters investigated in the various phases of the Consortium's research included:

- Material selection for board surface finishes, component finishes, and solders (e.g. tin/silver/copper solder, nickel/gold board surface finish, and tin component finish)
- Process selection (reflow profile, solder temperatures, and reflow environment)
- Mix of component types and finishes
- Acceptability and quality of lead-free solder joints
- Long-term reliability of the lead-free assemblies
- Nanotechnology solutions and halogen-free materials

To measure and analyze the performance of the lead-free materials during the experiments, the Consortium employed Six Sigma tools, a methodology used to address quality problems in a manufacturing environment.

"We are extremely fortunate to have the Six Sigma skill set of Sammy Shina of UMass Lowell and Greg Morose of TURI to design the lead-free electronics experiments. Since the balanced experiments evaluated many different factors at once, we were able to realize our goal of speed to market. We learned a great deal in a short period of time. A lot of businesses don't have this type of expertise."

Karen Ebner
Senior Quality Engineer
Raytheon

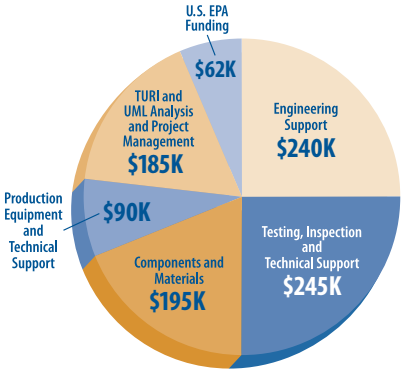
With careful selection of materials and manufacturing parameters, the first four phases of the Consortium's research have proven to its members that lead-free electronics assembly and rework is not only possible, but that its results are equal to or better than what is achieved with lead. The Consortium is currently conducting research to investigate the long-term reliability of lead-free materials for critical applications such as medical, defense, aerospace, and IT infrastructure.

Estimated Value of Contributions Total More Than $1M

Consortium members contributed their resources to find lead-free alternatives. TURI estimates the cost for materials, equipment usage, engineering time and technical expertise provided by the companies and organizations to total more than $1 million for the four phases of research.

"If you added up all the components, materials and testing costs, the dollar amount would be enormous, probably more than any one company could manage. And even then, you wouldn't have gained the depth of knowledge that has been so valuable throughout this process."

Helena Pasquito
Manufacturing Skills Instructor
Cobham Defense Electronic Systems
Lowell, MA



Consortium Contributions

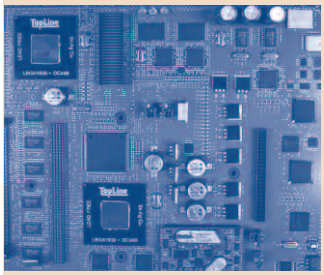
The Consortium has been a success because of the willingness of the companies to share their deep technical knowledge, contribute resources, materials, equipment, and collaborate with government and academia towards a common goal of transitioning the industry to lead-free electronics.

The following companies and organizations have contributed resources for one or more of the four phases of the Consortium research:

- AIM, Montreal, Canada
- Air Products and Chemicals, Allentown, PA
- Analog Devices, Wilmington, MA
- American Power Conversion, Billerica, MA
- Benchmark Electronics, Hudson, NH
- BTU International, Billerica, MA
- Cobham DES - M/A-COM, Lowell, MA
- DDI, Sterling, VA
- EMC, Hopkinton, MA
- FreedomCAD, Nashua, NH
- Hadco Corporation, Haverhill, MA
- Int. Rectifier, Leominster, MA
- Isola, Chandler, AZ
- Multicore Solders, Richardson, TX
- Ormecon, Ammersbek, Germany
- PWB Interconnect Solutions, Ontario, Canada
- Raytheon, Tewksbury, MA
- Schneider Electric, N. Andover, MA
- Skyworks, Woburn, MA
- Solectron, Westborough, MA
- Stentech, Salem, NH
- Teradyne, North Reading, MA
- Texas Instruments, Attleboro, MA
- Textron Systems, Wilmington, MA
- Toxics Use Reduction Institute, Lowell, MA
- U.S. EPA, Boston, MA
- University of Massachusetts Lowell
- Vitronics Soltec, Stratham, NH
- Wall Industries, Exeter, NH
- Yankee Soldering, E. Greenwich, RI

Long-Term Reliability Testing on Track

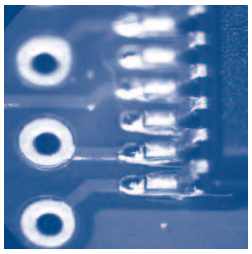
The current Phase 4 testing addresses long-term reliability, rework capabilities, through-hole component assembly process optimization, application of nanotechnology solutions, and performance of the latest lead-free materials. It also includes an investigation of printed circuit boards made with halogen-free materials.



This lead free printed circuit board, which used tin/silver/copper solder, was tested for reliability and rework experiments.

Competing Globally

The Consortium connects peers in industry with their suppliers and customers to address industry challenges and build competitiveness. The European Union regulations provided the initial business driver for companies to transition to lead-free products. Customer demand provided the impetus to continue searching for long-term reliable lead-free electronics for mission critical electronics applications.



A close up of a tin/silver/copper alloy used for solder joints and gold used for the board surface finish.

For the companies who learn from the results of the Consortium's work and transition to lead-free sooner rather than later, there's a window of opportunity to position their lead-free products as a competitive differentiator. Added to that are the benefits of achieving significant pollution prevention and toxics use reduction.

"We're excited to work with UMass Lowell's researchers who are looking into new technologies like nano surface finishes. It's just great to see their energy and enthusiasm as they investigate new and safer materials."

Deb Fragoza
Principal Hardware Engineer, EMC

For More Information

The Consortium has published and presented the results of its testing efforts widely, including 40 papers, articles and presentations for national and international professional conferences and technical journals. Consortium members have also published a book edited by Sammy Shina entitled *Green Electronics: Design & Manufacturing*.

Be sure to visit the TURI web site at www.turi.org/industry to download materials and find out more details about the Consortium results.

Contact Greg Morose, project manager of the New England Lead-Free Electronics Consortium at the Toxics Use Reduction Institute at UMass Lowell, 978-934-2954, Gregory_Morose@uml.edu or contact Prof. Sammy Shina of UMass Lowell, 978-934-2590, Sammy_Shina@uml.edu.

About the Toxics Use Reduction Institute

The Toxics Use Reduction Institute (TURI) at the University of Massachusetts Lowell provides the resources and tools to help Massachusetts businesses and communities make the Commonwealth a safer place to live and work. Established by the state's Toxics Use Reduction Act of 1989, TURI provides research, training, technical support, laboratory services and grant programs to reduce the use of toxic chemicals while enhancing the economic competitiveness of local businesses. Learn more at www.turi.org.

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