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Study of a dipping method for flip-chip flux coating

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ABSTRACT

A dipping method for flux coating is proposed in the paper. Flow process of the flux transferred into the groove is investigated by using an optical detection means. Flow process influenced by gluing speed and viscosity is analyzed by using two indicators including reflective area ratio and flow velocity. Experimental result shows that stably reflective area ratio of glue is associated with gluing speed instead of viscosity; and it decreases with the increase of gluing speed in a same viscosity. The reason is that different gluing speed changes the amount of the glue transferred to the groove. Flow velocity of glue is related with gluing speed, a greater gluing speed leads to greater maximum flow velocity at the same viscosity, which may be due to larger gluing speed gives greater inertial force to the glue. Real chip experiments verified the feasibility of this method.

1. Introduction

Flux coating is one of the key processes during flip-chip packaging. Flux is applied on the solder bumps or substrate to remove oxides and pre-bonding flip chip on the substrate before reflow [1,2]. Flux coating can be usually achieved through dipping flux, jetting flux and rotary fluxing [3]. Dipping flux has been a commonly used method in standard WLCSP (Wafer Level Chip Scale Packaging) and flip-chip processes, and flux is placed on rotary tray and scraped by a doctor blade in this method [4].

In order to obtain an ideal fluxing effect, dipping amount of flux must be strictly controlled, too small an amount of flux will cause a poor joint, and too much flux can impede the flow of underfill fluids. To control the dipping amount of flux precisely, the smooth of the flux surface must be ensured and the liquid level must be unchanged after repeated dipping. As to volatile flux, solvent of which is quite easy to volatilize, the flux solute content must also keep stable to avoid effecting bonding quality. Dipping method using rotary tray will inevitable cause the flux solute content increasing as the flux is placed on plate large area and exposed to the air prolonged. To reduce the evaporation of solvent, exposed area of the flux should be as small as possible.

Quality control is also an essential process in flux coating. Weighing can be used to control of film thickness quality [5]. But it presented several problems when use solvent-filled flux as the solvent is quickly to evaporate, and is become inapplicable as the film become thinner and less area. An optic flux thickness measure method using a unique dual-light interferometer is developing [6]. But it still has not good means to measure fluid in a groove quantitative.

Flux is a typical non-Newtonian fluid; mathematical models are usually established to predict rheological process [7,8]. However, it is difficult to establish appropriate mathematical model to predict rheological process when liquid is conditioned in a groove, applied an inertia force, and influenced by properties of its own.

In response to these issues, this paper puts forward a gluing method for flux dipping, by which the flux is placed in a sealed container and transferred to the flux groove in a gluing way, makes the chip immerge into flux groove and dips just enough flux on chip solder bumps. This design can reduce the exposed area of flux and prevent the flux solvent from evaporation, thereby maintaining the stability of flux solids content; at the same time, it can avoid dropping of the liquid level effectively after repeated dipping by using one dipping one gluing approach. We also proposed an optical method to observe flux rheological process when it transferred to groove from container.

Flux flow process is recorded by an image acquisition system in this paper, images is processed based on an improved Otsu method [9,10]. According to two indicators including reflective area ratio and flow velocity, flow process influenced by different gluing speed and viscosity is analyzed and contrasted in this paper. Through real chip experiment, the feasibility of this dipping method is verified.

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2. Platform design and experiment

2.1. Gluing method for dipping flux

Basic idea for this dipping method is placing the flux in a sealed container, flux is transferred into flux groove by a gluing way, and then makes the chip immerged into flux groove and dipping moderate amount of flux on chip solder bumps. The flow path of gluing method was shown in Fig. 1. This method includes the following processes. The flux container moves back and forth once on the plate, as shown in Fig. 1(a), so that the flux in container transferred to the flux groove on the plate; at the same time, move the chip to just above of the flux groove with a nozzle. Bring the chip down to an appropriate location, as shown in Fig. 1(b), so that moderate flux was coated on the chip solder bumps. Move the chip up and complete flux coating as shown in Fig. 1(c).

