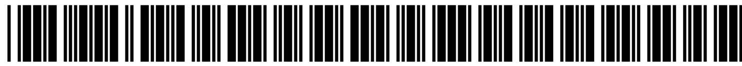
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(54) **FLIP-CHIP PACKAGE WITH THERMAL DISSIPATION LAYER**

(71) Applicant: **Intel IP Corporation**, Santa Clara, CA (US)

(72) Inventors: **Richard Patten**, Langquaid (DE); **Bernd Waidhas**, Pettendorf (DE); **Sonja Koller**, Regensburg (DE)

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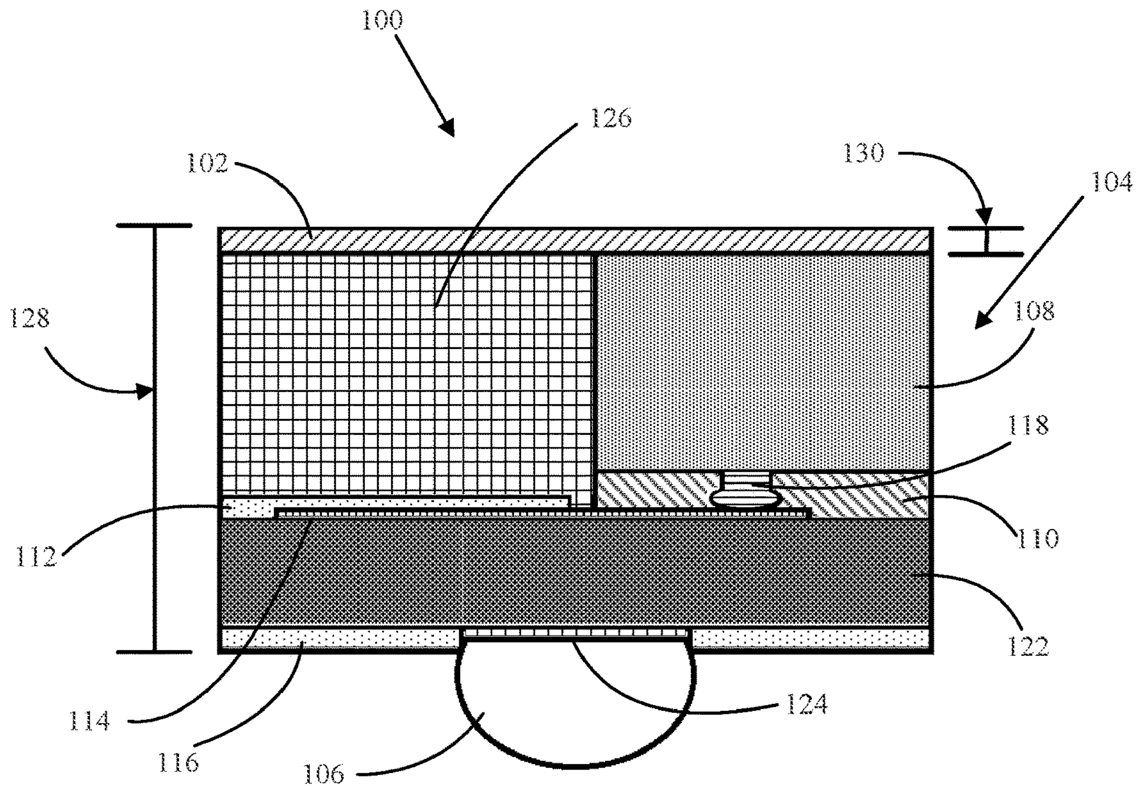
(57) **ABSTRACT**

Embodiments herein may relate to a flip-chip chip scale package (FCCSP) with a thermal dissipation layer to dissipate heat from the FCCSP during operation of the FCCSP. The thermal dissipation layer may be applied to a surface of the FCCSP through a sputter coating process and may operate as a heat spreader for the FCCSP. Other embodiments may be described and/or claimed.



