S P O T L I G H T

## Development of High-Reliability Pb-Free Solder Spheres for BGA

## 1. Overview

Along with the recent and rapid progress made in the development of electronic equipment and smaller-size parts having higher functions, semiconductor devices have become more compact, yet comprise a greater number of pins. Furthermore, the BGA (ball grid array) component type has also rapidly replaced the conventional lead frame type. BGA itself has been evolving at a brisk pace into fine-pitch ball grid array (F-BGA), chip size package (CSP), and water level CSP (WL-CSP). BGA is now commonly used in mobile electronic units such as cellular phones, digital cameras, and laptop PCs. In addition, at the RoSH command of EU-WEEE prohibiting the use of lead-containing solders for all kinds of household electric appliances, lead-free solders have been increasingly used.

Nippon Steel Corp. (NSC) has been developing a solder sphere manufacturing process technology for BGA and solder material technology, while producing and supplying solder spheres by utilizing the related technologies of its subsidiary Nippon Micrometal Corp. (NMC).

## 2. Lead-Free Solder Spheres for BGA

While conventionally solder balls mainly used for BGA contain eutectic SnPb and have a relatively large diameter between 760  $\mu$  m and 500  $\mu$  m, NSC has actively researched and developed Pb-free solder spheres having a smaller size of 300  $\mu$  m (order with a sufficient joint reliability, to meet demands for higher performance in portable appliances as well as for freedom from lead. **Table 1** lists the commercially available solder spheres currently produced by NMC.

The Sn-Ag-Cu lead-free solder, now a main stream product, has intrinsic problems of a higher fusion point than conventional SnPb solder (SnPb: 183 , SnAgCu: 220 ) and a higher hardness than the latter. It is so far unable to meet customer specification for drop impact resistance (of withstanding 30 drops at 1,500G) required especially for portable appliances, and the successful development of solder spheres capable of satisfying the requirement has been a significant task.

For the purpose of improving the drop impact resistance of leadfree solder, NSC has (1) engineered an optimum solder alloy component composition of low-Ag Sn-Ag-Cu material which quite possibly has a ductility different from high-Ag Sn-Ag-Cu materials (ouch as Sn-4.0Ag-0.5Cu, Sn-3.0Ag-0.5Cu), the main components of leadfree solder currently in use, and (2) the control of the thickness of an intermetallic compound layer formed in the joint interface by elucidating the factors that dominate the drop impact resistance property. Further developed is an Sn-Ag-Cu alloy LF35 for solder spheres having a high resistance to drop impacts.

## 3. Features of Pb-Free Solder Spheres LF35 Having High Resistance to Drop Impacts

The NSC-developed LF35 has a drop impact resistance 2 to 3 times as high as that of lead-free solders currently mainly in use (**Fig. 1**). Its Ag is as low as 1.2Ag, and the thickness of its intermetallic compound layer grown in joint interface is controlled with elements added in very small amount (**Fig. 2**). It successfully cleared the reference level of 30 drops at an impact of 1,500G, required for portable units. Thus, NSC and NMC have been producing and supplying LF35 as an alloy capable of dramatic improvements in joint reliability of semiconductor devices for mobile units. This product is actually used or highly favored by a number of leading semiconductor manufacturers.

NMC-LF / Composition	NMC-LF35	NMC-LF24	NMC-LF45	NMC-LF31
Sn	Bal.	Bal.	Bal.	Bal.
Ag	1.20	2.60	3.00	4.00
Cu	0.50	0.60	0.50	0.50
Solidus Line (deg.C)	219	216	218	217
Liquidus Line (deg.C)	225	218	219	219
Specific Gravity	7.30	7.40	7.39	7.41
Tensile Strength (MPa)	~29.0	~35.0	~36.0	~37.0
Elongation (%)	~55.0	~43.0	~45.0	~38.0
Thermal Expansion x10 <sup>-5</sup> /K (125deg.C)	2.2	2.2	1	1
Young Modulus (GPa)	47.6	39.0	1	1

Table 1 Pb-free solder spheres lineup of NMC





Fig. 2 Inter metallic compound thickness after 3 time reflows and high temperature storage  $(150\ ,100h$  )

For further information, contact Sales Promotion Division, Nippon Micrometal Corporation