

IMPROVED PUNCH CUTTING TOOL FOR CIRCUITIZED ORGANIC SUBSTRATES AND PROCESS FOR THE SAME

FIELD OF THE INVENTION

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The present invention is for an improved Punch cutting tool and process for the same in which a circuitized organic substrate is prepared for use in the manufacture of ball grid arrays (BGAs), Board on Chip (BOC) and memory module etc.

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BACKGROUND OF THE INVENTION

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A circuitized organic substrate is first manufactured from core substrate material. The core substrate material usually has one or two layers of solder resist and a plurality of bonding fingers in the centre of each unit of core substrate material. The centre of the circuitized organic substrate is then punched to remove unwanted portions (referred to as "slot holes"), thereby exposing the bond fingers. After punching out the slot holes, the circuitized organic substrate is further processed by placing of memory chips and could be manufactured into memory SD cards and memory cards for use in mobile phones, computers and cameras etc.

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Currently manufacturers use routing method (milling) with CNC machines. Due to increased demand for circuitized organic substrates, the current routing method is no longer able to support the increased demand and lead times required by the market.

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Punch cutting of the slot holes and/or outer shape of SD card have been proposed. A precise small area has to be punched out of a very small unit of substrate core material, all of which are already manufactured and arranged into an array of electronic units in a circuitized organic substrate board. The punch cutting operation therefore requires high precision due to the minuteness of the electronic units. The punch cutting operation has to be fast, accurate and precise, and yet not cause damage to the circuitized organic substrate.

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When the slot holes of the circuitized organic substrate are punched out, the industry requirements are that there be no burr, no hair line crack, no chipping,

no scratches, no finger prints, no oil stains allowed on both sides of the circuitized organic substrate after the slot hole has been punched away.

A punching assembly has been described in U S Patent No. 6 173 632. This prior art invention describes a cutting apparatus for separating semiconductor packages such as ball grid arrays (BGAs) from a substrate wherein the apparatus makes a dual cut at a single station through multiple material layers without creating slivers of material. However this prior art invention is used for cutting semiconductor packages which have different requirements. Certain procedures referred to in this patent such as straight cut, requirement for a pre-drill hole, step clamp on the solder resist and cutting of the semiconductor packages after molding are not acceptable for punch cutting slot holes from circuitized organic substrates .

The requirements for punching slot holes in circuitized organic substrates is that the cutting is carried out before wire bonding and molding, without any need for pre-drill holes. In order not to damage the circuitized organic substrate, a stepper would have to be applied on as little an area of the circuitized organic substrate as possible and the bonding fingers but not on the solder resist. The stepper has to be set to an accuracy of ± 0.005 mm on the surface of the circuitized organic substrate and the tip of bonding fingers. The area of contact between the stepper and circuitized organic substrate should be ± 0.05 mm around the profile of the slot hole to be cut. The post-production inspection requires 40 X magnification which is more stringent than the prior art.

U. S. Patent No. 6 173 632 therefore is for an invention dealing with back end of the substrate processing such as semi-conductor packages. The punch cutting assembly described in U. S. Patent No. 6 173 632 cannot offer any solution to the more exacting requirements for punch cutting slot holes in circuitized organic substrates. What is required is an improved punch cutting tool at the front end for punching of slot holes and insertion of electronic chips for the manufacture of ball grid arrays, board on chip and memory modules etc.

It is recognised that punch cutting of slot holes would offer these advantages:-

- Improved accuracy
- Improved productivity
- Shorten lead time
- Reduce system and space cost
- 5 Reduce routing cost and
- Lower costs of wastage due to lower number of rejects

The inventor has proposed an improved punch cutting tool for punch cutting slot holes in the circuitized organic substrate as well as an improved process
10 for the same. The improved punch cutting tool includes a stripper insert cum stepper which is precisely ground and machined as a single unit, with two separate functions:-

- a stripper insert;
- 15 a stepper

(In the description and claims, when reference is made to the workings of the entire inventive device, it will be referred to as "stripper insert cum stepper". When reference is made to the workings of the stripper insert only, it will be
20 referred to as "stripper insert" and when reference is made to the workings of the stepper, it will be referred to as "stepper".)

The improved punch cutting tool also includes a punch cutter having a horizontal profile closely dimensioned to the dimension of the slot hole to be
25 punch cut from the circuitized organic substrate, the profile of the punch cutter including other dimensions such as angle of punch, radius, and V-shaped shear angle. Such an improved punch cutting tool would reduce the damage to the circuitized organic substrates during the punch cutting process such as hair line crack, burr, chipping and scratches.

