Reliability of thermo-setting anisotropically conductive adhesives in Chip on Glass application

J. Liu, L. Ljungkrona

Abstract Thermo-setting type anisotropically conductive adhesives have been identified to possess key properties suitable for interconnection of bare chip directly to glass substrate (CoG). The CoG technology offers higher electric performance, shorter signal delays and further miniaturisation compared to the conventional heat seal interconnecting technology.

This paper summarizes reliability testing results using thermo-setting anisotropically conductive for CoG interconnection. Anisotropically conductive adhesives in paste and film are used for interconnection on the following bumping surfaces: chemical plated Ni and electrolytically plated Au.

Mechanical and electric measurements were performed before and after environmental tests in terms of temperaturer cycling between -40 and +85 °C for 1000 cycles and in terms of different constant humidity conditions at 60 °C, 95% RH and at 85 °C, 85% RH, each for 1000 hours. The results show that high-reliable anisotropically conductive adhesive joints can be obtained for the CoG application.

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1 Introduction

Today, driver chips for most flat panel displays, e.g. LCDs and EL-displays, are mounted directly onto a PWB or a FPC, which is then connected to the display with e.g. heatseals. The demand for higher reliability and smaller dimensions has focused interest on using flip-chip or TAB techniques for mounting the driver and LED chips directly onto the glass substrate.

The use of solder for joining of chip to glass leads to difficulties due to the high temperatures needed for the reflow process. The high temperature might destroy the glass and/or the liquid crystals in LCDs, Kubo et al. (1986), Erlewein et al. (1984). One way of eliminating this problem is to use conductive adhesives instead of solder. The adhesives are generally cured at much lower temperatures.

New types of thermosetting anisotropically conductive adhesives are today available from companies such as Hitachi Chemicals, Sony Chemicals, Hysol in Japan and Zymet in USA. Table I shows some novel anisotropically conductive adhesives that have been considered and evaluated for display applications using chip on glass technique. These new types of adhesives have the potential to increase the reliability and packaging density of flat panel display products.

The objective of this project is to clarify the use of thermosetting anisotropically conductive adhesives for joining of driver chips to flat panel displays on glass using the flip-chip technique. Both anisotropically conductive paste and film/sheet have been used in the present work.

2 Results of literature study

A literature and patent survey was carried out before the experimental work was started. Since the beginning of 1980 chip-on-glass applications for LCD-displays have been presented in the literature. The majority of the work are from Japanese companies such as Matsushita, Seiko, Citizen and so forth, all with significant interests in the LCD-application.

From the literature survey the following four different types of bonding process with flip-chip technique have been reported:

- Soldering with eutectic solder.
- Pressure connection.
- Isotropic conductive adhesive applied to the bumps.
- Anisotropic conductive film applied to the interconnection layer.
Table 1. Novel anisotropically conductive adhesives for display applications

<table>
<thead>
<tr>
<th>Company</th>
<th>Hitachi Chemicals</th>
<th>Hysol</th>
<th>Zynnet</th>
<th>LCD-mikroelektronik</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anisolm 7000 series and C48d(3)</td>
<td>TG-9000R</td>
<td>TS-9000R</td>
<td>ZXUV101</td>
<td>001–008</td>
</tr>
<tr>
<td>Tape/Sheet</td>
<td>Paste</td>
<td>Paste</td>
<td>Paste</td>
<td></td>
</tr>
<tr>
<td>Heat activated</td>
<td>Heat activated</td>
<td>UV activated</td>
<td>Heat or UV</td>
<td></td>
</tr>
<tr>
<td>thermostetting</td>
<td>thermostetting</td>
<td>thermostetting</td>
<td>activated</td>
<td></td>
</tr>
<tr>
<td>Gold-plated plastic balls</td>
<td>Silver or gold particles</td>
<td>Gold</td>
<td>Gold</td>
<td></td>
</tr>
<tr>
<td>−40 to 100</td>
<td>−40 to 80</td>
<td>−30 to 100</td>
<td>−40 to 130</td>
<td></td>
</tr>
</tbody>
</table>

*Application temperature range given by manufacturers

2.1 Soldering with eutectic solder

Oki reports a process where the chip is soldered to the glass using eutectic solder, Kubota et al. (1991). The process is used for LED chips to a printer head and not for LCD applications. Therefore one can tolerate a process which uses the higher temperatures needed for reflow of the solder bumps. In order to increase the reliability of the solder joint a sealing resin is applied under the chip. Oki provides some results from using different types of sealing resins. Hitachi presents a solder process for LCD displays, Kubo et al. (1986), which also uses sealing of the chip in order to improve the reliability of the joint.

2.2 Pressure connection

Electrical connection is established by deforming non-melting conductive materials at the bump locations using pressure and heat. A shrinking isolating adhesive is injected between the chip and glass in order to keep the chip in place and ensure that the bumps are pressurized. The adhesive works also as a sealing resin which improves the reliability of the joint, Masuda et al. (1989).

2.3 Bonding with isotropic conductive adhesives

Isotropic conductive adhesives are used in some processes for LCD-applications, Omoto (1991). The adhesive is applied to the bumps on the chip. The adhesive is thereafter cured. Also in this case an insulating adhesive might be applied as sealing between the chip and the glass.

2.4 Bonding with anisotropic conductive film

Anisotropic conductive film (ACF) is used by SEIKO, Casio and other companies for LCD-displays, Endoh et al. (1993). The conductive particles are deformed during bonding which provides the electrical connection. In this case a sealing is obtained at the same time as when bonding.

Recently, Lee et al. (1995) presented a work where ACAs in paste form were applied to fine pitch displays using CoG method. Difficulties were found when interconnecting 50 μm pitch modules.

2.5 Test material

A layout of the test chip is shown in Fig. 1. There are two wire bond structures in a daisy chain configuration, which in this work is used to determine the number of open joints. The chip size is 4.6 × 4.6 mm. The minimum pad pitch is 380 μm and the pad size is 104 × 105 μm.

Two different bump structures were tested and are presented in Table 2. The structure of the bump (BA and BB) is clearly seen from the SEM-photo of the bump in Figure 2. The height of the bumps is 25 μm. The electroless nickel plating process has been described in a previous work, Liu (1992).

Five different anisotropic conductive adhesives were used in tests: two paste adhesives and two film adhesives, see Table 3. A specification of the glass substrate used in the work is presented in Table 4.

![Fig. 1. Layout of test chip. Chip size: 4.6 × 4.6 mm, min pad pitch: 380 μm, pad size 104 x 105 μm.](image)