Parylene Coated Machining Tools for Ball Mounting Process

Field of the Invention

[0001] The present invention relates to ball mounting process for ball grid array (BGA). In particular, the invention relates to a polymer coating of machining tools for ball mounting process.

Background

[0002] In the present complex and competitive business world, precisions and efficiency is becoming more demanding in all manufacturing process. In a semiconductor manufacturing processes, in particular, a ball mounting process of ball grid array (BGA) chip, solder balls placement's precision and performance significantly affect the overall throughput of manufacturing process.

[0003] It is known that many factors contribute to the overall performance of the ball mounting process. These factors include quality of solder balls and solder flux. Solder balls with inferior spherical accuracy usually affect pick-up efficiency by the ball tool. The imperfect spherical condition of solder balls often causes the poor pick-up efficiency via the vacuum suction. On the other hand, viscosity of the solder flux affects the volume accuracy of the flux to be applied on the substrate. However, the quality of the two factors is ultimately dependent on the source of supplies of the solder balls and flux. Extra efforts are required to ensure the quality meets the ball mounting process.

Summary

[0004] In accordance with one aspect of the present invention, there is provided a ball mounting apparatus for ball mounting process of ball grid array (BGA) chip, the ball mounting apparatus comprises a pin tool for picking up solder flux and dipping onto pre-determined positions on a substrate for mounting the BGA chip; a template having a plurality of holes/depressions oriented in correspond to the pre-determined positions, wherein each hole/depression is adapted to hold one solder ball in place; and a ball tool having a suction plate for picking up the solder balls from the parylene coated template via vacuum suction, wherein the ball tool is operable to place the solder balls over the solder flux on the substrate. Either the template or the suction plate or both are coated with a layer of parylene coating on at least a surface thereon, thereby reduces solder flux stickiness to surface of the parylene coated template or suction plate or both.

[0005] In one embodiment, the parylene coating is coated on the template and/or the suction plate entirely.

[0006] In another embodiment, the suction plate is made by graphite with potholes defined thereon.

[0007] The ball mounting apparatus according to claim 1, wherein the template and/or the suction plate is made by brass.

[0008] In a further embodiment, the layer of parylene is coated by the steps of providing the template and/or the suction plate in a deposition unit; loading a dimer in a vaporizer; vaporizing the dimer; pyrolyzing the vaporized dimer; depositing monomer to form a layer of coating on the template and/or the suction plate; and controlling timing of the deposition.

[0009] In another aspect, there is provided a ball mounting method for ball grid array (BGA) chip, the method comprises picking up solder flux; dipping the solder flux onto predetermined position on a substrate for mounting the BGA chip; putting solder balls in placed on a template having a plurality of holes/depressions oriented in correspond to the pre-determined positions; picking up the solder balls from the parylene coated template via a suction plate; and mounting the solder balls over the solder flux on the substrate.

[0010] In yet another aspect, there is provided a template for ball mounting process of a ball mounting apparatus. The template comprises a plurality of holes/depressions defining on a surface of the template; and a layer of parylene coating coated on at least the surface of the template.

[0011] In a further aspect, there is provided a suction plate for ball mounting process of a ball mounting apparatus. The suction plate comprises a plurality of holes/depressions defining on a surface of the suction plate; and a layer of parylene coating coated on at least the surface of the suction plate.

[0012] In one embodiment, the parylene coating is coated on the suction plate entirely. The suction plate may be made by graphite.

[0013] The holes/depressions defined on the template and the suction plate are arrange at pre-determined positions that correspond to the locations where solder balls are required on the BGA, wherein each hole/depression is adapted to hold one solder ball in place.

Brief Description of the Drawings

[0014] This invention will be described by way of non-limiting embodiments of the present invention, with reference to the accompanying drawings, in which:

[0015] **FIG. 1** illustrates a schematic diagram of a deposition system in accordance with one embodiment of the present invention; and

[0016] **FIG. 2** illustrates a flow diagram of a deposition process in accordance with one embodiment of the present invention.

Detailed Description

[0017] In line with the above summary, the following description of a number of specific and alternative embodiments is provided to understand the inventive features of the present invention. It shall be apparent to one skilled in the art, however that this invention may be practiced without such specific details. Some of the details may not be described at length so as not to obscure the invention. For ease of reference, common reference numerals will be used throughout the figures when referring to the same or similar features common to the figures.