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SUMMARY OF THE INVENTION

A first object of the invention is an improved punch cutting assembly for punching of a slot hole in a unit of a circuitized organic substrate, said unit of
35 circuitized organic substrate consisting of a layer of core substrate material, bonding fingers and one or more layer of solder resist, said slot hole being an

area in the unit of circuitized substrate with bonding fingers, which is to be punch cut, leaving the bonding fingers exposed, the punch cutting assembly having a top die shoe, lower die shoe, both of which are guided by a high precision ball bearing guide pillar, wherein a plurality of units of the circuitized organic substrate is placed on a die plate, said punch cutting tool comprising:-

a means to stabilise and hold the upper surface of the circuitized organic substrate; and

a punch cutter

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wherein the means to stabilise and hold the upper surface just lightly touches the upper surface of the circuitized organic substrate, so that the punch cutter can punch cut a slot hole in the circuitized organic substrate, the means to stabilise and hold the upper surface stabilizes the circuitized organic substrate from the reactive force of the punch cutter on it, thereby reducing damage to the circuitized organic substrate such as hair line crack, burr, chipping and scratches.

Preferably, the means to stabilise and hold the upper surface of circuitized organic substrate comprises:-

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a stripper insert cum stepper;

wherein the stripper insert is placed slightly above the core substrate material and beyond the profile of the slot hole to be punch cut; and

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wherein the stepper is placed on a contact area of the substrate core material and the bonding fingers, said stepper lightly touching the core substrate material and the bonding fingers.

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Preferably, the stripper insert cum stepper is precisely grounded and machined to form a single unit.

Preferably the height of the stripper insert cum stepper from the core substrate material is be set to an accuracy of +/- 0.005 mm.

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Preferably the stripper insert cum stepper is machined to the required dimensions and shape of the profile of the slot hole, said stripper insert cum stepper being controlled by the height of the mechanical stopper such that the stripper insert does not touch the core substrate material but there is a gap
5 between the stripper insert and the circuitized organic substrate.

Preferably, the stripper insert cum stepper is held by a main stripper plate.

Preferably, the stripper insert cum stepper is controlled by compression spring
10 and mechanical stopper.

Preferably, the stepper is placed on the bonding fingers of the circuitized organic substrate and a contact area, the contact area defined as the area around the perimeter of the profile of the slot hole, the contact area being only
15 an area of ± 0.05 mm width.

Preferably, the height of the stripper insert cum stepper from both bonding fingers and contact area of the core substrate material is properly set to an accuracy to ± 0.005 mm by means of a mechanical stopper so that the
20 stepper lightly touches both bonding finger and contact area of the core substrate material.

A second object of the invention is for a punch cutter to have a horizontal profile closely dimensioned to the dimension of the slot hole to be punch cut
25 from the circuitized organic substrate.

Preferably, the profile of the punch cutter includes other dimensions such as angle of punch, radius, and V-shaped shear angle.

30 Preferably, the punch cutter has a V-shaped shear angle of punch from 100 degree to 125 degree.

Alternatively, the punch cutter has two or more V-shaped shear angles of punch.
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Preferably, the punch cutter has a radius for better tool life and cutting condition.

Preferably, the punch cutter has a very small cutting clearance of 0.002 – 0.003 mm/side.

5 A third object of the invention is for a process for punch cutting a slot hole in an unit of circuitized organic substrate, using an improved punch cutting tool of the invention, together with punch cutting assembly having a top die shoe, lower die shoe both of which are guided by a high precision ball bearing guide pillar, the said process comprising the following steps:-

10 loading the plurality of units of a circuitized organic substrate to be punch cut onto the punch cutting assembly;

applying a stripper insert cum stepper onto the upper surface area of the circuitized organic substrate;

15 placing said stripper insert so that it is placed slightly above the core substrate material and beyond the profile of a slot hole of core substrate material to be punch cut;

20 placing said stepper of the stripper insert cum stepper onto the upper surface of the circuitized organic substrate so that it lightly touches an area of the core substrate material surrounding the perimeter of a profile of the slot hole to be punch cut;

25 the stepper lightly touching the bonding fingers and a contact area, the contact area being +/- 0.05 mm wide of the surface of the core substrate material surrounding a perimeter of the slot hole to be punch cut;

30 setting the height of the stripper insert cum stepper to an accuracy of +/-0.005 mm by the precision ground mechanical stopper such that the stepper just touches the tips of the bonding fingers and contact area in the core substrate material;

