

**METHOD OF PREPARING AN INTEGRATED CIRCUIT PACKAGE
FOR LASER MARKING**

The present invention relates to a method of preparing an integrated circuit (IC) package for laser marking, an IC package prepared by such a method and a method of laser marking an IC package prepared by such a method. In particular, the present invention relates to a method of preparing an IC package which includes bonding a laser-markable film to a surface of an encapsulated integrated circuit chip.

BACKGROUND OF THE INVENTION

At present, marking on IC packages is achieved either through ink printing or laser marking. Ink printing techniques are generally considered undesirable due to environmental concerns and high consumable and system maintenance costs. Further, marks produced by such techniques are often non-durable. As such, increasingly more companies are adopting the alternative laser marking techniques.

Conventional laser marking techniques produce permanent and inkless marks directly on the surfaces of IC packages. However, using laser marking techniques, the contrast of the marks is generally poor and vary significantly with different IC compound materials, and indeed different batches of the same IC compound material. One method being used to improve laser marking contrast involves overlaying a heat sensitive film onto the surface of the IC package during laser marking. The mark is then produced by melting the film by the application of a laser beam, thus bonding the film to the surface of the IC package. In this case, the result is similar to ink-jet printing and has the inherent undesirable effects mentioned above.

Another potential method for improving laser marking contrast involves the introduction of laser sensitive pigments into the compounds of the IC package. In this case, however, since the compounds of IC packages are generally formulated with very tight specifications, taking into consideration the matching of thermal expansions with the various substrates, mechanical durability, dimensional stability and accuracy etc, reformulating of the compounds to promote laser marking contrast will generally not be easily accepted by the industry.

A laser marking technique that can produce laser marks with high contrast and at the same time which does not change the current compounds being used in IC packages would therefore be highly desirable. Accordingly, the present invention advantageously provides a method of preparing an integrated circuit package for laser marking by a laser beam which is capable of providing lasting high contrast marks, but which does not render it necessary to change the compounds used in the preparation of the IC packages.

SUMMARY OF THE INVENTION

According to one aspect of the present invention there is provided a method of preparing an integrated circuit package for laser marking, said method comprising:

encapsulating an integrated circuit chip by an encapsulating transfer moulding process; and

bonding a laser-markable film to a surface of the encapsulated integrated circuit chip to be marked.

The invention also provides an integrated circuit package prepared by a method as described in the immediately preceding paragraph.

The invention further provides a method of laser marking an integrated circuit package prepared by a method as described above, the method comprising:

applying a laser to the integrated circuit package to mark the laser-markable film on a surface thereof.

The bonding of the laser-markable film to the surface of the encapsulated IC chip may be achieved by any suitable technique provided that the bond is strong enough to withstand the environmental conditions which may be placed on the IC package, including changes in temperature and humidity and including rough handling of the IC package during soldering and other assembly operations. For example, the film may be bonded onto the surface by adhering the film to the surface using an adhesive. This process may be conducted after the encapsulation process. In this procedure, a layer of adhesive material is generally provided on the surface of the encapsulated IC chip and the film adhered thereto. This technique, however, does involve some disadvantages in that the application of an adhesive to the surface may affect the properties of the encapsulation layer. Also, using this technique, an extra process step is added to the production of the IC package. Furthermore, the detailed surface impressions of the IC chips may be difficult to maintain using the

adhesive method, at least part of the detail being lost due to the application of the adhesive prior to the bonding of the film to the surface of the IC package.

5 In a particularly preferred embodiment of the invention, given the above-mentioned disadvantages associated with bonding of the film using an adhesive, the film is bonded to the surface of the encapsulated chip during the encapsulating transfer moulding process, preferably by placing the film on a surface of a mould to be used in the encapsulating transfer moulding process prior to the process and bonding of the film to the surface of the encapsulated chip by hot adhesion during the encapsulating transfer moulding process. Preferably the film to be bonded is placed on the top and bottom surfaces of the
10 encapsulation mould before the encapsulation transfer moulding process. In this technique, when compound is injected into the mould, the films on the mould surface will adhere to the surfaces of the IC chip to form a laser-markable layer for later laser marking processes. The film bonding process is also advantageously incorporated into the encapsulation transfer moulding process to provide a one step manufacturing process. Moreover, the details of the
15 complex chip surface impressions is easily maintained using this technique.