[0018] In one embodiment of the present invention, there is provided a ball mounting process for the Ball Grid Array (BGA). BGA uses solder balls arranged in grid form as a conducting medium for electrical signals between BGA chip and printed circuit board. A ball mounting apparatus is adapted to mount the solder chip through the ball mounting process. The ball mounting apparatus comprises a pin tool, a ball tool and a template for mounting solder balls onto a substrate. Operationally, the pin tool picks up solder flux and dip onto pre-determined grid positions on the substrate for each solder ball. The template comprises tiny holes/depressions oriented in correspond to the pre-determined grid positions for holding each solder ball in place. When the solder balls are freed from a ball tray as it moves along an axis of the template, the solders balls are held in place accordingly on the template. The ball tool incorporating a suction plate picks up the solder balls from the template via vacuum suction and places the balls over the solder flux on the substrate. The solder flux acts as bonding compound to hold the solder balls in their respective position. During operations, the

tendency of parts stained with the flux is high. It is unavoidable. Therefore, the contaminated parts are required to be cleaned frequently.

[0019] Depending on the specification of the BGA chip, the size of the solder balls may be in a range from 0.15mm to 0.76mm. In such configuration, the relevant template and suction plate have an average of 15,000 holes/depressions up to maximum of 40,000 holes/depressions with a smallest pitch distance of 0.4mm measured from a center of each hole/depression to the center of the adjacent holes/depressions. Typically, though not limited to, the templates and the suction plates are made by graphite for example, which is brittle and toxic. Graphite is formed by compress powder under high compression process which forms micro-potholes. These micro-potholes are often mistaken as the holes/depressions required for the ball mounting process. In most occasions, these potholes often cause damages to the solder balls as well as the BGA. Conventionally, such templates and suction plates are usually processed in an enclosed chamber.

[0020] The template and/or the suction plate are coated with a layer of parylene coating on at least the surface that comes into contact with the solder balls for reducing or eliminating solder flux stickiness to the template surface, which can sometime be undesirable due to poor flux quality. Undesirable stickiness would affect handling and positioning of the solder balls during the ball mounting process. Parylene coating process on such ball mounting apparatus significantly improve the overall handling of the ball mounting process.

[0021] For the parts that made up of graphite or brass, for example, the coating smoothen the surface and fills up the potholes, which in turn, improve ball mounting handling. The smoother surface further makes parts cleaning easier.

[0022] Besides, parylene coating also reduces or prevents moisture from affecting the material properties and function including wide range of plastic and meal. Among others, such coating helps to increase wear resistance, smoothen surface and protects the material property from being affected by moisture such as rust. The gaseous nature of deposition process allows parylene to penetrate and coat surfaces that are unreachable by liquid coatings, including sharp points, deep cavities and other hard to reach areas, which is particularly suitable for parts with the tiny micro-sized holes/depressions. Because the parylene process does not include a liquid phase, the coating does not pool in low areas, bridge across substrate features, or exhibit liquid properties such as meniscus or capillary action. Parylene film has low static and dynamic coefficient of friction, giving it dry film lubricity that can be valuable in some applications. A thin parylene film is a pure, polycrystalline and amorphous linear polymer distinguished by superior dielectric, gas barrier and mechanical properties, giving it the ability to meet coating requirements in very thin layers.

[0023] The nature of the film and its room temperature deposition process allows parylene to be used on many substrates, including ferrites, rubbers, silicone elastomers, paper, resins, plastics, silicon, metal and even on granular materials. Since parylene is highly effective in very thin coating, delicate substrates such as electronic sensors or diaphragms can be protected without any significant mechanical or leading effects.

[0024] Parylene coating does not cure in the conventional manner, substrate are not subjected to sheer stress, elevated temperatures or solvents. The automated parylene vacuum deposition coating process lends itself to precise quality control measures.

[0025] **FIG. 1** illustrates a schematic diagram of a deposition system **100** for depositing parylene onto a template **101** in accordance with one embodiment of the present invention. The deposition system **100** comprises a vaporizer **110**, a pyrolysis unit **120**, a deposition unit **130**, a trap **140**, and a vacuum pump **150**. The polymer deposition is performed in a vacuum environment created by the vacuum pump **150**. The trap **140** installed between the deposition unit **150** and the vacuum pump **140** provides adequate purging of precursors from the system while creating the vacuum environment. A dimer of polymer is loaded into the vaporizer **100**. The dimmer is then converted to a reactive vapor in the vaporizer **110** and sent to the pyrolysis unit **120** to cleave the dimer into monomer vapor. The monomer vapor is then passed to the deposition unit **120** for coating on the object loaded therein in a form of polymer. The deposition process is performed in a vacuum environment created by the vacuum pump **150**.