35 punch cutter applied downwards onto the area of the slot hole to be punch cut;

the profile of the punch cutter matching the profile and dimensions of the slot hole to be punch cut,

wherein the force of the impact will cause the circuitized organic substrate to
5 react to the force by edge rolling over and the bonding fingers to lift up, but
with the stripper insert cum stepper effectively pressing onto the core substrate
material and bonding fingers, the circuitized organic substrate is held down
by the stripper insert cum stepper, thereby avoiding much reactive movement,
and consequently avoiding damage such as hair line crack, burr and chipping to
10 the circuitized organic substrate.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the invention, its advantages, and the objects
15 attained by its use, reference should now be made to the accompanying
drawings. The accompanying drawings illustrate one or more embodiments of the
invention and together with the description herein, serve to explain the workings
and principles of the invention.

20 FIG. 1 is a view of a portion of a circuitized organic substrate.

FIG. 1A showing an enlarged view of an individual unit.

FIG. 1B is a view of a SD card substrate.
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FIG. 2 shows a circuitized organic substrate with a layer of core substrate
material with one layer of solder resist .

FIG. 2A shows a circuitized organic substrate having a layer of core substrate
30 material with two layer of solder resist, top layer and a bottom layer of
solder resist.

FIG. 3 shows the circuitized organic substrate with a plurality of bonding fingers
electrically connected to the core substrate material.
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FIG. 4 is a view showing the damage caused to the top side of a circuitized organic substrate using the conventional punching process.

5 FIG. 5 is a view showing the damage caused to the bottom side of a circuitized organic substrate using the conventional punching process.

FIG. 6 shows an IC chip connected to the circuitized organic substrate to form a BOC.

10 FIG. 7 shows a perspective view of a portion of the core substrate material indicating the area around which the slot hole is to be punch cut.

FIG. 8 is a perspective view of the stripper insert cum stepper showing the stepper touching the contact area of the circuitized organic substrate and the
15 bonding fingers before the punch cutting operation.

FIG. 9 is a top view of the circuitized organic substrate showing the contact area (shaded portion) which is in contact with the stepper portion of the
20 stripper insert cum stepper.

FIG. 10 is a perspective view of the punch cutting tool of the invention, consisting of the punch cutter with a profile of V-shaped shear angle in cooperation with the stripper insert cum stepper.

25 FIG. 11 is a partial cross section view of an assembly for punch cutting operations including the punch cutting tool of the invention.

FIG. 12 is an enlarged cross section view of the stripper insert cum stepper and punch cutter of the invention.
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FIG. 13 is a view of a portion of the circuitized organic substrate after the slot hole has been punched out and removed.

FIG. 14 is a view of the profile of a punch cutter of the invention.
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FIG. 15 is a view of another profile of a punch cutter of the invention.

FIG. 16 is a view of a punch cutter with multi V-shaped shear angles.

FIG. 17A, 17B and 17C are perspective views of how the circuitized organic substrate in the form of an array of individual units are progressively
5 processed by the punch cutting assembly for punch cutting of the slot holes.

DETAILED DESCRIPTION OF THE INVENTION

FIG. 1 is a view of a portion of a circuitized organic substrate (105) made of
10 many individual units. FIG. 1A is an enlarged view of an individual unit. FIG. 1B is a view of a portion of a SD Card's substrate.

The circuitized organic substrate (105) consists of a layer of core substrate material (3) and one or two layers of solder resist (2). FIG. 2 shows a layer of core
15 substrate material (3) with a top layer of solder resist (2) while FIG. 2A shows a layer of core substrate material (3) with a top and bottom layer of solder resist (2).

FIG. 3 is a magnified view of an individual unit of the circuitized organic
20 substrate (105) with a plurality of bonding fingers (1) electrically connected to the core substrate material (3). The bond fingers (1) are portions of interconnects formed on the underlying layer of solder resist (2) in the circuitized organic substrate (105). When the slot hole (140) is punch cut, the bond fingers (1) are exposed as a plurality of wires. After the slot hole (140) is punched through, and
25 an IC chip placed therein, the bond fingers (1) will eventually connect the unit of circuitized organic substrate (105) with the IC chip placed therein. It can be seen that the slot hole (140) must be punch cut in a clean and efficient manner, without damage to the remaining core substrate material (3) including the bond fingers (1) else the insertion of an IC chip would be of no use or cause
30 intermittence functional problem in the field.

