

A SYSTEM, PROCESS AND A JIG FOR FORMING CONFORMAL EMI SHIELD ON PACKAGE-LEVEL ELECTRONICS OR A PORTION THEREOF

FIELD OF INVENTION

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The invention relates to the formation of a conformal electromagnetic interference shield on package-level electronics. More particularly, the invention relates to a system and process having a jig which facilitates this formation.

10 BACKGROUND OF THE INVENTION

Electromagnetic Interference (EMI) refers to a natural phenomenon where electromagnetic radiation interferes with the intended operation of electronic circuitry through electromagnetic induction, electrostatic coupling, or conduction. Current trends for electronic circuitry are becoming more advanced, with them having higher clock frequencies and fast edge rates in a form of a miniaturized electronic package. However, such packages emit some form of electromagnetic radiation and inevitably becomes a source of man-made electronic interference. In a densely packed printed circuit board (PCB) having multiple electronic packages of different functionalities, there will be electromagnetic interference due to the interactions between each of the electronic packages, which leads to faults in circuit board's intended operation.

Rudimentary methods to resolve the electromagnetic interference between each of the electronic packages typically involve the use of an external shield housing, which covers the electronic packages to prevent it from emitting or being affected by electromagnetic radiation based on the concepts of the Faraday Cage. Even so, the inclusion of external shield housing on a PCB makes it bulkier and heavier, making it an unviable EMI shielding option for PCBs with a small form factor.

To resolve this problem, instead of an external shielding box, the encapsulation mould

portions of an electronic package is coated with one or more layers of conductive metal, referred to as a conformal EMI shield. This is done through physical vapour deposition, which can be carried out through a sputtering process. In the sputtering process, a target material (which is the aforementioned conductive metal) is bombarded with energetic ions, which causes the atoms of the target material to be “knocked off”. These freed atoms from the target material then travel to the electronic package and are deposited at its encapsulation mould portions. The sputtering process provides a uniform layer of deposited metal, while also having a high rate of scalability.

- 10 However, when the target material is being deposited on the electronic package, due to the conversion from kinetic energy to thermal energy, the electronic package itself may experience heating. If this heat is not properly dissipated during the sputtering process, it may lead to outgassing which deforms the formation of the conformal EMI shield, or worse, may lead to failure of the electronic component due to its thermal tolerance being exceeded. Therefore, there is a need for a solution, preferably in the form of an apparatus included during the formation of the conformal EMI shield, which resolves this problem of thermal management during the sputtering process.

There are a few patented technologies over the prior art relates to the formation of a conformal EMI shield on an electronic package. Among them is CN110047826A, which discloses provides a kind of semiconductor package and its manufacturing methods that includes shielding multiple sides of the package. It also discloses a kind of jig for supporting the packages and facilitates the process of applying a conformal EMI shield on an electronic package, which includes the sputtering process. The jig covers the contacts of the semiconductor package so that they do not get sputtered with the EMI shield layer.

Another such patented technology is US7964938B2, which discloses the manufacture of a semiconductor package having a function of shielding EMI which includes a jig.

The jig is used in a plasma sputtering, wherein a nickel alloy is coated on the surface of a semiconductor package by a sputtering method to form a conformal EMI shield.

Yet another patented technology is CN103576602 (A), which discloses a kind of jig for
5 applying a conformal EMI shield on an electronic package. The jig has two parts, a frame for securing the electronic package and a base. The formation of a conformal EMI shield is done through sputtering.

While the aforementioned prior arts relate to the formation of a conformal EMI shield
10 on an electronic package, they fail to disclose means to address the problem of thermal management during the sputtering process. Accordingly, it would be desirable to have a system and process for the formation of a conformal EMI shield on an electronic package, which includes a jig which facilitates this formation by providing thermal management during the sputtering process.

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SUMMARY OF INVENTION

The main objective of the invention is to provide an apparatus that facilitates thermal management during the sputtering process for forming an electronic interference (EMI)
20 shield. To achieve this objective, there is a jig having an arcuate surface and having one or more securing means. Prior to the sputtering process, the electronic packages are laid on a tray. This tray would then be secured on top of the jig through the securing means. The combinative configuration of the arcuate surface and the securing means ensures continuous contact between the electronic packages and the jig so that heat can be
25 dissipated from the electronic packages to the jig during the sputtering process.