The container is used to contain the flux. Bottom of the container is getting through. Rubber-like elastic material was placed at the junction of container and plate. When the container moves through the groove, flux will flow into the groove. At the same time, the junction ring will take away excess flux and leave a moderate amount of flux in the groove. To ensure a good sealing performance between container and plate to prevent leakage of glue from the container, and to ensure a smooth process of gluing and achieves stable gluing results, the surface roughness value of the plate should be less than Ra = 1.6.

2.2. Hardware of experiment system design

The dipping method involves twice flux transfer. First, the flux is transferred from the container to flux groove by gluing, and second, the flux is transferred from flux groove to the chip solder bumps by dipping. To achieve two flux transfer steps above, a motion control system that uses upper and lower machine structure decency is designed, computer as a host computer system, motion control card for the next-bit machine. The motion control card sends the command signal accessed from the host computer to the motor driver, and then the motor driven by the driver drives the implementation structures to achieve action. The hardware of the motion control system involve motion control card, servo motor, and servo driver matched with the servo motor. Main parameters of motion control system hardware are shown in Table 1.

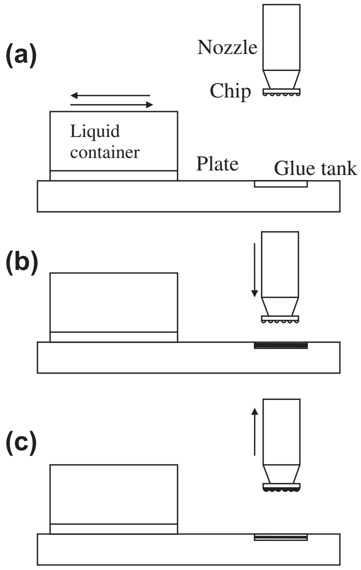

Fig. 1. Process of gluing method for flux dipping.

Table 1
Main parameters of motion control system hardware.

Parts	Model	Main parameters
Motion control card	DMC-2410B	PCI bus Maximum pulse frequency 5 MHz Rated power 400 W
Servo motor	Panasonic MHMD042G1U	Incremental encoder Encoder resolution 10,000 p/r
Servo driver	MINAS-A5B series MBDHT2510E	Matched with servo motor

To achieve program operation, three motion axes are used, each axis corresponding to a servo motor and a servo driver [11–13]. *X*-axis is used to drive the glue container and completing gluing action; *Y*-axis is used to moving the nozzle and the chip to the flux groove top. *Z*-axis is used to move up and down to achieve chip drawing and flux dipping. For positioning precisely, a homing switch is mounted on each axis; for operating safely, a positive direction limit switch and a negative direction limit switch are mounted on each end of the axes. Motion accuracy of the screw can reach to 0.5 μm

An image acquisition system is designed to observe the flux flow process in the groove, which consists of image acquisition card, camera, lens and light source. Main parameters of the image acquisition system hardware show in Table 2.

This image acquisition system allows us acquire images at a speed up to 14f/s at the full resolution 1624 × 1234. Transmission speed of 1394B interface is high; the theoretical maximum speed can reach 800 Mbit/s, this enable the images transmission real-time. Lighting system is a brightness adjustable circular fluorescent lamp and it can ensure the uniformity of the light in all directions.

The designed surface roughness of the plate is Ra = 1.6. Size of the groove is 5 × 5 mm, and deep of the groove is 1 mm.

The composition of the hardware system is shown in Fig. 2, the camera and lens are mounted on the *Z* axis; the camera position can be adjusted through the motion of *Z* and *Y* axes. To ensure a coincident center between light source and lens and uniform of the illumination, light source is fixed to the camera lens.

2.3. Software program design

Labview8.6 has been chosen in the software program to integrate motion control system and image acquisition system. It can connect external equipment seamlessly by calling the DLL (Dynamic Link Library) [14,15].

Modular programming is a very effective and practical development method and is designed in the program. The procedure is

Table 2
Main parameters of image acquisition system hardware.

Parts	Model	Main parameters
Image acquisition card	FWB-PCI3202A	Interface: 1394B Maximum speed: 800 Mbit/s Resolution: 1624 × 1234
Camera	GUPPY Pro F201B	Format: 1/1.8 Maximum speed: 14f/s
Lens	Myutron FV3020	Focus: 30 mm Aperture: 1:2.0
Light source	Circular fluorescent lamp	Diameter: 180 mm Rated power: 20 W