



ELSEVIER

Contents lists available at ScienceDirect

Progress in Materials Science

journal homepage: www.elsevier.com/locate/pmatsci

Magnetic nanoparticle-based solder composites for electronic packaging applications



Siyang Xu ^{*}, Ashfaque H. Habib, Andrea D. Pickel, Michael E. McHenry

Department of Materials Science and Engineering, Carnegie Mellon University, Pittsburgh, PA, United States

ARTICLE INFO

Article history:

Received 12 March 2014

Received in revised form 11 August 2014

Accepted 12 August 2014

Available online 4 September 2014

Keywords:

Magnetic nanoparticles

Solder composites

Microstructure

Mechanical property

Electronic packaging

ABSTRACT

Sn–Ag–Cu (SAC) alloys are regarded as the most promising alternative for traditional Pb–Sn solders used in electronic packaging applications. However, the higher reflow temperature requirement, possible intermetallic formation, and reliability issues of SAC alloys generate several key challenges for successful adoption of Pb-free solder for next generation electronic packaging needs. Localized heating in interconnects can alleviate thermal stresses by preventing subjection of entire package to the higher reflow temperatures associated with the SAC solders. It had been demonstrated that SAC solder–FeCo magnetic nanoparticles (MNPs) composite paste can be reflowed locally with AC magnetic fields, enabling interconnect formation in area array packages while minimizing eddy current heating in the printed circuit board.

Solder/magnetic nanocomposite pastes with varying MNP concentration were reflowed using AC magnetic fields. Differential scanning calorimetry results show a reduced undercooling of the composite pastes with the addition of MNPs. TEM results show that the FeCo MNPs are distributed in Sn matrix of the reflowed solder composites. Optical and SEM micrographs show a decrease in Sn dendrite regions as well as smaller and more homogeneous dispersed Ag₃Sn with the addition of MNPs. The MNPs promote Sn solidification by providing more heterogeneous nucleation sites at relatively low undercoolings. The mechanical properties were measured by nanoindentation. The modulus, hardness, and creep resistance, increase with the MNP concentration. The enhanced mechanical properties are attributed to grain boundary and dispersion strengthening.

The reflow of solder composites have been modeled based on eddy current power loss in the substrate and magnetic power losses

^{*} Corresponding author.

in the solder bumps. Induction reflow of pure solder bumps (<300 μm) in an area array package using 500 Oe magnetic field at 300 kHz requires excessive eddy current power loss in the substrate, resulting in extreme temperatures that lead to blistering and delamination of the substrate. Solder–MNP composites with modest MNP loading showed temperature increases sufficient to achieve solder reflow when subjected to the same AC magnetic fields. Thermomechanical behavior of a solder joint was also modeled under cyclic temperature variations. The stress and strain are highly localized at the interface between solder and substrate. Plastic work accumulated per cycle can be used for lifetime prediction.

In this article we review lead-containing and lead-free solder systems, and the electronic packaging technologies pertinent to soldering process. Recent research on the effects of MNPs on localized heating, microstructure evolution, mechanical properties, and thermomechanical reliability are summarized.

© 2014 Elsevier Ltd. All rights reserved.

Contents

1.	Introduction to solders and soldering	97
1.1.	Lead-bearing solders	98
1.2.	Lead-free solders	98
1.2.1.	Sn–Ag–Cu solders	98
1.3.	Key properties of solders	100
1.3.1.	Wetting ability	100
1.3.2.	Mechanical properties	101
1.3.3.	Thermal properties	103
1.3.4.	Electrical properties	104
1.4.	Reflow soldering	104
2.	Motivating applications in electronic industry	105
2.1.	Hierarchy of interconnection levels in electronic packaging	105
2.1.1.	First-level interconnection (FLI)	105
2.1.2.	Second-level interconnection (SLI)	105
2.2.	Challenges related to Pb-free solders	105
2.2.1.	High reflow temperature	106
2.2.2.	Microstructural phenomena	106
2.2.3.	Reliability issues	107
2.2.4.	High-temperature solders	108
2.3.	Strategies to address lead-free solder challenges	108
2.3.1.	Localized reflow	108
2.3.2.	Microstructural refinement	109
2.3.3.	Solder nano-composites	109
3.	Magnetization dynamics and power loss	110
3.1.	Eddy current losses	110
3.2.	Hysteresis losses	111
3.2.1.	Stoner–Wohlfarth model of hysteresis	111
3.3.	Relaxation losses	112
3.3.1.	Rosensweig's model for magnetization relaxation	113
3.4.	Resonance losses	116
3.5.	Materials for magnetic heating applications	116
3.5.1.	Materials parameters	117
4.	Synthesis and localized reflow of magnetic nanoparticle-based solder composites	117
4.1.	Materials choice	117

Download English Version:

<https://daneshyari.com/en/article/1655894>

Download Persian Version:

<https://daneshyari.com/article/1655894>

[Daneshyari.com](https://daneshyari.com)