

ANALYSIS OF TEMPERATURE DISTRIBUTION AND OPTIMIZATION OF THE CONFIGURATION AT HEATING TOOL IN THE CHIP BONDING PROCESS AT CAMERA MODULE OF MOBILE PHONE

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INTRODUCTION

Recently, the demand of camera phone is remarkably increasing with the development of technology at the mobile phone market[1]. The core part of the camera phone is the camera module which consists of a Complementary Metal-Oxide Semiconductor (CMOS) chip, Adhesive conductive film (ACF) and Flexible PCB (FPCB). The camera module is manufactured in the following sequence. 1. Bonding of CMOS chip with Flexible PCB (FPCB) with ACF in between, 2. Packing and 3. Final inspection. The bonding process is carried out using flip mounting technology. The flip mounting technology is a method to attach the CMOS chip with PCB by electronic and mechanical means. The flip mounting technology varies with respect to i) the material ii) shape of bump and iii) the connecting method. Further this technology can be divided according to the connecting methods. The first method is using the soldering process, second method is

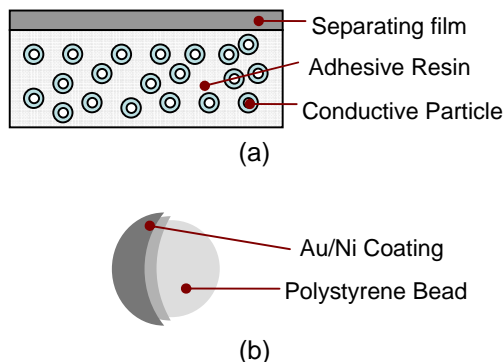


FIGURE 1. (a) Schematic Diagram of ACF
(b) Conductive Particle

by employing heat-supersonic method and the third method is by using the adhesive process. This paper deals with adhesive method which is now widely used in industries.

FIGURE 1 shows the structure of ACF used in adhesive process [2-4]. The flip chip bonding process using ACF is explained as follows; The ACF consists of conductive particles and adhesive resins packed between separating films. The ACF is firmly attached with the PCB

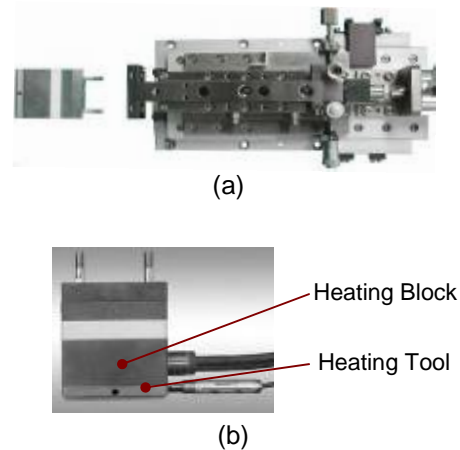


FIGURE 2. The Flip Chip Bonding Equipment
(a) Whole model (b) Heating Unit

by applying a low pressure and the separating film is removed. The position of the camera module integrated chip (CMOS) is then aligned to that of the substrate. And the final bonding is accomplished by heating and pressing, as shown in FIGURE 3. At this time, the pressure is set to 2~3MPa and the temperature is set to 180~220°C, where the temperature depends on the kind of ACF used. The two opposite faces of the CMOS and the substrate with ACF now acts like an electrode. When the adhesive resin melts due to temperature and pressure, high conductivity is achieved between the faces of the electrode as the conductive particles are crashed in the small space between CMOS and PCB [5]. In the other parts except the faced electrode, high insulation is obtained. The high

adhesive strength of ACF results in firm mechanical attachment of CMOS with the PCB substrate.

In these processes, the failure of ACF attachment is considered as a serious defect. This is caused by excessive variation of temperature in the bonding surface of the flip chip bonding tool. It is observed that the temperature variation between central part and the surrounding areas of the bonding surface is high, which has resulted in poor adhesion. Therefore, minimizing temperature variation at the bonding surface is a important concern in this process.

