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Reliability of Cu-Cu direct interconnections using ultrasonic bonding process between RPCB and FPCB

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1. Abstract

The purpose of this paper is to bond electrodes between the rigid printed circuit board (RPCB) and flexible PCB (FPCB) using ultrasonic vibration. The electrodes of FPCB and RPCB were Cu.

The peel strengths of the joints were investigated with various parameters, such as bonding pressure and time. This study showed that the electrodes between the RPCB and FPCB were successfully bonded without any adhesive at a low temperature for a short time, compared to other bonding methods: adhesive bonding and thermo-compression bonding.

2. Introduction

Modern portable electronic products are required to be thin, light and functionally complicated. Therefore, the demand for flexible printed circuit board (FPCB), which has low weight, high glass transition temperature and superior flexibility, continues to expand with market growth of the multimedia portable electronics.[1)] The electrical and mechanical bonding technique of electrodes on PCBs is essential for use two different PCBs in a product. Thermo-compression bonding method causes heat damage and warpage, due to its high bonding temperature, while adhesive bonding method has disadvantages such as high bonding pressure, low performance and reliability.[2)] Ultrasonic bonding process is one of the most suitable bonding methods, because of its high mechanical and electrical performance, high reliability, short processing time, low processing temperature and environment-friendly process.[3)] Cu-Cu bonding is compared to solder-based connection because: (1) ultra-fine pitch can be achieved; (2) Cu has better electrical and thermal conductivities; and (3) Cu has much better electro-migration resistance and can endure higher current density in high speed and functional electronic devices. Advantages such as (2) and (3) are due to the absence of an intermetallic compound (IMC) and Sn layer in Cu-Cu bonding. Cu-Cu bonding has been employed using thermo-compression bonding with application of high heat and pressure (typically ~ 350-400 C and ~ 200 kPa).[4)] In this study, the microstructural evolution and mechanical property of the rigid PCB (RPCB)-to-FPCB joint bonded using ultrasonic vibration were investigated with increasing bonding pressure, time and temperature.

3. Experimental Procedure

In this study, two different PCBs were prepared: 18 μm-thick FPCB and 1 mm-thick RPCB.

The FPCB was bonded with RPCB After wet cleaning with 10 vol.% H_2SO_4 solution. The RPCB was fixed using a fixture to prevent mis-alignment during bonding. The electrodes of the FPCB aligned those of the RPCB, and then these electrodes were bonded with different bonding times and pressures using ultrasonic energy.

The microstructure of the sample was observed using scanning electron microscopy (SEM) in back-scattered electron imaging mode (BEI). Elemental analysis was also carried out using energy dispersive X-ray spectroscopy (EDS).

To investigate the effect of bonding conditions on the bonding strength, the peel test was carried out at ambient temperature and humidity. The testing speed and angle were 100 μm/s and 90 °, respectively. The fracture surface was observed and analyzed using SEM and EDS.

4. Results and Discussion

Figure 1 illustrates the effect of the bonding time on the peel strength of the FPCB-to-RPCB joint. The peel strength of the PCBs reached 11.5 N/cm at a bonding time of 0.7 s, and decreased to 7.2 N/cm as bonding time was increased to 2 s.

Longer bonding time usually contributes to enhance the peel strength because of increasing diffusivity and mobility of atoms with increased temperature due to the friction energy. However, excessive bonding time caused the damaged electrodes than electrodes bonded at optimum bonding condition. Damaged PCB also caused low peel strength.

Figure 2 shows the relationship between the peel strength and bonding pressure. The peel strength increased from 3.3 N/cm to 11.9 N/cm with increasing bonding pressure. It is suggested that

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increasing bonding pressure increased the diffusion between the Cu electrodes

More studies and results will be discussed in this presentation.

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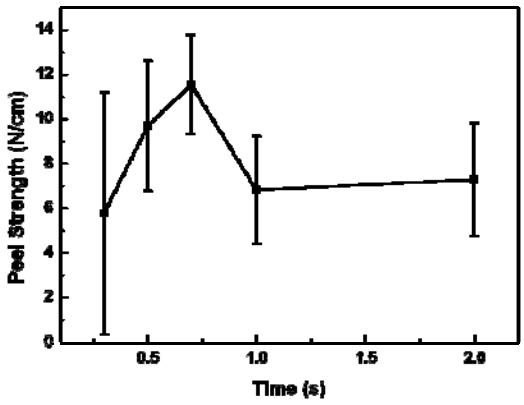

Figure 1 Peel strength of RPCB-to-FPCB joint with increasing bonding time.

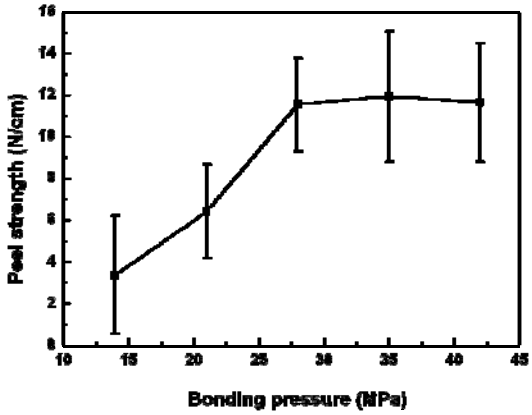

Figure 2 Peel strength of RPCB-to-FPCB joint with increasing bonding pressure.