Microwave welding solder paste in separated magnetic field center

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Introduction

With the fast development of the flexible printed circuits (FPC), the welding technology is facing great challenges. The main problem of the current welding technology is that the temperature of the substrate is usually unavoidably higher than that of the solder paste in conventional welding process, since the volume of the substrate under the solder is much larger than the volume of the solder. Flexible circuits which are made of polyimide or polyester films would be damaged if they are placed in an environment with high temperature.

Our previous research also show that metallic powders can be heated in microwave magnetic field when the oxide layers isolate the metallic core and confine the current to the surface of every particle which allows the microwaves to penetrate into the sample. The solder paste is a mixture of metallic powders (including tin, silver, and copper particles) and flux. The flux separated the metallic particles and cut off their conductive connection. Thus, according to the theory, the solder paste should be heated fast in the center of microwave magnetic field. Previous researches have been done on microwave magnetic field heating of solder paste, but it has not studied the heating effect between the substrate and the solder and the microstructure.

Experimental

In this work, microwave single mode cavities were applied to determine whether microwave electric field or magnetic field is superior in welding solder paster on circuit substrate. The comparison between microwave welding and conventional heating of solder paste is also studied. solder paste welding in microwave magnetic field center has been explored. A circuit with solder paste is put into a conventional furnace or microwave electric /magnetic field center. The experimental setup is shown in Fig. 1, a 2.45 GHz microwave single-mode cavity system consisting of a tunable microwave solid-state source, a circulator, a water load, a directional coupler a microwave single-mode cavity with adjustable short pavement, an infrared thermometer, and a microwave power meter was used in the experiment.

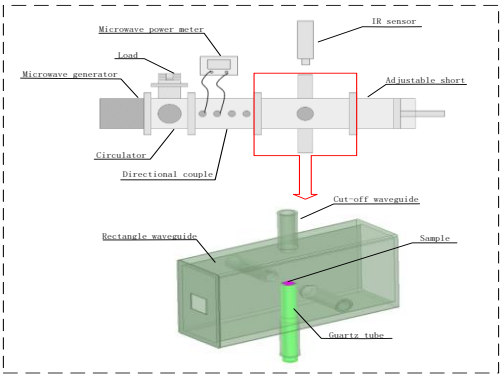

Fig. 1. Schematic of the microwave heating system

Results

Fig.2(a) shows the temperature profile of the samples in the center of the microwave electric and magnetic fields. In the center of microwave electric field, the circuit without solder paste can be rapidly heated to 343.6℃ in 10s; The circuit with solder paste can also be rapidly heated to 490.9℃ in 10s. Although the dielectric loss of the circuit was small, the circuits experienced a rapid temperature rise and scorched in the excessive microwave electric field. In the center of microwave magnetic field, the circuit without solder paste was barely heated. Its temperature rise is only 40.3℃. While the circuit with solder paste can be heated to 192.2℃ in 10s. Fig.2(f) shows that solder paste reaches a good molten state and the circuit is not damaged. In these experiments we monitored the microwave incident power and reflected power, the power consumption is almost the same, so the distribution of field strength in the cavity can be approximately the same and the heating time is 10 seconds. In previous studies, microwave melting of solder paste took more than 60 s. In contrast, the method in this paper can greatly accelerate the melting speed of solder paste without adding additional flux with high dielectric loss.

To verify the effectiveness of the conventional heating method, we used a tube furnace as the heat source. The substrate with solder is placed in the center of the tube furnace. Because the melting temperature of the solder paste (Sn96.5Ag3Cu0.5) is 218℃, the set heating temperature is 250℃ (30℃ above the melting point of the solder paste). Because the conventional furnace needed to heat through heat transfer for the whole chamber, the process of heating to 250℃ takes a long time. Fig.2(b) is the temperature rise curve of the sample in conventional heating furnace. It took around 9 minutes for the conventional furnace to melt the solder paste, while it took less than 10 seconds to welding solder paste on the substrate in microwave, either electric or magnetic center.

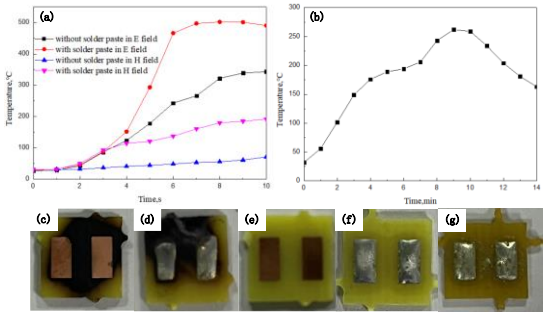

Fig. 2. Temperature rise curve of (a) conventional heating and (b) microwave heating, (c) the circuit without solder paste in E field, (d) the circuit with solder paste in E field, (e) the circuit without solder paste in H field, (f) the circuit with solder paste in H field and (g) the circuit with solder paste in conventional furnace