The flip chip bonding equipment is shown in FIGURE 2. The lower part of the bonding unit is called 'Heating Unit'. The Heating unit contains of a heating block with a cylindrical cartridge type heater and a heating tool. On the upper side of the heating unit, ceramic blocks are assembled for the purpose of insulating. The heater is adjusted by a PID control. A K-type thermocouple located between the heater and the bonding surface is used as a feedback sensor.

CONFIGURATION OF THE HEATING UNIT

The purpose of this paper is to find an optimal condition to minimize the temperature variation of the bonding surface at the heating unit with a cylindrical cartridge heater as the heating source. The heating unit used in this work has several bolt holes for fixing the heater and the temperature sensor. The counter-bores also exist for assembling the heating block with the heating tool. Most of the parts have chamfer. To prevent thermal deformation the surface between the heating block and the heating tool, are made with small progressive steps.

The heat source is considered as a simple solid cylinder of radius r and length L in which energy generated as shown FIGURE 4(b). The energy generated is assumed to be constant because of PID feedback controller. It is also assumed that the temperature is not changed with respect to the time (steady-state).

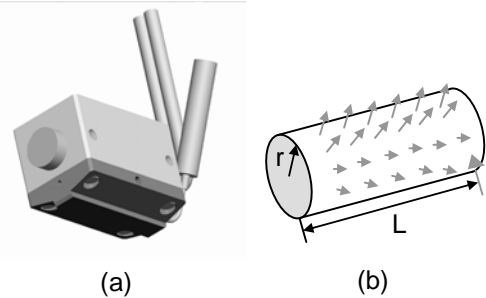


FIGURE 4. The Cylindrical cartridge heater (a) Heating Unit (b) Modeling of Heater

$$\frac{1}{r} \frac{\partial}{\partial r} (kr \frac{\partial T}{\partial r}) + \frac{1}{r^2} \frac{\partial}{\partial \phi} (k \frac{\partial T}{\partial \phi}) + \frac{\partial}{\partial z} (k \frac{\partial T}{\partial z}) + \dot{q} = \rho c_p \frac{\partial T}{\partial t}$$

Where,

$$\rho c_p \frac{\partial T}{\partial t} = 0, \quad \frac{1}{r^2} \frac{\partial}{\partial \phi} (k \frac{\partial T}{\partial \phi}) = 0, \quad \frac{\partial}{\partial z} (k \frac{\partial T}{\partial z}) = 0$$

FINITE ELEMENT ANALYSIS OF THE HEATING UNIT

Except the fixing bolt for the heater and the temperature sensor, the temperature distribution of the current model (with the bolt for only for assembly) is analyzed using a FEM software as shown in FIGURE 5(a) and 5(b). The central temperature distribution of the bonding surface

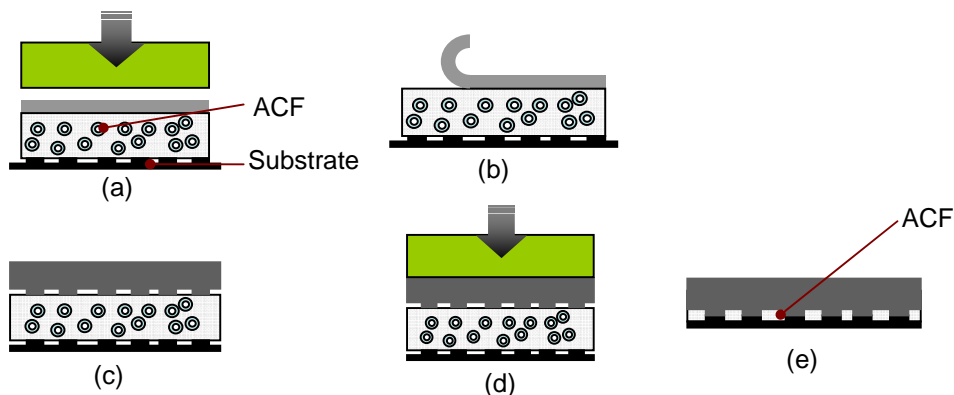


FIGURE 3. The Principle of attachment process using ACF. (a)Pre-c (b)Removing the separator film (c)Aligning the IC to the substrate (d)Final-Bonding (e)Completion

is shown in FIGURE 5(c).

