Scientists develop revolutionary nanotechnology copper solder

October 25 2012

(Phys.org)—Scientists in the Advanced Materials and Nanosystems directorate at the Lockheed Martin Space Systems Advanced Technology Center (ATC) in Palo Alto have developed a revolutionary nanotechnology copper-based electrical interconnect material, or solder, that can be processed around 200 °C. Once fully optimized, the CuantumFuse solder material is expected to produce joints with up to 10 times the electrical and thermal conductivity compared to tin-based materials currently in use. Applications in military and commercial systems are currently under consideration.

"We are enormously excited about our CuantumFuse breakthrough, and are very pleased with the progress we're making to bring it to full maturity," said Dr. Kenneth Washington, vice president of the ATC. "We pride ourselves on providing innovations like CuantumFuse for space and defense applications, but in this case we are excited about the enormous potential of CuantumFuse in defense and commercial manufacturing applications."

In the past, nearly all solders contained lead, but there is now an urgent need for lead-free solder because of a worldwide effort to phase out hazardous materials in electronics. The European Union implemented lead-free solder in 2006. The State of California did so on January 1, 2007, followed soon thereafter by New Jersey and New York City.

The principal lead-free replacement – a combination of tin, silver and copper (Sn/Ag/Cu) – has proven acceptable to the consumer electronics industry that deals mostly with short product life cycles and relatively benign operating environments. However, multiple issues have arisen: high processing temperatures drive higher cost, the high tin content can lead to tin whiskers that can cause short circuits, and fractures are common in challenging environments, making it difficult to quantify reliability. These reliability concerns are particularly acute in systems for the military, aerospace, medical, oil and gas, and automotive industries. In such applications, long service life and robustness of components are critical, where vibration, shock, thermal cycling, humidity, and extreme temperature use can be common.

"To address these concerns, we realized a fundamentally new approach was needed to solve the lead-free solder challenge," said Dr. Alfred Zinn, materials scientist at the ATC and inventor of CuantumFuse solder. "Rather than finding another multi-component alloy, our team devised a solution based on the well-known melting point depression of materials in nanoparticle form. Given this nanoscale phenomenon, we've produced a solder paste based on pure copper."

A number of requirements were addressed in the development of the CuantumFuse solder paste including, but not limited to: 1) sufficiently small nanoparticle size, 2) a reasonable size distribution, 3) reaction scalability, 4) low cost synthesis, 5) oxidation and growth resistance at ambient conditions, and 6) robust particle fusion when subjected to elevated temperature. Copper was chosen because it is already used throughout the electronics industry as a trace, interconnect, and pad material, minimizing compatibility issues. It is cheap (1/4th the cost of tin; 1/100th the cost of silver, and 1/10,000th that of gold), abundant, and has 10 times the electrical and thermal conductivity compared to commercial tin-based solder.

The ATC has demonstrated CuantumFuse with the assembly of a small test camera board. "These accomplishments are extremely exciting and promising, but we still have to solve a number of technical challenges before CuantumFuse will be ready for routine use in military and commercial applications," said Mike Beck, director of the Advanced Materials and Nanosystems group at the ATC. "Solving these challenges, such as improving bond strength, is the focus on the group's ongoing research and development."

Provided by Lockheed Martin

Citation: Scientists develop revolutionary nanotechnology copper solder (2012, October 25) retrieved 18 April 2024 from
https://phys.org/news/2012-10-scientists-revolutionary-nanotechnology-copper-solder.html