

METHOD AND APPARATUS FOR SINGULATION OF ELECTRONIC DEVICES**FIELD OF THE INVENTION**

The present invention is related to the packaging of semiconductor
5 devices. In particular, the present invention is related to the method and
apparatus for the electrical isolation and singulation of integrated circuit
(IC) device packages.

BACKGROUND OF THE INVENTION

The packaging of semiconductor and IC devices by plastic molding of
10 the chip is well known in the art. The package typically contains a molded
plastic covering which protects the IC devices inside. Interconnections
extending from the packages allow electrical connection between the
device and the external circuitry. Miniaturization now allows chip scale
packages (CSP) of as small as 3mmX3mm to be molded by reducing the
15 package size to approach the chip size. To increase packaging efficiency,
recent trends in packaging technology have been towards chip array chip
scale packages, in which an array of chips are molded together in a
single mold cavity as a panel. Packages such as QFN (Quad Flat Non-
lead) and chip-array BGA are examples of CSPs that are produced in a
20 panel array. The individual package can then be singulated, before
being sent for testing and higher level packaging.

The traditional ways of singulation are punching, stamping or sawing. For new packages such as chip array CSP, which have multiple chips embedded within the same layers of material, punching and stamping cannot be used. Conventional sawing techniques also do not give

5 satisfactory results due to the following reasons. Heat produced by the sawing process requires the use of a coolant. Water is typically used as a coolant because it can also act as an electric conductor for discharging static electricity generated from the sawing process. This wet process, however, increases the chances of device failure during subsequent

10 uses, reducing the reliability of the package. Mechanical stress from the sawing process increases the risk of delamination. For packages such as QFN, which require the cutting of copper layer(s), burr and sticky particles pose difficulties in producing satisfactory singulated products, and also results in high wear rate of the saw. Furthermore, with the trend

15 towards miniaturization of package sizes, holding of the package becomes increasingly difficult. There is therefore a need to provide a method and apparatus for the singulation of IC devices that alleviates the above-stated problems.

SUMMARY OF THE INVENTION

Accordingly, the present invention provides, in one aspect, an apparatus for the singulation of IC packages, particularly for packages having multilayers of organic and metallic materials. The apparatus uses
5 a cool, clean and dry process that does not result in the generation of burr or loose particles.

In another aspect, the present invention provides a novel method of cutting a panel of IC packages to achieve electrical isolation without singulation. This allows testing to be performed while the packages are
10 still in the partially-cut panel form, substantially reducing the handling difficulties associates with the small CSP packages.

The present apparatus and method uses laser ablation technique. Ablation is achieved under conditions in which the substrate material is converted to plasma under short laser pulses which do not give sufficient
15 time for significant thermal penetration to occur. The fluence is controlled and multiple scanning under high speed is used.

In the preferred embodiment, the fluence of the laser beam is less than around $100\text{J}/\text{cm}^2$, the wavelength of the laser used is below 550nm, while the pulse width of the beam is kept between around 100-500ns.
20 The beam spot diameter on the workpiece is well controlled, and in the range of about 10-300 μm . Multiple scanning is performed, such that for each scan, a certain depth of cutting is achieved. For electrical isolation of

the packages (i.e. the copper layers of the substrates are debussed), controlled depth cutting may be achieved using the same multiple scanning technique. The isolated packages can then be tested while still in the partially-cut panel form. After testing, singulation is performed, preferably by repeating the laser ablation process, but with increased number of scans as compared to the electrical isolation step.

The apparatus in the preferred embodiment includes a laser generator for generating a high frequency and low pulse energy laser beam, an optical system for delivery said laser beam onto a prescribed location, and a transfer system for transferring an IC device into the prescribed location.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic diagram of a laser cutting apparatus according to the present invention.

Figure 2 is a schematic diagram of another laser cutting apparatus according to the present invention.

Figure 3 is a schematic diagram to show the path of the laser beam in a laser cutting apparatus according to the present invention.

DESCRIPTION OF THE INVENTION

The apparatus and method according to the present invention allows the clean, cool and dry singulation of an IC device. The invention uses laser energy to sequentially ablate various layers of substrate material on a panel of molded IC devices with minimal heat generation. Laser ablation is defined in the present invention as the conversion of the mold flash into plasma and other volatile species due to photodecomposition by the laser beam.

Table 1 shows an example of the property of a double frequency Q-switched short wavelength Nd:YAG laser beam which causes ablation of the substrate according to the present invention.

LASER PROPERTY OF THE PRESENT INVENTION	
Wavelength	532nm
Pulse width	Less than 500ns
Pulse energy	0.1-10mJ/532nm
Repetition Rate	Less than 100kHz
Cooling	water
Beam spot dimension(diameter)	2mm

TABLE 1

Generally, controlled depth electrical isolation for chip array CSP packages according to the conditions shown in Table 1 may be achieved using 2-8 scans at a low power e.g. about 2 watts, depending on the depth and material that need to be cut. For complete singulation, 10-20 scans may be performed. In the more preferred embodiment, the pulse width is less than 300ns, the pulse energy is 0.1-10mJ/532nm, the repetition rate is 10-50kHz, the beam spot is 20-200 μ m and the fluence larger than 5J/cm².