Advantageously, the continuous contact between the electronic packages and the jig reduces the occurrence of outgassing during the sputtering process, and this ensures consistent sputtered deposition of the conformal EMI shield. Moreover, as this

continuous contact also allows for heat dissipation, the thermal tolerance of the electronic components will not be exceeded, and therefore this reduces failure of the electronic components due to poor thermal management during the sputtering process.

- 5 The invention intends to provide a jig for supporting at least one singulated electronic package during a sputtering process where a conformal electromagnetic interference shield is formed on the singulated electronic packages, the jig comprising a body having an arcuate surface on which the singulated electronic packages are received. The arcuate surface allows substantially continuous contact between the jig and the
10 singulated electronic package.

Preferably, the jig further comprises securing means to hold the singulated electronic package on the arcuate surface, the securing means including a plurality of embedded magnets located adjacent to the body of the jig. Preferably as well, the arcuate surface
15 of the jig is a raised paraboloid.

The invention also intends to provide a system, for forming a conformal electromagnetic interference shield on at least one singulated electronic package, comprising a tray preparation module which prepares a tray by mounting an electromagnetic interference tape onto a frame, with the electromagnetic interference
20 tape covering the entirety of the frame, a pick and place module for placing at least one singulated electronic packages onto the tray, a jig for supporting the tray having the singulated electronic packages which comprise a body having an arcuate surface, and a sputtering machine which forms a conformal electromagnetic interference shield on the singulated electronic packages through a sputtering process. The arcuate surface of the
25 jig allows substantially continuous contact between the jig and the singulated electronic package.

Preferably, the jig of the system further comprises a securing means is provided to hold the tray, which has the singulated electronic packages, on the arcuate surface, the

securing means comprising a plurality of embedded magnets located adjacent to the body of the jig.

Preferably, the system further comprises a pre-tape mounting module for laminating a pre-tape to cover the exposed contacts of a pre-singulated electronic package.

Preferably, the pick and place module of the system places the singulated electronic packages on the tray with the pre-tape of the singulated electronic packages in contact with the electromagnetic interference tape.

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Preferably, the system further comprises a pressure roller module that firmly secures the singulated electronic packages on the tray by applying pressure across the x-direction and the y-direction.

15 Preferably, the system further comprises a robot arm that passes the tray from the pick and place module onto the jig, passes the jig together with the tray into and out from the sputtering machine, or a combination thereof.

The invention also intends to provide a method, for forming a conformal electromagnetic interference shield on at least one singulated electronic package comprising the steps of preparing a tray by mounting an electromagnetic interference tape onto a frame, disposing at least one singulated electronic packages onto the tray, supporting the tray using a jig having an arcuate surface; and forming a conformal electromagnetic interference shield on at least one singulated electronic package on the tray through a sputtering process. The arcuate surface of the jig allows substantially continuous contact between the jig and the singulated electronic package.

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Preferably, the method further comprises the step of securing the singulated electronic packages on the tray by applying pressure across the x-direction and the y-direction,

using a pressure roller module.

Preferably, the method further comprises the step of detaching the singulated electronic packages from the tray after the completion of the sputtering process.

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One skilled in the art will readily appreciate that the invention is well adapted to carry out the objects and obtain the ends and advantages mentioned, as well as those inherent therein. The embodiments described herein are not intended as limitations on the scope of the invention.

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BRIEF DESCRIPTION OF THE DRAWINGS

To facilitate an understanding of the invention, there is illustrated in the accompanying drawing the preferred embodiments from an inspection of which when considered in connection with the following description, the invention, its construction and operation and many of its advantages would be readily understood and appreciated.

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FIG. 1 is a diagram illustrating the top view of the jig of the present invention.

20 **FIG. 2a** is a diagram illustrating a side view of the jig of the present invention when viewed from the top or bottom.

FIG. 2b is a diagram illustrating a side view of the jig of the present invention when viewed from the left or right.

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FIG. 3a is a diagram illustrating tray where the electronic packages will be laid upon.

FIG. 3b is a diagram illustrating tray where the electronic packages laid upon.

FIG. 4 is a diagram illustrating the cross-sectional view of the instance where the tray is placed on top of the jig.

FIG. 5 is a diagram illustrating the process flow chart where an EMI conformal shield is formed on one or more electronic packages.

DETAILED DESCRIPTION OF THE INVENTION

The present invention relates to the formation of a conformal electromagnetic interference (EMI) shield on package-level electronics. More particularly, the invention relates to a system and process having a jig which facilitates this formation. The invention may also be presented in a number of different embodiments with common elements. According to the concept of the invention, the jig comprises a body having an arcuate surface with one or more securing means.