DETAILED DESCRIPTION OF THE INVENTION

As discussed above, the bonding of the laser-markable film to the surface of the encapsulated IC chip to be marked may be achieved using an adhesive, but is more preferably achieved during the encapsulating transfer moulding process by placing the film
20 on surfaces of the mould to be used in the encapsulating process and bonding of the film to the surface of the encapsulated chip by hot adhesion during the encapsulating transfer moulding process. The following detailed description is particularly aimed at providing preferred embodiments relating to the more preferred bonding technique of hot adhesion of the film during the encapsulating process.

25 The laser-markable films which are used according to the invention, preferably provide high contrast on application of a laser and show good adhesion to the compounds used to encapsulate the IC chip. Advantageously the films used are thermally stable at the transfer moulding process temperature to provide smooth film attachment during the transfer moulding process. That is, the film should not be melted or degraded during the transfer
30 moulding process.

The requirements of the laser markable film to produce high marking contrast can be achieved by one or a combination of the following mechanisms. Interaction with the laser beam results in a photo-chemical reaction that chemically changes the marked area to a different colour. This change causes a negligible change in the surface topographic texture of the film or IC package. Another mechanism is that interaction between the laser beam and the film results in a thermal-chemical reaction, usually with the aid or inclusion of oxygen in the ambient environment, that produces a product of a different colour. This usually results in some surface topographic texture changes such as roughening at the marked area.

10 The films to be used may be determined based on the above-mentioned advantageous characteristics. However, in a preferred embodiment, the laser-markable film is one which includes a polypropylene (PP), polyethylene terephthalate (PET), polycarbonate (PC), polyimide or polyester film. The films may also include a laser-sensitive pigment which may be added during the manufacture of the film to render the films laser-markable. Some
15 colour concentrates which are commercially available, such as the Fastmark7 concentrates from M. A. Hanna Color, may also be used to produce the laser marking effectiveness. Some commercially available films which have been found to be particularly effective as the laser-markable film include the PET film of 3M Ltd trade marked as PP25007. The PC film from G E Plastics commercially known as LEXAN7 Textures 8B35, and the polyester film
20 of Sony Chemicals Ltd.

 The laser-markable film may include a monolayer or multilayer structure. If the film includes a multilayer structure, it may advantageously include a protective outer coat and/or an inner adhesive coat to facilitate protection of the IC package and facilitate increased adhesion of the film to the package respectively.

25 The thickness of the laser-markable film is generally controlled within a range to ensure good bonding of the film to the package and to ensure a satisfactory cosmetic result. It has been found that a film which is excessively thick tends to reduce the bonding strength and makes the film attachment visible. On the other hand, it has been found that a film which is excessively thin maybe difficult to deal with during processing. As such, the
30 thickness of the film is preferably between 20 to 100 microns.

 In order to enhance the bonding of the film onto the IC package, the film maybe pre-treated by a suitable surface treatment. In particular, according to certain embodiments of

the invention, the film is pre-treated by corona "air" plasma treatment and solvent, for example alcohol, wipe treatment. As will be recognised, the pre-treatment of the film will be selected depending on the nature of the film and also depending on the nature of the compounds being used as encapsulating compounds for the IC package.

5 The laser marking of the film may be conducted using a conventional laser, the parameters of which may be determined taking into account the materials of the laser-markable film in question. Generally, a UV laser with a wavelength of from 248 to 355 nm and short pulse duration will be used for high quality photo-chemical colour change marking. Preferably the laser has a pulse duration of from 1 to 50 ns, a beam energy of from 10 to 50
10 mJ and a focal spot size of from 0.050 to 0.200 mm. The visible and IR lasers operating in either CW mode or CW Q-switch mode with wavelengths from 500 nm to 11000 nm will be used for the thermal-chemical colour change marking.

EXAMPLES

15 The following examples are provided for exemplification only and should not be construed as limiting on the invention in any way.

Example 1 - Application of laser-markable film

20 A polyester film manufactured by Sony Chemical Singapore Pte Ltd was used as the laser-markable film. The structure of this film incorporated a hard coat (2 microns), a polyester film (25 microns) a pigment layer (3-5 microns) and a dry adhesive layer (20 microns). The total thickness of the film was 50-52 microns. For the encapsulation process, the surface coated with dry adhesive was placed facing the IC chip cavity, and the hard coat was placed against the mould surface.

