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Evaluation of high ductile ENIG plated electrodes bonded with transverse ultrasonic

Jong Gun Lee[1], Jong Bum Lee[1], Jung Rae Jo[1], Jung Hoon Moon[2] and Seung Boo Jung[1†] ([1] School of Adv. Mat. Sci. & Eng., Sungkyunkwan Univ.; [2] Dep. Mechanical Eng., Suwon Science College)

1. Introduction

Interconnection technology for joining metallic pads of flexible printed circuit boards (FPCB) to the outer leads of modules, displays, rigid printed circuit boards (RPCB) and similar components is of increasing importance in the electronics industry.[1)] The FPCB is light, thin and flexible to fit into compact electronic devices and it can be applicable to various electronic products such an liquid crystal display (LCD) modules, hand held electronics and so on.[2)] Nonconductive film (NCF) bonding technology has been researched and applied as interconnect materials due to the fine pitch capability and simple process. Compared with anisotropic conductive film (ACF), NCF does not contain conductive particles and require high bonding pressure with heat to bond the electrodes electrical conduction is provided by direct and mechanical contact between the two surfaces of the electrodes when applying the heat and pressure.[3,4)] FPCB and RPCB have been broadly used in electronics because of their characteristics of flexibility, low cost, and high packaging density. As occasion demands, these printed circuit boards (PCBs) are needed to be used in an electronic package. Ultrasonic bonding at room temperature could be suitable for bonding the FPCB to the RPCB because of low bonding temperature, short bonding time, low-cost, and environmentally friendly operation.[5)] Depending on the vibration direction of the horn, the ultrasonic bonding can be divided into longitudinal and transverse vibration systems. The transverse ultrasonic bonding is suitable for metal to metal and flip chip bonding because of the theoretically unlimited joint materials.[6)] Electroless nickel immersion gold (ENIG) is formed by the deposition of electroless nickel-phosphorous on a catalyzed copper surface, followed by a thin layer of immersion gold. ENIG is a very versatile surface finish. The high ductile ENIG is similar ENIG surface finish. Growing dimension of immersion Ni was different.

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sbjung@skku.ac.kr

Ni layer of ENIG surface finish was growing transverse direction. However Ni of high ductile ENIG surface finish was growing longitudinal direction.

2. Experimental

FPCBs with two different surface finishes—ENIG and high ductile ENIG—were bonded to ENIG RPCB substrates, using transverse ultrasonic vibration energy (ultrasonic bonder, Jeil ultrasonic) at room temperature. The pitch size and number of electrodes were 0.3 mm and 38, respectively. Table 1 show PCB of surface finish conditions. In order to find the optimum range of bonding time and pressure, the 90 ˚ peel test of the FPCB to RPCB joint was conducted. The displacement rate of the peel test was 0.1mm/min. The bending test angle limits was from 0 to 60 ˚. FPCB and RPCB bonding interface and fracture surface were analyzed by scanning electron microscopy (SEM) and energy dispersive spectroscopy (EDS).

3. Results

Figure 1 shows the cross sectioned images of the ultrasonic bonded joints between FPCB and RPCB. In the Figure 1(c), incomplete bonding was observed, and the non-bonded areas were found along the FPCB pad interface. During ultrasonic bonding, the temperature produced along the joint interface was not high enough to cause melting of the bonding materials. Figure 2 shows the peel strength of ENIG and high ductile ENIG surface finish. Both ENIG and high ductile ENIG bonding strength increased with bonding time up to 2 s. However, the strength decreased at 3.0 s due to excessive bonding time and energy. The peel strength of high ductile ENIG was stronger than ENIG bonding.

4. Discussions

FPCBs with Au/Ni/Cu-pads and Au/high ductile Ni/Cu-pads were directly bonded to RPCB with Au/Ni/Cu-pads by the ultrasonic bonding process at ambient temperature.

The joint strength was influenced by the bonding parameters such as time and surface finish. Both ENIG and high ductile ENIG bonding strength increased with bonding time up to 2 s. However, excessive ultrasonic energy caused the PCB damaged. The electrodes with high ductile ENIG surface finish showed better peel strength than that with ENIG.

Acknowledgment

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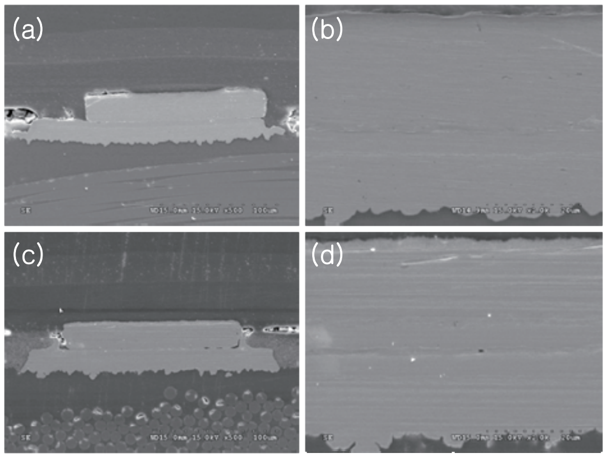

Fig. 1 Cross-sections of the bonded joints versus different surface finish FPCB type; (a) High ductile ENIG X500; (b) High ductile ENIG FPCB X2000; (c) ENIG X500; (d) ENIG FPCB X2000

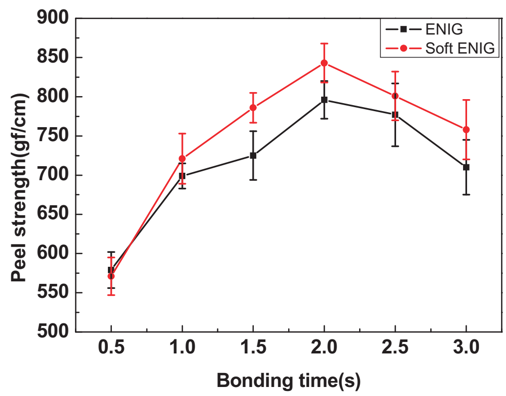

Fig. 2 Peel strength of bonded joints between RPCB and FPCB

Table 1. Specifications of the RPCB and FPCB used in this study.

Pitch size (㎛)	300 ㎛
Electrode number (ea)	38 ea
Surface finish RPCB(ENIG)	Electroless Ni(5 ㎛) immersion Au(0.03 ㎛)
Surface finish FPCB (ENIG)	Electroless Ni(5 ㎛) immersion Au(0.03 ㎛)
Surface finish FPCB (High ductile ENIG)	Electroless Ni(2 ㎛) immersion Au(0.03 ㎛)
NCF thickness (㎛)	20 ㎛