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The invention will now be described in greater detail, by way of example, with reference to the drawings.

FIG. 1 illustrates the top view of the jig **100** of the present invention to be used in the sputtering process. **FIG. 2a** and **FIG. 2b** both illustrate the side views of the jig **100**, which shows its arcuate surface **101**. **FIG. 3a** illustrates the tray **200**, while **FIG. 3b** illustrates it with one or more singulated electronic packages **300** are laid upon prior to the sputtering process. The singulated electronic packages **300** in this context refers to Surface Mount Technologies (SMT) such as, but will not be limited to, Land Grid Array (LGA) packages, Ball Grid Array (BGA) packages and the likes. Fundamentally, each of these singulated electronic packages **300** have at least an encapsulation mould or an insulation layer which protects the integrated circuitry within it.

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In the present embodiment of the invention, the singulated electronic packages **300**

originate from a wafer-level packaging process flow. In such a process, a silicon wafer containing the integrated circuitry of the electronic packages is packaged using an encapsulation mould prior to dicing. Preferably, after the silicon wafer is packaged with the encapsulation mould, it is mounted in its entirety with a pre-tape to seal its metal
 5 contacts. This is to prevent the contacts from being exposed to sputter material or be contaminated by the back spill of sputter material during the sputtering process later. The pre-tape **301** is mounted using a pre-tape mounting module, and is preferably comprised of a Polyethylene Terephthalate (PET) release liner layer, a heat-activated adhesive layer and a polyimide film layer. Upon mounting of the pre-tape **301**, the
 10 dicing process is done so that at least one singulated electronic package **300** is produced.

The tray **200**, shown in **FIG. 3a**, comprises a frame **201**, preferably made of ferromagnetic material, and is shaped similarly to a quadrilateral annulus. One surface of the frame **201** is taped entirely with EMI tape **202**. The adhesive portion of the EMI
 15 tape **202** is exposed on the other surface through the hole of the frame **201**, thus forming the tray **200**. The EMI tape **202** preferably comprises a PET release liner layer, a silicon adhesive layer and a polyimide film layer. The tray **200** is then loaded with the electronic packages **300** using a pick-and-place machine. The pick-and-place machine picks each of the singulated electronic packages **300**, flips it, and places them on the
 20 tray **200**. This is so that the encapsulation mould of the electronic package **300** faces upwards, while the pre-tape **301** layer on the electronic package **300** faces downwards to be adjacent to the EMI tape **202**. This results in the loaded tray **200** as per **FIG. 3b**.

As shown in **FIG. 1**, **FIG. 2a** and **FIG. 2b**, the jig **100** preferably has a cuboidal body
 25 having an arcuate surface **101**. Additionally, the jig **100** may further comprise a plurality of embedded magnets **102**, which are the securing means for securing the loaded tray **200** when it is mounted on top of the jig **100**. These embedded magnets **102** are located adjacent away from the sides of the jig **100**. When the loaded tray **200** is mounted on top, the frame **201** of the loaded tray **200** is vertically adjacent to the embedded magnets

102. Hence, the embedded magnets **102** will magnetically attract the frame **201** of the tray **200** so that the tray **200** is secured in place on the jig **100**. The means to secure the loaded tray **200** on the jig **100** need not be limited to the use of magnets. Other devices such as clamps may also be used, wherein it clamps the frame **201** of the tray **200** to the jig **100** to secure it in position. Finally, the cylindrical indented portions on the sides of the jig **100** as seen in **FIG. 1**, **FIG. 2a** and **FIG. 2b** facilitate the transport of the jig **100** to and fro the sputtering chamber, preferably by using a robot arm.

FIG. 4 illustrates the result when the loaded tray **200**, having the singulated electronic components **300**, is placed on the jig **100**. Presenting **FIG. 4** in a cross-sectional manner properly shows the intended outcome from this combinative configuration. As seen, the frame **201** of the tray **200** is secured in place by the embedded magnets **102** of the jig **100** through magnetic attraction. By doing so, the EMI tape **202** portion of the tray **200** is slightly stretched and it bulges upwards due to the arcuate surface **101** of the jig **100**, which is preferably the shape of a raised paraboloid. As a result, continuous contact is formed between each of the electronic package **300** and the jig **100**. During the sputtering process for the formation of the EMI conformal shield, sputter material is deposited onto the encapsulation mould portion of the electronic package **300**. Thermal energy produced from this process is dissipated from the electronic package **300** to the jig **100**. The thermal dissipation is further enhanced by the polyimide film present in both the pre-tape **301** and EMI tape **202** as it is a good thermal conductor. Thus, thermal energy is transferred away from the electronic package **300** through conduction.