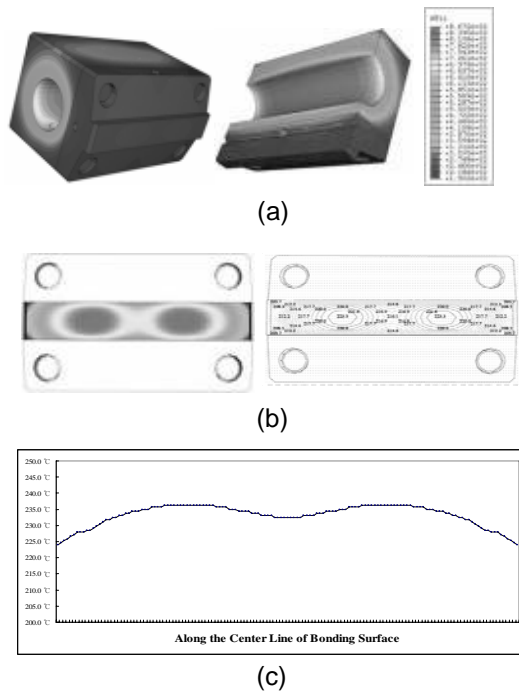


FIGURE 5. The Analyzed Result (a) The Result of whole model (b) The Result of the bonding surface (c) The temperature distribution along the center line in the bonding surface

A temperature drop at the central area in the bonding surface is noticed because the feedback sensor and fixing bolt are missing. It depends on the kind of sensor and its position. If the kind and position of sensor are known, and then the size, number and position of fixing bolt can be decided accordingly.

THE BASIC MODEL AND ANALYSIS

A basic model, which is the simplest feature without holes for assembly and progressive steps, is considered for optimization using FEM analysis and the design of experiments. From FIGURE 5, it is noted that a small bolt hole can change the temperature gradient at the bonding surface. If the fixing bolt is assembled, the temperature distribution is altered as shown in FIGURE 5. So, it is concluded that the bolt hole should not exist at the center side of the heating tool.

Suggested basic model is shown in FIGURE 6(a) and the analyzed result is shown as FIGURE 6(b) under the same conditions of FIGURE 5.

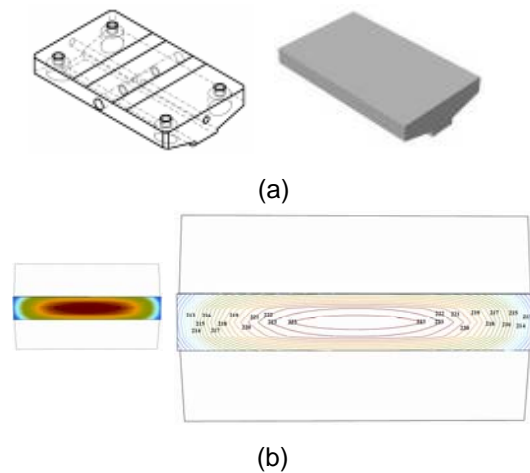


FIGURE 6. The Basic Model and the Analyzed Result (a) Current Model and Basic Model (b) The Result of the bonding surface at the Basic Model

CHANGING THE CONDITIONS

Because the fixing bolt and the chamfers are all omitted, remaining variable are the size and the position of the heater. From the heater, constant heat flux is flown out by the PID controller.

Configuration of the Heating Unit

When the size of the heater is bigger than the current model, the temperature distribution of the bonding surface is shown in FIGURE 7 under the same condition.