Due to the small size of the individual unit, inspection under 40 X magnification must be carried out to check for hair line crack (10), burr (11) and chipping. The shaded area around the core substrate material (3) is the contact
35 area (20) for the stepper (8) in the punch cutting operation. The contact area (20) matches the profile of the slot hole (140) to be punched out. The stepper

(8) portion of the stripper insert (104) cum stepper (8) is only placed lightly on the contact area (20) which is confined only to an area of ± 0.05 mm width around the perimeter of the slot hole (140) to be punched out.

- 5 FIG. 4 is a view showing the damage caused to the top side of a circuitized organic substrate (105) using a conventional punching method. When a slot hole (140) is punched, damage can be caused to the circuitized organic substrate (105). Hair line crack (10), burr (11) and chipping on core substrate material (3) can result on the top side of the core substrate material (3).
- 10 Such damage to the remaining core substrate material (3) including the bond fingers (1) would nullify the effort to place of an IC chip therein.

- FIG. 5 is a view showing the damage caused to the bottom side of a circuitized organic substrate (105) using a conventional punching method.
- 15 When a slot hole (140) is punched, damage can be caused to the circuitized organic substrate (105). Crack (10) on the solder resist (2) and burr (11) can result on the bottom side of the core substrate material (3). Such damage to the remaining core substrate material (3) including the bond fingers (1) would nullify the effort to place of an IC chip therein.

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- FIG. 6 shows an IC chip connected to the circuitized organic substrate (105) to form a BOC. The IC chip is placed on the circuitized organic substrate (105) where the punched out slot hole (140) created by the punch cutting operation is. The IC chip is connected to the bond fingers (1) with the gold wires. The
- 25 circuitized organic substrate (105) with the IC chip can be further manufactured into memory SD cards and memory cards for use in mobile phones, computers and cameras etc.

- FIG. 7 shows a perspective view of a portion of the core substrate material (3) indicating the area around which the slot hole (140) is to be punch cut. The slot hole (140) will expose the bond fingers (1) which would connect with the IC chip to form the BOC.
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- FIG. 8 is a perspective view showing a stripper insert (104) cum stepper (8) before the punch cutting operation. The stripper insert (104) cum stepper (8) is made from a single stripper insert (104) with a stepper (8) grounded on it. Since
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the circuitized organic substrate (105) is a very minute electronic unit, the stripper insert (104) cum stepper (8) has to be very small. As such, the stripper insert (104) cum stepper (8) has to be precisely grounded and machined to form a single unit.

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The stepper (8) rests lightly on the contact area (20) of the core substrate material (3) and the tip of bond fingers (1) while the stripper insert (104) provides space (clearance) for the surrounding core substrate material (3), solder resist (2) and bonding fingers (1) outside the contact area (20). The stepper (8) is placed
10 on a contact area (20) which is ± 0.05 mm wide surrounding the perimeter of the slot hole (140) profile to be punched. The stepper (8) therefore lightly touches both bonding finger (1) and the contact area (20) of core substrate material (3) as defined. The height of the stripper insert (104) cum stepper (8) has to be properly set (accuracy to ± 0.005 mm) by means of a mechanical
15 stopper (200) such that the stepper (8) just touches the top side of the bonding finger (1) and the contact area (20) of core substrate material (3) as defined. If the stepper (8) is placed firmly onto the contact area (20) or is not touching the contact area (20) at all, the impact of the punch cutting of the slot hole (140) would push the core substrate material (3) upwards, resulting in damage to the
20 core substrate material (3) and bonding finger (1) causing hair line crack (10), chipping or scratches or open circuit or burring of the core substrate material (3), rendering it useless.

FIG. 9 is a top view of the circuitized organic substrate (105) showing the
25 contact area (20) (shaded portion) which is in contact with the stepper (8) of the stripper insert (104) cum stepper (8). The contact area (20) (shown as shaded area) is only an area of ± 0.05 mm width around the perimeter of the slot hole (140). The stripper insert (104) of the stripper insert (104) cum stepper (8) provides clearance to the outer area of the upper surface of the core substrate material (3) and bonding fingers (1) beyond the contact area (20). Accuracy and
30 precision is therefore required for the stripper insert (104) cum stepper (8) when it is placed onto the upper surface of the circuitized organic substrate (105). Placing the stepper (8) so that it lightly rests on the bonding fingers (1) is advantageous as there is less roll over at the cutting edge. It also prevent the
35 bonding fingers (1) from lifting up due to the impact of the punch onto the circuitized organic substrate (105) and also acts to hold the circuitized organic