It should be noted that the body of the jig **100** need not be cuboidal, and the tray **200** also need not be in the shape of a quadrilateral as seen in the **FIG. 1** to **FIG. 3b**. Alternatively, the body of the jig **100** may be cylindrical, and the tray **200** may be circular in shape by having the frame **201** to be in the shape of an annulus. Moreover, the arcuate surface **101** of the jig **100** need not be limited to a paraboloid, and ideally can be any form of extruded surface that will make the EMI tape **202** bulge upwards in

a taut manner as seen in **FIG. 4** when the tray **200** loaded with the electronic packages **300** is placed on the jig **100**. Additionally, the layers of the pre-tape **301** and EMI tape **202** used need not be limited to what has been described previously, and may be comprised of other type of tapes with good thermal conductivity properties such as
5 Kapton tape, Upilex® or the likes.

The process flow chart where an EMI conformal shield is formed on one or more electronic packages **300** using the jig **100** is illustrated in **FIG. 5**.

10 The process flow chart starts with step **501**, which is part of the wafer-level packaging process, wherein the encapsulation mould has been formed on top of the wafer to form the pre-singulated electronic package. The metal contacts of the pre-singulated electronic package are covered by taping them with pre-tape **301**. Following this, in step **502**, the pre-singulated electronic package goes through a dicing process so that it
15 becomes a plurality of singulated electronic packages **300**. With this, the steps which cover the wafer-level packaging process portion is completed.

The tray **200** is then prepared in step **503**. The preparation of the tray **200** follows similarly with what was described above, with a frame **201** being taped with EMI tape
20 **202**. Upon the completing the tray **200**, the following step, step **504**, is done, where the singulated electronic packages **300** are individually picked up, flipped and laid upon the tray **200** using a pick and place machine. Flipping of the singulated electronic packages **300** is required so that the encapsulation mould of the electronic package **300** faces upwards, while the pre-tape **301** layer on the electronic package **300** faces
25 downwards to be adjacent to the EMI tape **202**. This results in the loaded tray **200** as previously seen in **FIG. 3b**.

Following this, step **505** is done where the singulated electronic packages **300** are secured on the tray **200** using a pressure roller module. The pressure roller module

applies pressure across the x-direction and the y-direction of the loaded tray **200**. This may be done through rotating the tray **200** by 90°, after the first roll, or by rotating the roller by 90° after the first roll. After this, the loaded tray **200** is now ready to be placed on the jig **100** to undergo the sputtering process.

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As the loaded tray **200** is placed on the jig **100** as per step **506**, they become configuratively similar to what was shown in **FIG. 4**. The next step would be step **507**, where the loaded tray **200** and the jig **100** are loaded into the chamber of a sputtering machine, for the sputtering process of step **508**. During step **508**, preferably, 3 layers of metal are deposited onto the encapsulation mould of each singulated electronic package **300** to form the conformal EMI shield. These layers correspond to the conventional SuS-CU-SuS layer buildup, with the first seed layer being the stainless steel, the second bulk layer being pure copper, and the final finisher layer being stainless steel. During the sputtering process of step **508**, the electronic packages **300** may be heated up to due to the metal layers being deposited of the on them. The continuous contact between the electronic package **300** and jig **100** will contribute in dissipating this heat, or thermal energy, away from the electronic package **300** to jig **100** through conduction, thus ensuring the temperature of the electronic packages **300** stays within the limits of thermal tolerance. This also reduces the occurrence of outgassing, which may deform the conformal EMI shield layer which is being formed on the encapsulation mould portion of the electronic package **300**.

Upon the completion of the sputtering process, the jig **100** together with the tray **200** are unloaded from the sputtering chamber as per step **509**, and is left in room temperature to cool down. After that would be step **510**, where the loaded tray **200**, containing the electronic packages **300**, is detached from the jig **100**, and the jig **100** can then be reused for the following incoming loaded trays **200**. The final step is step **511**, where the electronic packages **300**, now having the conformal EMI shield layer, are then removed from the loaded tray **200** for a further quality inspection process. The

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EMI tape **202** is disposed of so the electronic packages **300** may be removed. With this, the formation of a conformal EMI shield on the electronic packages **300** is described completely.