25 A Lauffer transfer moulding machine was used for the encapsulation and film lamination process at a moulding temperature of from 165EC to 185EC and a pressure of from 50 to 100 bar. In this regard, it has been found for a particular encapsulation compound, Sumikon7 EXE 7320C, a processing temperature of 170EC and a pressure of 50 bar is most preferable.

Example 2 - Reliability tests, pull strength and bonding mechanism

Temperature test carried out at 260EC for 24 hours produced no bonding delamination or film breakdown, and the laser markings were still clearly visible. Thermal cycling test of 586 cycles over 586 hours with a temperature range from 40EC to 125EC suggested that no noticeable film peeling or delamination resulted. A 14-day humidity cycle test was carried out at a humidity level of 85/85. The samples were then passed through a reflow oven at a temperature of up to 220EC. No noticeable film peeling or delamination was observed.

The bonding strength was measured according to the standardized testing method recommended by ASTM D903-94. The peel strength, i.e. the peel load per unit width of bonding area, was calculated. The average value of the peel strength for the polyester film bonding was 0.6 N/mm, which is comparable to the strength of the film.

Example 3 - laser marking process

Laser marking of an IC package prepared in accordance with the invention was conducted according to the following parameters:

Laser wavelength: 355 nm

Pulse duration: 3 ns

Pulse energy: 20 mJ

Focal spot size: 0.1 mm

The marks produced were found to have high contrast and high resolution, the laser marking changing the marked area on the film from a transparent or translucent or black to a light grey or lighter shades of other colours. The mechanism of the colour change is thought to be the result of both photochemical and thermal reactions. Surface damage to the film was found to be minimal. Further, it has been found that the application of a method did not change the performance characteristics of the original IC packages and is therefore applicable to the existing IC compound formulations in the art.

Those skilled in the art will appreciate that the invention described herein is susceptible to variations and modifications other than those specifically described. It is to be understood that the invention includes all such variations and modifications. The invention also includes all of the steps, features, compositions and compounds referred to or indicated in this specification, individually or collectively, and any and all combinations of any two or more of said steps or features.



Claims:

1. A method of preparing an integrated circuit package for laser marking, said method comprising:
encapsulating an integrated circuit chip by an encapsulating transfer moulding
5 process; and
bonding a laser-markable film to a surface of the encapsulated integrated circuit chip to be marked.
2. A method according to claim 1, wherein said film is bonded to said surface of the encapsulated chip during said encapsulating transfer moulding process.
- 10 3. A method according to claim 2, wherein said film is placed on a surface of a mould to be used in said encapsulating transfer moulding process prior to said process and bonded to said surface of the encapsulated chip by hot adhesion during said encapsulating transfer moulding process.
4. A method according to claim 3, wherein said film is placed on top and bottom surfaces
15 of said mould.
5. A method according to claim 1, wherein said film includes a polypropylene, polyethylene terephthalate, polycarbonate, polyimide or polyester film.
6. A method according to claim 1, wherein said film includes a laser sensitive pigment.
7. A method according to claim 1, wherein said film has a layered structure including a
20 protective outer coat and/or an inner adhesive coat.
8. A method according to claim 1, wherein said film has a thickness of from 20 to 100 microns.
9. A method according to claim 1, comprising pretreating said film to enhance bonding of said film to said encapsulated chip.
- 25 10. A method according to claim 9, wherein said pretreatment is selected from corona plasma treatment and solvent wipe treatment.
11. A method according to claim 1, wherein said encapsulating transfer moulding process



is conducted at a temperature of from 165EC to 185EC and a pressure of from 40 to 100 bar.

12. A method according to claim 11, wherein said encapsulating transfer moulding process is conducted at a temperature of 170EC and a pressure of 50 bar.

13. An integrated circuit package prepared by a method according to any one of the
5 preceding claims.

14. A method of laser-marking an integrated circuit package prepared by a method according to any one of the preceding claims, said method comprising:

applying a laser to said integrated circuit package to mark the laser-markable film on a surface thereof.

10 15. A method according to claim 14, wherein said laser has a wavelength of from 248 to 355nm and short pulse duration.

16. A method according to claim 15, wherein said laser has a pulse duration of from 1 to 30 ns, a beam energy of from 10 to 40 mJ and a focal spot size of from 0.100 to 0.200 mm.

17. A method according to claim 14, wherein said laser is a CW or Q-switch having a
15 wavelength from 500 nm to 11000 nm.