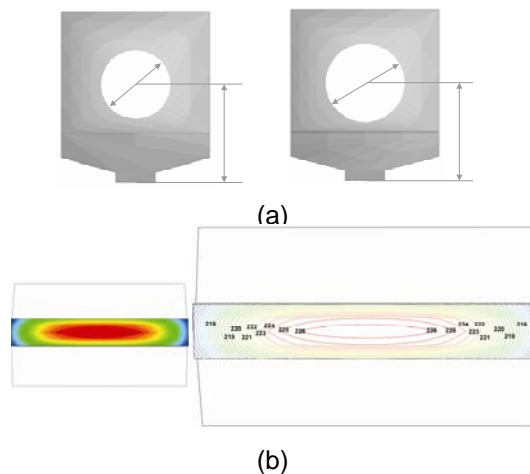


FIGURE 7. Changing size of the heater (a) Basic Model and Modified Model (b) The Result of the Modified Model

Under the same condition, the temperature distribution of the bonding surface when the

position of the heater is changed is shown in FIGURE 8.

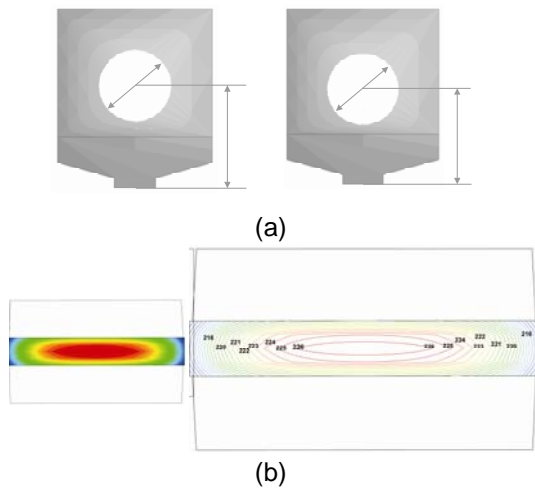


FIGURE 8. Changing position of the heater (a) Basic Model and Modified Model (b) The Result of the Modified Model

As the heater feature (cylindrical shape) approaches a flat surface similar to the bonding surface, the temperature variation along the narrow width is reduced. The result is shown in FIGURE 9

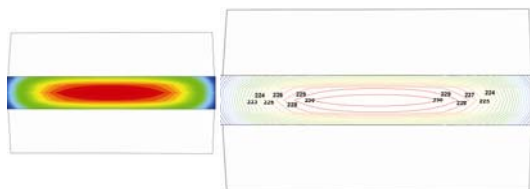


FIGURE 9. The temperature distribution of the bonding surface at changing the size and position

In the FIGURE 9, one can conclude that the temperature distribution at the bonding surface changes with the change of the size and the position of the heater and if a bigger sized cylindrical heater approximating a flat surface is used will result in reduced temperature variation.

DESIGN OF EXPERIMENTS

A design of experiment is established from the basic model with two factors.

Main factors are the position and the size of heater. The heater size and its position are limited to the cross sectional size of the heating

tool unit and a constraint exists as shown in the FIGURE 10[6].

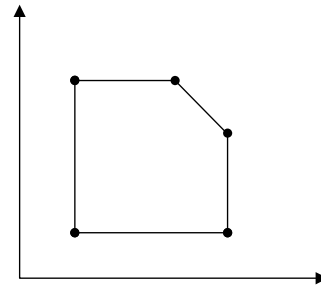


FIGURE 10. A constrained design region in two variables

CONCLUSIONS

As the heater feature $\phi 14$ approaches flat surface similar to the bonding surface, the temperature variation along the narrow width is reduced. And the temperature variation of the bonding surface is also reduced as the position of the heater is close to the bonding surface. Thus, if the cylindrical heat source of bigger size when placed close to the bonding surface will achieve reduced temperature variation.

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