substrate (105), nullifying the lifting up effect of the core substrate material (3) due to the force and subsequent return of punch cutter (5) to its original position. The stepper (8) resting on the contact area (20) also acts to press the circuitized organic substrate (105) by exerting downward pressure on it, during the punch cutting operation, thereby nullifying the lifting up effect of the circuitized organic substrate (105) arising from the reactive impact of the punch into the core substrate material (3). Since other areas of the circuitized organic substrate (105), solder resist (2) and bond fingers (1) are not touched by any part of the stepper (8), damage such as die mark, scratches, crack (10) could not be caused to the circuitized organic substrate (105).

Tiny powder particles from the impact of the punch cutting operation on the circuitized organic substrate (105) is another problem arising from punch cutting operations. Due to the contact area (20) being confined to ± 0.05 mm around the profile of the slot hole (140) to be punched out, the clearance around the stripper insert (104) provide room for the powder particles to move freely. As such, tiny powder particles will not cause any unnecessary die mark or contact mark to remain on the circuitized organic substrate (105).

FIG. 10 is a perspective view showing a punch cutting tool (120) of the invention consisting of the punch cutter (5) with a profile of V-shaped shear angle (30) in cooperation with the stripper insert (104) cum stepper (8) of the invention. The stepper (8) just lightly touches the surface of the core substrate material (3) within the contact area (20), before the punch cutting operation. Different cutting edge profile of the punch cutter (5) offers different types of cutting punch. Angle of punch control is set at 100 degree to 125 degree, depending on the core substrate material (3) thickness. A radius (21) is also applied to provide better cutting result at the intersection point of V-shaped shear angle (30). The V-shaped shear angle (30) of the punch provides better shearing action and cutting result with a very small cutting clearance of 0.002-0.003 mm/side. If the V-shaped shearing angle (30) is correctly selected, no crack (10) nor burr (11) on both the core substrate material (3) and solder resist (2) could arise.

The shape of the profile of punch cutter (5) could be any profile and need not necessarily be restricted to straight lines.

FIG. 11 is a partial cross section view of an assembly for punch cutting operations using the punch cutting tool (120) of the invention. The punch cutting assembly (130) for punch cutting has a top die shoe (100) and lower die shoe (102), guided by a highly precision ball bearing guide pillar (109). The circuitized organic substrate (105) to be punch cut is placed on the die plate (106) and held in place by the stripper insert (104) cum stepper (8). The stripper insert (104) cum stepper (8) is held by a main stripper plate (101) and its clamping and stripping action is controlled by compression spring (108) and the mechanical stopper (200).

FIG. 12 is an enlarged view of the stripper insert (104) cum stepper (8) and punch cutter (5) of the invention. The height control of the stripper insert (104) cum stepper (8) is set by precision ground mechanical stoppers (200). The punch cutter (5) is guided by the stripper insert (104) cum stepper (8). The stripper insert (104) cum stepper (8) acts as a precision clamp as well as a precision guide for the punch cutting operation. The stripper insert (104) cum stepper (8) is properly machined to the required dimensions and shape and the stepper (8) is precisely ground on it. The stripper insert (104) cum stepper (8) is carefully controlled by the height of the mechanical stopper (200) such that the stepper (8) just lightly touches both the core substrate material (3) and bonding fingers (1) within the contact area (20). Only the stepper (8) will touch the bond fingers (1) and core substrate material (3) within the contact area (20). Such precise height of the stripper insert (104) cum stepper (8) requires the height to be set to an accuracy of ± 0.005 mm. The tiny contact area (20) also prevents "powder stain" on other functioning area whereby the powder particles arising from the cutting of the slot hole (140) causes the fibre in the core substrate material (3) to break up forming powdery particles and settle on the remaining core substrate material (3).

When the circuitized organic substrate (105) is placed in position, the whole top part of the assembly comes down [top die shoe (100), punch holder (103), main stripper plate (101), stripper insert (104) cum stepper (8), ball bearing guide pillar (109), punch cutter (5) and compression spring (108)]. The whole top part comes down until the stripper insert (104) cum stepper (8) touches the mechanical stopper (200). The main stripper plate (101) and stripper insert (104) then stop and move into position on the circuitized organic substrate (105) at the same time. The

compression spring (108) provides the clamping force but the other parts continue going down, including the punch cutter (5), so that a slot hole (104) is punch cut through the circuitized organic substrate (105).

