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The reliability of ultrasonic bonded Cu to Cu electrode with Sn-58Bi solder paste for IC card package

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1. Introduction

In chip bonding of integrated circuit (IC) card, the thermo-compression process had been applied to the flip-chip bonding of chips on the plastic substrates by using the conductive polymer material. However, thermo-compression bonding process often raises problems such as large thermal deformations of the assembly, cost and long process time. Therefore, it is necessary to find another method to reduce the bonding temperature, time and pressure[1)]. In this respect, the ultrasonic bonding technology became an interesting potential field of research due to several advantages such as short bonding time, low bonding temperature, low bonding pressure, good electrical and mechanical performance, and environmentally friendly[2)].

Generally, the ultrasonic system composed by the generator, transducer and ultrasonic horn can be built in order to work at a fix frequency called the resonance frequency. The optimal frequency can be obtained starting from a lower own frequency close to resonance one of ultrasonic stepped horn and adjusting its dimensions. To achieve optimal performance of ultrasonic system, It is necessary to take into account all relevant effects and parameters that affect the dynamics of the system. One of the most important element of the ultrasonic system was the ultrasonic horn. It must have the required dynamic properties, which must be determined already in design phase[3)].

In this study, the ultrasonic horn was designed by Finite-Elements-Method (FEM) simulations at the resonance frequency of 55 kHz and the ultrasonic horn was fabricated based on the result of simulation. And the microstructure and mechanical property of the chip bump to Cu electrode joint bonded using ultrasonic vibration were investigated with increasing time and temperatrue.

2. Experiment design

We performed the modal analysis by using the COMSOL Multiphysics "structural mechanics" - Eigenfrequency module. In order to construct the ultrasonic horn, we used the Ti grade 5 (Ti-6Al-4V) as material of ultrasonic horn. The table 1 shows the technical parameters of Ti grade 5 such as the sound propagation velocity, Young's modulus, density and Poisson coefficient. The longitude ultrasonic bonder was fabricated with a constant resonance frequency of 55 kHz. The resonance frequency was checked by the oscilloscope.

The substrate was the PVC(Poly Vinyl Chloride) of 85.60 × 53.98 x 0.76 mm^3 in size. The Cu wire with 120 um of the diameter as the electrode was inserted in substrate surface. The Chip was 13 mm x 12 mm in size and had two Cu bumps. The chip and substrate were fixed on the anvil by a fixture to prevent the movement of the chip and substrate during ultrasonic bonding. The bump of the chip was bonded to electrode of substrate with Sn-58Bi solder paste with different bonding times at room temperature.

To investigate the effect of bonding conditions, the bending test was carried out at ambient temperature and humidity and the microstructure of the sample was observed using scanning electron microscopy (SEM).

Table 1. Parameters of Ti-6Al-4V

Parameter	Unit	Value
Sound velocity	m/s	5073
Young's modulus	GPa	110
Density	kg/m^3	4420
Poisson's ratio	-	0.31

3. Result and discussion

Figure 1 shows the meshing statistics and the relative amplitude for a 3D model. According to the basic principles of finite element method theory, the smaller the mesh element size is possible to analyze the more exact results. In this case, the number of element was 19822 elements for 3D model. The relative amplitude at resonance frequency were presented in figure 1-(b). The theoretically computed resonance frequency was 57641 Hz. As shown in figure 2, The resonance frequency of the fabricated ultrasonic horn was 54837 Hz by measuring the oscilloscope.

Figure 3 shows the cross-sectional OM image of Cu electrode and Cu bump joint with Sn-58Bi

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solder. The Sn-58Bi solder paste was melted by ultrasonic during the short bonding time, 1s. And then, The Sn-58Bi solder played a role as the interconnection between Cu electrode and Cu bump.

4. Conclusion

In this study, the ultrasonic system was fabricated as chip bonding machine in order to bond the Cu electrode and Cu bump with Sn-58Bi solder paste. The ultrasonic horn was fabricated based on the simulation result and As a measured result by the oscilloscope, the resonance frequency of ultrasonic horn was about 55 kHz.

The Cu/Sn-58Bi/Cu joint was well bonded at bonding condition of the ultrasonic with 55 kHz of resonance frequency .

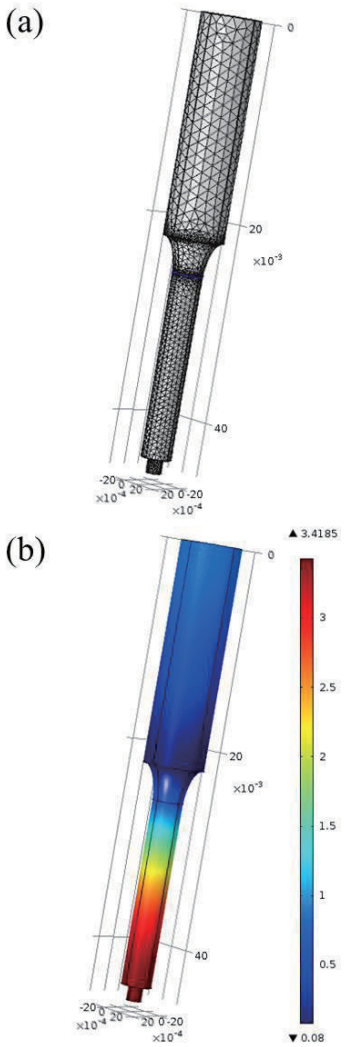

Fig. 1 (a) Meshing statistics (b) The relative amplitude for a 3D model

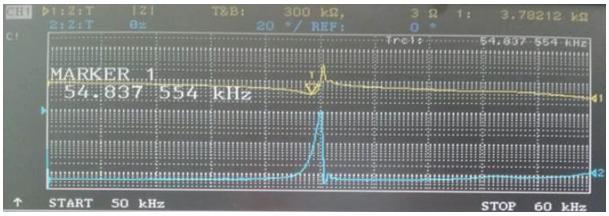

Fig. 2 Resonance frequency of the fabricated ultrasonic horn by the oscilloscope

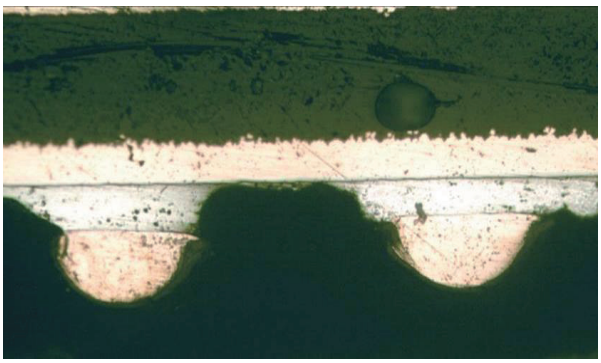

Fig. 3 The cross-sectional OM image of Cu electrode and Cu bump joint with Sn-58Bi solder

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