As an example, a CABGA (chip-array ball grid array) package with a copper layer of 0.1mm thickness packaged in an epoxy organic material at a depth of 0.1mm depth may be debussed by scanning a laser beam for 3-8 times with a beam spot diameter of 30 μ m. The frequency is 10KHz and the pulse energy 0.2mJ, and the pulse width is 100ns.

Figure 1 shows an example of a laser cutting apparatus in which the beam of a double-frequency Q-switched Nd:YAG laser 20 is directed onto a panel 22 of IC devices (not shown) on a stage 24 by the use of a scanner 26 and appropriate optical components 28. A computer control system 30 controls a controller 32 which in turn controls the stage 24 and the triggering of the laser via a trigger 34 such that the laser beam is directed at the boundary between the embedded IC devices. A vision system 25, coupled to the control system and the stage, is provided to control the route of cutting. No water cooling system is provided such that the entire process is dry.

Figure 2 shows the details of a specific example of an apparatus for cutting a panel of IC devices. In this apparatus, the panel **50** with IC devices **42** embedded therein, are transferred by a transfer system to holding station **40**. The holding station may be, for example, a stage and guide track or a stage with vacuum suction outlets. A laser beam from a laser generator **44** is directed into a scanner or galvanometer **46**, which directs the beam to the boundary between the IC devices. The exact positioning of panel **50** is controlled by a vision alignment system **47**. The scanner may be programmed such that the laser beam performs controlled-depth cutting or through-cutting along certain cutting routes. Controlled-depth cutting allows the panel to be cut until the electrically conductive layers at the boundaries are cut, but stops short of completely cutting through all the plastic mold material. This allows the individual IC packages to be electrically isolated from each other while being physically maintained as an array. The electrically isolated IC devices can then be sent for testing as a partially-cut panel. After testing, the cutting process may be repeated, but with a higher number of scans to ensure complete singulation of the IC packages. In this embodiment, an exhaust inlet **52**, is provided to suck away the decomposed fume generated by the ablation of the packaging material. An air blower (not shown) may also be optionally provided for blowing away the ionized vapor as it is formed.

Figure 3 shows a third embodiment of the present invention in which the laser generator **56** is position sideways. In this embodiment, a beam expander **58** is provided to enlarge the beam spot diameter, and a series of mirrors **60** are used to direct the focused beam onto the X-Y scanner or galvanometer **62**. The scanner then directs the beam onto the appropriate boundaries of the panel between the IC packages under the guidance of the vision alignment system **63**.

While the present invention has been described particularly with references to Figs 1 to 3, with specific examples cutting chip array CSP packages, it should be understood that the figures are for illustration only and should not be taken as limitation on the invention. In addition it is clear that the method and apparatus of the present invention has utility in many applications where cutting of molded material is required. It is contemplated that many changes and modifications may be made by one of ordinary skill in the art without departing from the spirit and the scope of the invention described.



CLAIMS

- 1 1. An apparatus for singulating a molded panel with a plurality of IC
2 devices comprising :

3 a laser generator for generating a laser beam, said laser beam
4 scanning multiple times at high speed over a prescribed area of said
5 molded panel;

6 an optical system for delivery and focusing said laser beam; and

7 a transfer system for transferring said panel into a prescribed
8 position from which ablation by said laser beam can occur;

9 said apparatus ablating said panel in the absence of a water cooling
10 system to obtain singulated IC devices.
- 11 2. A method for cutting a panel of IC devices connected by a multilayer
12 substrate comprising :

13 generating a laser beam, said laser beam capable of ablating the
14 substrate in said panel without water cooling;

15 ablating said panel at a prescribed position to a prescribed depth
16 such that said IC devices are electrically isolated but physically
17 connected by non-conducting material in said substrate;

18 testing said IC devices; and

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- 19 singulating said IC devices by complete ablation said substrate at
20 said prescribed position.
- 21 3. A method according to claim 1 wherein the fluence of said laser
22 beam is less than about $100\text{J}/\text{cm}^2$.
- 23 4. A method according to claim 1 wherein said laser beam scans 10-20
24 times and at a pulse width of 100ns on said prescribed surface.
- 25 5. A method according to claim 2 wherein the fluence of said laser
26 beam is less than about $100\text{J}/\text{cm}^2$.
- 27 6. A method according to claim 2 wherein said laser beam scans 2-8
28 times and at a pulse width of 100ns on said prescribed surface to
29 obtain ablation to said prescribed depth, said laser beam further
30 scanning 10-20 times and at a pulse width of 100ns on said
31 prescribed surface for singulation of said IC devices.

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