5 When the whole top part returns during the return stroke, the main stripper plate (101) and stripper insert (104) will stay in its lower position, held down by compression spring (108). The punch cutter (5) and other tool members of the whole top part will return first, until a certain height such that the whole top part returns to the original position.

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FIG. 13 is a view of a portion of the circuitized organic substrate (105) after the slot hole (140) has been punched out and removed. The advantage offered by this inventive device is that the precisely grounded stepper (8) of the stripper insert (104) cum stepper (8) is placed on the perimeter of the contact area (20)
15 of the circuitized organic substrate (105), thereby preventing damage such as contact mark, chipping, hair line crack (10) and burring in the circuitized organic substrate (105) and the solder resist (2).

FIG. 14 is a view of the profile of a punch cutter (5) of the invention. FIG. 15
20 is a view of another profile of a punch cutter (5) of the invention. FIG. 14 is a perspective view of the V-shaped shear angle (30) for complex profile cutting. The cutting profile of the punch cutter (5) as shown in FIG. 14 is different from the cutting profile of the punch cutter (5) shown in FIG. 15. The profile of the punch cutter (5) of FIG. 14 will punch a slot hole (140) of the shape shown
25 in FIG. 14 while the profile of the punch cutter (5) of FIG. 15 will punch a slot hole (140) of the shape shown in FIG. 15. The profile of the punch cutter (5) shown in FIG. 14 is "wavy" while the profile of the punch cutter (5) shown in FIG. 15 is a simple "V" shape. The inventor has determined that the angle of punch for effective punch cutting should be from 100 degree to 125
30 degree. The radius (21) also provide better tool life and cutting condition.

Each punch cutter (5) can have one or more V-shaped shear angles (30). However, the inventor has found out that the best V-shaped shear angle (30) is from 100 degree to 125 degree, providing optimum shear condition with causing
35 minimal damage such as burr and hair line crack (10) to the core substrate material (3), which are visually inspect under 40 X magnification.

Multi V-shaped shear angles (30) is to provide for positive V-shaped shear angle (30) for complex profile. An example of a punch cutter (5) with multi V-shaped shear angle (30) is shown in FIG. 16. Since all slot holes (140) to be cut require no pre-drill hole, a straight line cut with only a single V-shaped shear angle (30) would suffice. However for complex shaped slot holes (140), multi V-shaped shear angles (30) provide a more effective punch cutting operation.

A description of the process flow using the improved punch cutter (5) of the invention is given herein with reference to FIGS. 17A, 17B and 17C.

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As the process is running progressively, the individual units of the circuitized organic substrate (105) (in arrays of three, four or five individual units) are first loaded onto the punch cutting assembly (130). The array of individual units is automatically loaded onto the punch cutting assembly (130). The loading of the array is precisely guided using pilot pins, all these loading procedures being known in the art and therefore not described in greater detail herein. Once the individual units of circuitized organic substrate (105) are placed onto the die (106), the stripper insert (104) cum stepper (8) is placed onto the contact area (20), which is the tiny perimeter surrounding the slot hole (140) to be punch out, the contact area (20) being +/- 0.005 mm wide surrounding the perimeter of the slot hole (140).

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The height of the stripper insert (104) cum stepper (8) must also be properly set (to accuracy of +/-0.005 mm) by the precision ground mechanical stopper (200) such that the stepper (8) just touch the core substrate material (3) and the tip of bond fingers (1). Too heavy a step or too light a step would not achieve the desired result.

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During the punch cutting process, the punch cutting force will cut through the core substrate material (3) and cause rolling over edge at the bond fingers (1). Bond fingers (1) will also lift up when punch cutter (5) return. However, with the stepper (8) holding onto the core substrate material (3) and the tip of bonding fingers (1), it effectively preventing damage and roll over effect. The V-shaped shear angle (30) on the punch cutter (5) will also effectively prevent cracking of core substrate material (3) and burring during cutting process. Therefore hair line crack (10), burr (11) and

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chipping can be avoided in the punch cutting operation using the punch cutting tool (120) of this invention.

After the punch cutting, the array is removed and unloaded automatically. The unloading of the array being known in the art is therefore not described in greater detail herein. After unloading, the circuitized organic substrate (105) is visually checked under 40 X magnification to confirm there are no hair line crack (10), burr (11), tool mark or contact mark, chipping on both the top side and bottom side of the circuitized organic substrate (105).