- 5 Ultimately, the inclusion of the jig **100** in the system and method for the formation of conformal EMI shielding ensures continuous contact between the electronic packages **300** and the jig **100**. Thus, this reduces the occurrence of outgassing during the sputtering process to ensure consistent sputtered deposition of the conformal EMI shield. Moreover, as this continuous contact also allows for heat dissipation, the thermal
10 tolerance of the electronic packages **300** will not be exceeded, and therefore this reduces failure of the electronic packages **300** due to poor thermal management during the sputtering process.

The present disclosure includes as contained in the appended claims, as well as that of
15 the foregoing description. Although this invention has been described in its preferred form with a degree of particularity, it is understood that the present disclosure of the preferred form has been made only by way of example and that numerous changes in the details of construction and the combination and arrangements of parts may be resorted to without departing from the scope of the invention.

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CLAIMS

1. A jig (100) for supporting at least one singulated electronic package (300) during a sputtering process where a conformal electromagnetic interference shield is formed on the singulated electronic packages (300), the jig (100) comprising
- 5 a body having an arcuate surface (101) on which the singulated electronic packages (300) are received;
- wherein the arcuate surface (101) allows substantially continuous contact between the jig (100) and the singulated electronic package (300).
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2. The jig (100) according to claim 1, further comprising a securing means to hold the singulated electronic package (300) on the arcuate surface (101), the securing means including a plurality of embedded magnets (102) located adjacent to the body of the jig (100).
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3. The jig (100) according to claim 1 or claim 2, wherein the arcuate surface (101) is a raised paraboloid.
4. A system for forming a conformal electromagnetic interference shield on at least one singulated electronic package (300), comprising
- 20 a tray preparation module which prepares a tray (200) by mounting an electromagnetic interference tape (202) onto a frame (201), with the electromagnetic interference tape (202) covering the entirety of the frame (201);
- a pick and place module for placing at least one singulated electronic packages (300) onto the tray (200);
- 25 a jig (100) for supporting the tray (200) having the singulated electronic packages (300), comprising a body having an arcuate surface (101); and
- a sputtering machine which forms a conformal electromagnetic interference shield onto the singulated electronic packages (300) through a sputtering process;

wherein the arcuate surface (101) of the jig (100) allows substantially continuous contact between the jig (100) and the singulated electronic package (300).

- 5 5. The system according to claim 4, wherein the jig (100) further comprises a securing means is provided to hold the tray (200), which has the singulated electronic packages (300), on the arcuate surface (101), the securing means comprising a plurality of embedded magnets (102) located adjacent to the body of the jig (100).
- 10 6. The system according to claim 4 or claim 5, wherein the system further comprises a pre-tape mounting module for laminating a pre-tape (301) to cover the exposed contacts of a pre-singulated electronic package.
- 15 7. The system according to any one of claims 4 to 6, wherein the pick and place module places the singulated electronic packages (300) on the tray (200) with the pre-tape (301) of the singulated electronic packages (300) in contact with the electromagnetic interference tape (202).
- 20 8. The system according to any one of claims 4 to 7, wherein the system further comprises a pressure roller module that firmly secures the singulated electronic packages (300) on the tray (200) by applying pressure across the x-direction and the y-direction.
- 25 9. The system according to any one of claims 4 to 8, wherein the system further comprises a robot arm that passes the tray (200) from the pick and place module onto the jig (100), passes the jig (100) together with the tray (200) into and out from the sputtering machine, or a combination thereof.
10. A method for forming a conformal electromagnetic interference shield on at least one singulated electronic package (300) according to claim 4, comprising the steps of

preparing a tray (200) by mounting an electromagnetic interference tape (202) onto a frame (201);

disposing at least one singulated electronic packages (300) onto the tray (200);

supporting the tray (200) using a jig (100) having an arcuate surface (101); and

5 forming a conformal electromagnetic interference shield on at least one singulated electronic package (300) on the tray (200) through a sputtering process;

wherein the arcuate surface (101) of the jig (100) allows substantially continuous contact between the jig (100) and the singulated electronic package (300).

10 11. The method according to claim 10, wherein the method further comprises the step of securing the singulated electronic packages (300) on the tray (200) by applying pressure across the x-direction and the y-direction, using a pressure roller module.

12. The method according to claims 10 or 11, wherein the method further comprises the
15 step of detaching the singulated electronic packages (300) from the tray (200) after the completion of the sputtering process.

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