Development of Microball Bumping Technology for 150 µ m Pad Pitch

1. Introduction

The high density packaging of high-function semiconductor devices for CPUs used in PCs, etc. has been changing from a method using bonding wires and lead frames, to a flip chip (FC) interconnection technology of forming bumps on chip electrodes and directly bonding them to the PCB.

For the formation of bumps which has an important role in the development of FC interconnection, NSC developed a unique microball bumping technology of its own and researched the feasibility of its commercialization. As a result, in April 2005 a mass-production system of supplying services was established for forming bumps using this microball bumping technology.

On the other hand, research and development have also been continued for a technology that can form bumps at a narrower pitch. It is expected that there will be a rise in demand in the future. This newly developed technology is capable of producing bumps at a pitch of 150 µ m on actual production level (see **Fig. 1**). The following sections describe the features of these new technologies.

2. Features of Microball Bumping Technology

The two bumping methods currently applied mostly in FC interconnections are an electroplating and screen printing. Both of these methods, when appraised from the viewpoints of the accuracy and uniformity of bump height and the adaptability to lead-free solder, are not enough to assure satisfactory bump height accuracy and uniformity, and the electroplating method does not permit preadjustment of alloy components.

By contrast, the microball bumping technology, featuring the use of high-precision microballs, can assure remarkably high accuracy and uniformity of bump height even when applied to large wafers and can accommodate lead-free solder or other various types of solders because alloy components are freely adjustable in the process of microball manufacture.

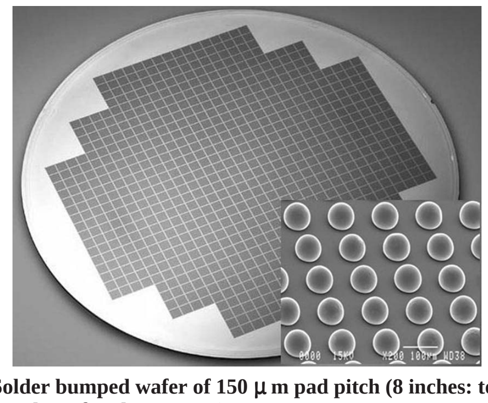

Fig. 1 Solder bumped wafer of 150 µ m pad pitch (8 inches: total number of pad = 652,288)

Particularly in recent years, it is a general practice to add very small quantities of elements to lead-free solder for the purpose of improving reliability of FC interconnection. Under the circumstance, the screen printing method can provide for pitches down to 200 µm at the narrowest, and only the microball bumping technology can achieve the very narrow pitch level of 150 µ m in addition to its capacity to permit fine alloy adjustment.

3. Microball Bumping Processes and Newly Developed Technology

The bump forming processes by the new technology are outlined in **Fig. 2**.

The following description outlines the technology newly developed for achieving 150 µ m pad pitch.

(1) UBM formation: UBM (under-bump metallization) formation is essential for solder bumping. A UBM forming technology has been established that is capable of compensating for the decrease of wet-ability due to the use of very small solder balls, particularly lead-free solder balls, and is capable of assuring reliability over a long period.

(2) Flux application: Prior to the placement of balls on electrodes, flux is applied to the electrodes. To ensure a narrow pitch, flux must be applied in an appropriate quantity and it must be applied evenly. The newly developed technology assures even application of flux in an appropriate quantity at a 150 µ m pitch even when conventional screen printing is used, and also can use a newly developed method of flux application by atomization.

(3) Ball placement: Balls are sucked and held in through holes in a ball arrangement plate and then fixed in position with the help of the adhesive strength of flux on electrodes. The ball positioning error in this process according to this newly developed technology is reduced to less than tens of ppm by the optimization of the ball arrangement plate and load weight.

(4) Reflow: Solder balls temporarily fixed by flux on electrodes are melted in a reflow oven in a nitrogen atmosphere to become bumps. If the flux is not evenly applied, part of the solder balls may be allowed to flow as the flux is softened and fluidized in the reflow oven. If the balls are arranged at a very narrow pitch, adjacent balls might come into contact with each other. The newly

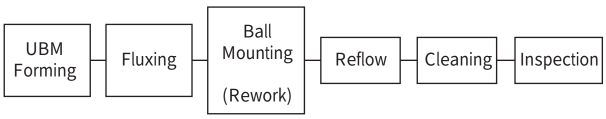

Fig. 2 Process flow of micro ball bumping

developed technology eliminates the cause of flux fluidization prior to the reflow and in addition, can control the surface properties of bumps.

These newly developed technologies have succeeded in realizing the performance of high yield rate, high bump height accuracy, high reliability (stability at high temperatures and void-free), and good bump surface properties.

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