OTHER EMBODIMENTS

The means to stabilise and hold the circuitized organic substrate (105) is described as a stripper insert (104) cum stepper (8) device. The stripper insert (104) cum stepper (8) device primarily acts to hold certain parts of the circuitized organic substrate (105) without damaging the circuitized organic substrate (105), and therefore performs these functions:-

before the punch cutting operation, the stepper lightly touches the upper surface of the circuitized organic substrate (105) thereby holding it in place and ready for the punch cutting;

during the punch cutting operation, minimises the force of reaction arising from the punch cutting operation;

during the punch cutting operation, the stripper insert (104) provides a clearance between the core substrate material (3) and the stripper insert (104) allowing room for the powdery particles caused by the punch cutting operation to move freely so that tiny powder particles will not cause any unnecessary die mark or contact mark to remain on the circuitized organic substrate (105);

during the punch cutting operation, the stepper (8) stabilises the upper surface of the circuitized organic substrate (105) and therefore allows the slot hole (140) to be dropped easily via the die opening;

5 in stabilising and holding the upper surface, the stepper (8) acts to
minimizes the reactive force of the punch cutter (5) on the circuitized
organic substrate (105), thereby reducing damage to the circuitized
organic substrate (105) such as hair line crack (10), burr (11), chipping
and scratches.

The stripper insert (104) cum stepper (8) device can also be described as a
positioning cum holding device for carrying out the punch cutting operation.

10 While two embodiments of the improved punch cutting tool have been described, it
should be apparent, however, that various modifications, rearrangements,
substitutions alterations and adaptations to those embodiments may occur to
persons skilled in the art with the attainment of some or all of the advantages of the
present invention. Accordingly, it should be clearly understood that the present
15 invention is not intended to be limited by the particular features and structures
hereinbefore described and depicted in the accompanying drawings. It is therefore
intended to cover all such modifications, alterations and adaptations without
departing from the scope and spirit of the present invention as defined by the
appended claims.

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ADVANTAGEOUS EFFECTS OF THE INVENTION

The invention offers high accuracy and faster punch cutting of slot holes (140)
in circuitized organic substrates (105) causing minimal damage.

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CLAIMS

1. An improved punch cutting tool (120) of a punch cutting assembly for punching of a slot hole (140) in a unit of a circuitized organic substrate (105),
5 said unit of circuitized organic substrate (105) consisting of a layer of core substrate material (3), bonding fingers (1) and one or more layer of solder resist (2), said slot hole (140) being an area in the unit of circuitized organic substrate (105) with bonding fingers (1), which is to be punch cut, leaving the bonding fingers (1) exposed, the punch cutting assembly having a top die shoe
10 (100), lower die shoe (102), both of which are guided by a high precision ball bearing guide pillar (109), wherein a plurality of units of the circuitized organic substrate (105) are placed on the die plate (106), the punch cutting tool (120) comprising:-

15 a means to stabilise and hold the upper surface of the circuitized organic substrate (105); and
a punch cutter (5)

wherein the means to stabilise and hold the upper surface just lightly touches
20 the upper surface of the circuitized organic substrate (105), so that the punch cutter (5) can punch cut through a profile of the slot hole (140), forming a slot hole (140) within the unit of circuitized organic substrate (105), the means to stabilise and hold the upper surface minimizes the reactive force of the punch cutter (5) on it, thereby reducing damage to the circuitized organic substrate
25 (105) such as hair line crack (10), burr (11), chipping and scratches.

2. A means to stabilise and hold the upper surface of circuitized organic substrate (105) as claimed in Claim 1, the means comprising:-

30 a stripper insert (104) cum stepper (8);

wherein the stripper insert (104) is placed slightly above the core substrate material (3) and beyond a profile of a slot hole (140) of core substrate material (3) to be punch cut; and

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wherein the stepper (8) is placed on a contact area (20) of the core substrate material (3) and the bonding fingers (1), said stepper (8) lightly touching the core substrate material (3) and the bonding fingers (1).

5 3. A stripper insert (104) cum stepper (8) as claimed in Claim 2 wherein the stripper insert (104) cum stepper (8) is precisely grounded and machined to form a single unit.

10 4. A stripper insert (104) cum stepper (8) as claimed in Claim 2 wherein the height of the stripper insert (104) cum stepper (8) from the core substrate material (3) is be set to an accuracy of ± 0.005 mm.

