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Rare Earth-Containing, Pb-Free Solders with Enhanced Ductility and Oxidation Resistance

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Inventors

Dr. Nikhilesh Chawla

Professor

School of Materials, Arizona State University

Ms. Martha Dudek

Ph.D. Graduate Student

School of Materials, Arizona State University

Intellectual Property Status

Patent Pending

Contact

Bill Loux

Director of Business Development

Arizona Technology Enterprises, LLC (AzTE)

480.884.1996 main

480.884.1992 desk

Email: bloux@azte.com

Background

Global concerns over the environmental impacts and health effects of Pb-based solders in consumer electronics has led to the development of Pb-free solder alternatives. Among the potential alternatives for Pb-Sn solder, Sn-Ag-Cu alloy is one of the most promising as a result of its relatively low melting temperature, superior mechanical properties, good solderability, and relatively low cost. Although these materials are, in principle, suitable as replacements for Pb-Sn, there remain many issues to address, in particular, the lower ductility of the alloy. The lower ductility of the solder has important implications because it relates directly to mechanical shock and drop resistance, which becomes increasingly important as consumer products become smaller and more portable. Indeed, Sn-4Ag-0.5Cu and Sn-3Ag-0.5Cu alloys, the current industry standard, are significantly worse than Pb-Sn alloys in terms of shock performance (as much as 40% lower) compared to eutectic Pb-Sn.

Invention Description

Researchers at Arizona State University have developed Sn-Ag-Cu solders with minute additions of the rare earth element Ce, which substantially improves the ductility of the solder alloy. Meanwhile, the presence of Ce, in addition to improving the ductility of solder, also refines the Sn dendrite microstructure and decreases the thickness of the Cu_6Sn_5 intermetallic layer that forms upon solder reflow to a Cu substrate. Equally important, while rare earth materials are notorious for being susceptible to oxidation, these Ce-containing solders have excellent oxidation resistance in comparison to other rare earth-containing solders (e.g. La, Y).

Potential Applications

- **Electronics**
- **Plumbing**

Benefits and Advantages

- **Provides Pb-Free Solder without Sacrificing Ductility** – traditional lower ductility Pb-free solders lack mechanical shock and drop resistance, which becomes increasingly important as consumer products become smaller and more portable (existing Pb-free alloys provide as much as 40% lower shock performance compared to eutectic Pb-Sn solder)
- **Possesses Excellent Oxidation Resistance Compared to Alternative Rare-Earth-Containing Solders** (e.g. La, Y)
- **Offers the Existing Benefits of Sn-Ag-Cu Alloys**
  - **Relatively Low Melting Point**
  - **Superior Mechanical Properties**
  - **Good Solderability**
  - **Relatively Low Cost**
- **Refines the Sn Dendrite Microstructure and Decreases the Thickness of the Cu_6Sn_5 Intermetallic Layer that Forms upon Solder Reflow to a Cu Substrate**