2P4-2

Proceedings of Symposium on Ultrasonic Electronics, Vol. 30 (2009) pp. 287-288
18-20 November, 2009

Effect of surface finish on mechanical properties of PCB joints bonded using ultrasonic energy

Jong-Bum Lee, Jong-Gun Lee and Seung-Boo Jung† (School of Adv. Mat. Sci. & Eng., Sungkyunkwan Univ.)

1. Abstract

The purpose of this paper is to find the effect of surface finish on electrodes between the rigid printed circuit board (RPCB) and flexible PCB (FPCB) using ultrasonic vibration. The electrodes of the FPCB were electroless-plated with electroless Ni/immersion Au (ENIG) and electroless Ni/electroless Pd/immersion Au (ENEPIG) and those of RPCB were electroless-plated with ENIG.

The peel strengths of the joints were investigated with various parameters, such as bonding pressure and time. This study showed that the thickness of intermetallic compound (IMC) bonded with ENEPIG surface finish was thinner than that bonded with ENIG surface finish.

2. Introduction

The flexible printed circuit board (FPCB) used for the manufacture is selected according to various characteristics such as flexibility, low weight, moisture absorption and mechanical behavior whereas the rigid printed circuit board (RPCB) shows low cost, high packaging density and immense published reliability data. Those PCBs have been therefore an interesting solution for a number of electrical and electronic equipment manufacturers. Hence, they need to be used and bonded on an electronic package. 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.[1,2]

ENIG is popular in the electronic industries, however it easily causes solder joint problems such as black pad issue. The black pad means brittle failure happening along the solder joint or wire bonding place. Therefore, a new surface finish-ENEPIG is developed to overcome this problem by introducing a Pd layer between Ni and Au.

Unfortunately, however, the interfacial reaction between ENEPIG and ENIG surface finish bonded with ultrasonic energy has rarely been reported. In this study, therefore, the micro structural configuration and mechanical property of the RPCB to FPCB joint bonded using ultrasonic vibration were investigated with increasing bonding pressure and time.

3. Experimental Procedure

In this study, the Cu electrodes of FPCB were electroless-plated with ENIG and ENEPIG. Dipping method was used for the Sn surface finish on electroless-plated electrodes of the FPCB. The purpose of Sn dipping method was to reduce the non-bonded area at the bonding interface.

The FPCB was bonded on RPCB after wet cleaning with 10 vol.% H_2SO_4 solution. The RPCB was fixed using a fixture to prevent mis-alignment during ultrasonic bonding. The electrodes were bonded with different surface finish, bonding time and pressure using ultrasonic energy.

In order to find the optimum strength at the various bonding time and pressure, the 90° peel test of the FPCB-to-RPCB joint was conducted. The displacement rate of the peel test was 0.1 mm/s, and the fracture surface was observed and analyzed using scanning electron microscopy (SEM) and energy dispersive X-ray spectroscopy (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 electroless plated with ENIG reached 780 gf/cm at a bonding time of 1 s, and decreased to 660gf/cm as bonding time was increased to 3 s. For the ENEPIG surface finished joint, the peel strength reached 800 gf/cm at a bonding time of 1 s, and then decreased as ENIG joint.

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 reaction layer thinner than electrodes bonded at optimum bonding condition. Thin reaction layer caused low peel strength.

Figure 2 shows the cross-sectional SEM images of ENIG/ENIG interfaces bonded for (a) 3 s and (b) 1s. Initial average dipped Sn thickness on

---

† sbjung@skku.ac.kr (S. B. Jung)

ENIG electrodes was 11 μm. The thickness of the reaction layer between ENIG and ENIG after ultrasonic bonding for 3s was measured to be about 1.5 μm which became thinner than 11 μm of initial Sn thickness. The IMC layer on RPCB side formed thinner than FPCB side which already formed the IMC during dipping process. On the other hand, the thickness of the reaction layer between ENIG and ENIG after ultrasonic bonding for 1s was measured to be about 8.5 μm. The crack between Sn and ENIG surface finished RPCB was found that causes the serious electrical failure after reliability test.

The peel strength of the electrodes bonded for 3 s was lower than that bonded for 1 s due to the excessive heat in the reaction layer. Overall reaction layer bonded for 1 s was thinner than that bonded for 3 s while the growth rate of the IMC layer was higher. The excessive heat also affected to the adhesion between Cu and polyimide lower that caused peel off at the interface between Cu and polyimide after peel test. Too much applied energy led to a change in the shape of electrodes on the RPCB. The PCBs are heated, softened and deformed during ultrasonic bonding, due to the viscoelasticity of the PCBs.[3)]

Acknowledgment

The present work was carried out with the support of a Next Generation New Technology Development Program (Project No. 10030049) of the Korea Ministry of Commerce, Industry and Energy (MOCIE).

References

1. K. Tanida, M. Umemoto, Y. Tomita, M. Tago, R. Kajiwara, Y. Akiyama and K. Takahashi: Jpn. J. Appl. Phys. **42** (2003) 2198.
2. J. Tsujino, T. Ueoka, Y. Asada, S. Taniguchi, and Y. Iwamura, Jpn. J. App. Phys. **37** (1998) 2996.
3. Lakes, R. S., Viscoelastic Solids, (CRC press, New York, 1999). pp.244-260.

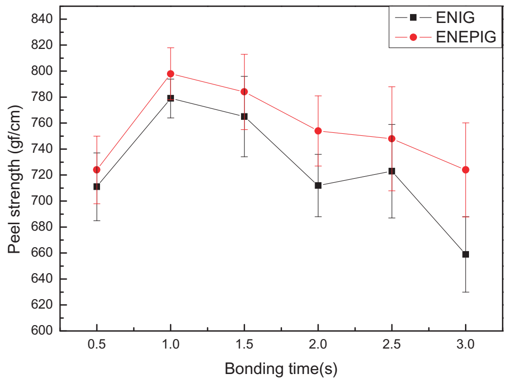

Fig. 1 Peel strength variation of FPCB-to-RPCB joints bonded with increasing bonding time

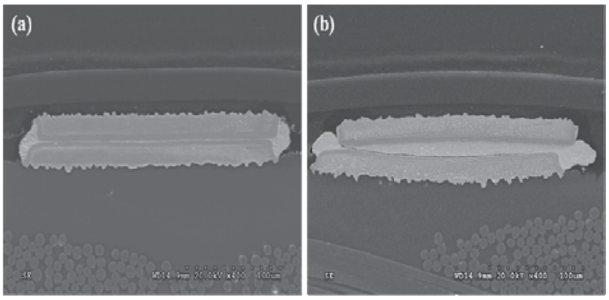

Fig. 2 Cross-sectional SEM images of ENIG/ENIG interfaces bonded for (a) 3 s and (b) 1 s