[0026] **FIG. 2** shows a flow diagram of a polymer deposition process in accordance with one embodiment of the present invention. The process will be described in conjunction with **FIG. 1.** In step **210**, the template **101** is loaded in the deposition unit **130**. In step **220**, a dimer of suitable coating material is loaded in the vaporizer **110**. The suitable coating material includes any coating material that has a

low permeability to moisture and corrosive gasses, such as parylene as described above. In step **230**, a vaporization process is performed for vaporizing the dimer at approximately 150°C, 1 Torr (or 1 mmHg) at the vaporizer **110**. In step **240**, a purolysis process (quantitative cleavage) is performed for pyrolyzing the dimer vapor at approximately 680°C, 0.5 Torr (or 0.5 mmHg) to form the monomer. The monomeric vapor enters deposition unit **130**, which is maintained in room temperature, and in step **250**, the vapor is spontaneously polymerized and deposited on the template **101**. In this step **250**, the thickness of the coating can be controlled within the deposition unit **130** by controlling the timing of deposition process. The deposition process step **230-250** is performed at a vacuum environment.

[0027] With the above deposition process, unlike vacuum metallizing, all sides of the template **101** are uniformly impinged with gaseous monomer and produced a conformal coating.

[0028] In another embodiment, the deposition process illustrated in **FIGs. 1** and **2** is used for depositing parylene onto a suction plate of the ball mounting apparatus.

[0029] Parylene is a generic name for members of a unique polymer series. The basic member of the polymer series is Parylene-N that is a completely linear and highly crystalline material. Parylene-C is a commercially available Parylene that is produced from the Parylene-N dimer modified by a substitution of chlorine atom for one of the aromatic hydrogen. Parylene-C has a useful combination of electrical and physical properties plus a very low permeability to moisture and corrosive gas. A non-limiting example of a parylene deposition system is PDS 2010 LABCOTER® 2.

[0030] The Parylene can be coated with the deposition system **100** and method as described in **FIGs. 1** and **2**. A dimer, in a form of powder is added to the system **100** and heated to 150°C, 1 Torr to change the dimer to vapor at the vaporizer **110**. The dimer molecule is further heated to around 680°C, 0.5 Torr to change the vapor molecule to monomer at the pyrolysis unit **120**. In the deposition unit **130**, the monomer is coated at room temperature in a form of transparent polymer film. The polymer film is a conformal layer and pinhole-free film coated on the subject substrate.

[0031] While specific embodiments have been described and illustrated, it is understood that many changes, modifications, variations and combinations thereof could be made to the present invention without departing from the scope of the invention.

Claims

1. A ball mounting apparatus for ball mounting process of ball grid array (BGA) chip, the ball mounting apparatus comprising:

a pin tool for picking up solder flux and dipping onto pre-determined positions on a substrate for mounting the BGA chip;

a template having a plurality of holes/depressions oriented in correspond to the pre-determined positions, wherein each hole/depression is adapted to hold one solder ball in place; and

a ball tool having a suction plate for picking up the solder balls from the parylene coated template via vacuum suction, wherein the ball tool is operable to place the solder balls over the solder flux on the substrate,

wherein either the template or the suction plate or both are coated with a layer of parylene coating on at least a surface thereon, thereby reduces solder flux stickiness to surface of the parylene coated template or suction plate or both.

2. The ball mounting apparatus according to claim 1, wherein the parylene coating is coated on the template or the suction plate entirely.

3. The ball mounting apparatus according to claim 1, wherein the template and/or the suction plate is made by graphite with potholes defined thereon.

4. The ball mounting apparatus according to claim 1, wherein the template and/or the suction plate is made by brass.

5. The ball mounting apparatus according to claim 1, wherein the layer of parylene is coated by the steps comprising:

providing the template and/or the suction plate in a deposition unit;

loading a dimer in a vaporizer;

vaporizing the dimer;

pyrolyzing the vaporized dimer;

depositing monomer to form a layer of coating on the template and/or the suction plate; and

controlling timing of the deposition.

6. A ball mounting method for ball grid array (BGA) chip, the method comprising:

picking up solder flux;

dipping the solder flux onto predetermined position on a substrate for mounting the BGA chip;

putting solder balls in placed on a template having a plurality of holes/depressions oriented in correspond to the pre-determined positions;

picking up the solder balls from the parylene coated template via a suction plate; and

mounting the solder balls over the solder flux on the substrate.

7. A template of a ball mounting apparatus, the template comprising:

a plurality of holes/depressions defining on a surface of the template; and

a layer of parylene coating coated on at least the surface of the template.

8. The template according to claim 7, wherein the parylene are coated on the template entirely.

9. A suction plate of a ball mounting apparatus, the suction plate comprising:

a plurality of holes/depressions defining on a surface of the suction plate; and

a layer of parylene coating coated on at least the surface of the suction plate.

10. The suction plate according to claim 9, wherein the parylene are coated on the suction plate entirely.