15 5. A stripper insert (104) of the stripper insert (104) cum stepper (8) as claimed in Claim 2 wherein the stripper insert (104) is machined to the required dimensions and shape of the profile of the slot hole (140), said striper insert (104) being controlled by the height of the mechanical stopper (200) such that the stripper insert (104) cum stepper (8) does not touch the core substrate material (3) but there is a gap between the stripper insert (104) and the circuitized organic substrate (105).

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6. A stripper insert (104) cum stepper (8) as claimed in Claim 2 wherein the stripper insert (104) cum stepper (8) is held by a main stripper plate (101).

25 7. A stripper insert (104) cum stepper (8) as claimed in Claim 2 wherein the stripper insert (104) cum stepper (8) is controlled by compression spring (108) and mechanical stopper (200).

30 8. A stepper (8) of the stripper insert (104) cum stepper (8) as claimed in Claim 2 wherein the stepper (8) is lightly placed on the bonding fingers (1) of the circuitized organic substrate (105) and a contact area (20) defined as the area around the perimeter of the profile of the slot hole (140), the contact area (20) being only an area $\pm$ of 0.05 mm width.

35 9. A stepper (8) of the stripper insert (104) cum stepper (8) as claimed in Claim 2 wherein the stepper (8) lightly touches both bonding fingers (1) and contact area (20) of the core substrate material (3), the height of the stepper (8)

from both bonding fingers (1) and contact area (20) of the core substrate material (3) properly set to an accuracy to ± 0.005 mm by means of a mechanical stopper (200) .

5 10. A punch cutter (5) as claimed in Claim 1 wherein said punch cutter (5) has a horizontal profile closely dimensioned to the dimension of the slot hole (140) to be punch cut through the organic circuitized substrate (105).

10 11. A punch cutter (5) as claimed in Claim 1 wherein the other dimensions of the profile of the punch cutter (5) includes angle of punch, radius (21), and V-shaped shear angle (30).

12. A punch cutter (5) as claimed in Claim 11 wherein said punch cutter (5) has a V-shaped shear angle (30) of punch from 100 degree to 125 degree.

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13. A punch cutter (5) as claimed in Claim 11 wherein said punch cutter (5) has two or more V-shaped shear angles (30) of punch.

20 14. A punch cutter (5) as claimed in Claim 11 wherein said punch cutter (5) has a radius (21) for better tool life and cutting condition.

15. A punch cutter (5) as claimed in Claim 11 wherein said punch cutter (5) has a very small cutting clearance of 0.002 – 0.003 mm/side.

25 16. A process for punch cutting a slot hole (140) in an unit of circuitized organic substrate (105), using a improved punch cutting tool (120) of Claim 1, together with a top die shoe (100), lower die shoe (102) both of which are guided by a high precision ball bearing guide pillar (109), the said process comprising the following steps:-

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loading the plurality of units of a circuitized organic substrate (105) to be punch cut onto the punch cutting assembly (130);

35 applying a stripper insert (104) cum stepper (8) onto the upper surface area of the circuitized organic substrate (105);

placing the stripper insert (104) so that it is placed slightly above the core substrate material (3) and beyond the profile of a slot hole (140) of core substrate material (3) to be punch cut;

5 placing said stepper (8) of the stripper insert (104) cum stepper (8) onto the upper surface of the circuitized organic substrate (105) so that it lightly touches an area of the core substrate material (3) surrounding the perimeter of a profile of the slot hole (140) to be punch cut;

10 the stepper (8) lightly touching the bonding fingers (1) and a contact area (20), the contact area (20) being ± 0.05 mm wide of the surface of the core substrate material (3) surrounding a perimeter of the slot hole (140) to be punch cut;

15 setting the height of the stripper insert (104) cum stepper (8) to an accuracy of ± 0.005 mm by the precision ground mechanical stopper (200) such that the stepper (8) just lightly touches the tips of the bonding fingers (1) and contact area (20) in the core substrate material (3);

20 punch cutter (5) applied downwards onto the area of the slot hole (140) to be punch cut; and

the profile of the punch cutter (5) matching the profile and dimensions of the slot hole (140) to be punch cut,

25 wherein the force of the impact will cause the circuitized organic substrate (105) to react to the force by edge rolling over and the bonding fingers (1) to lift up, but with the stripper insert (104) cum stepper (8) effectively pressing onto the core substrate material (3) and bonding fingers (1), the circuitized organic
30 substrate (105) is held down by the stripper insert (104) cum stepper (8), thereby avoiding much reactive movement, and consequently avoiding damage such as hair line crack (10), burr (11) and chipping to the circuitized organic substrate (105).

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