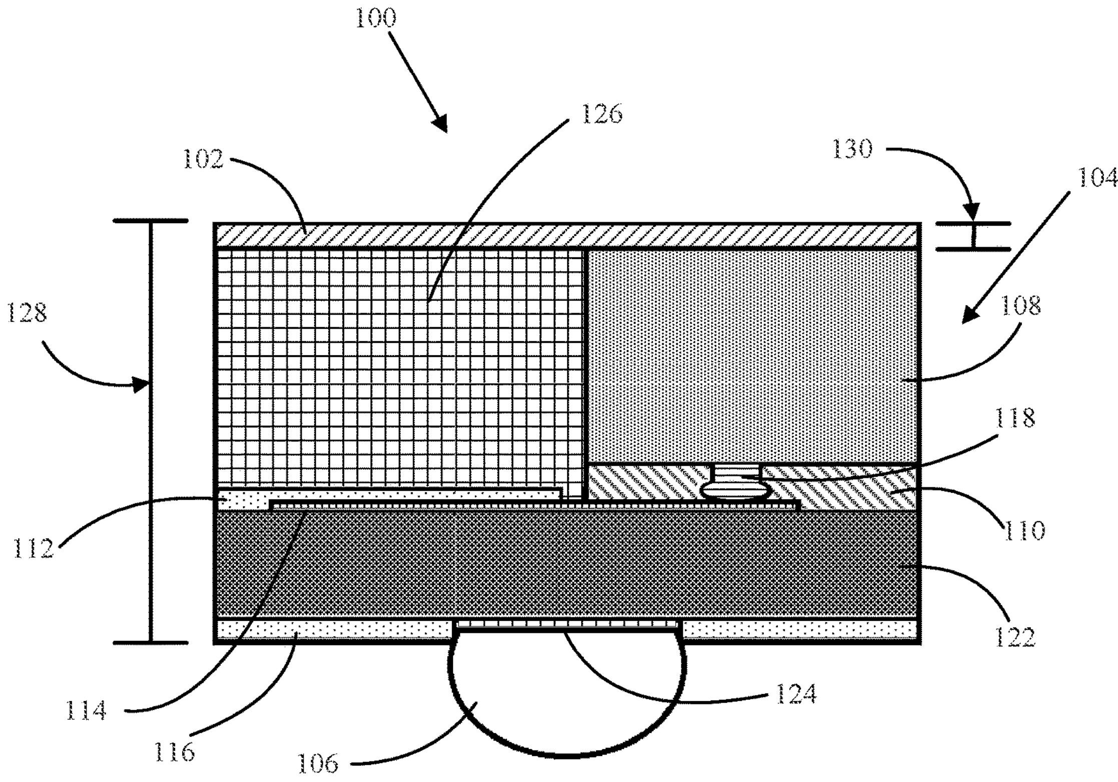


FIGURE 1

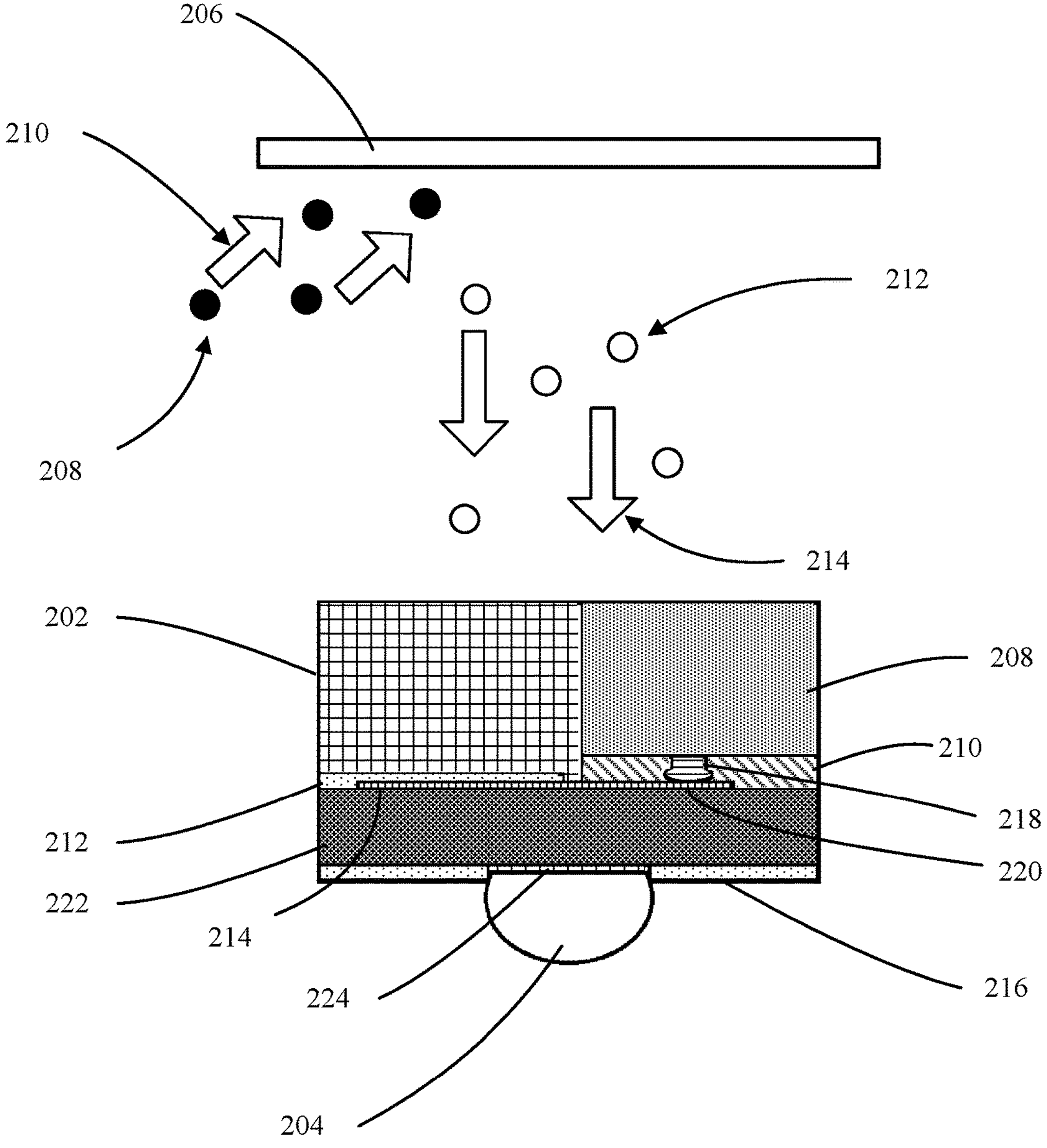


FIGURE 2

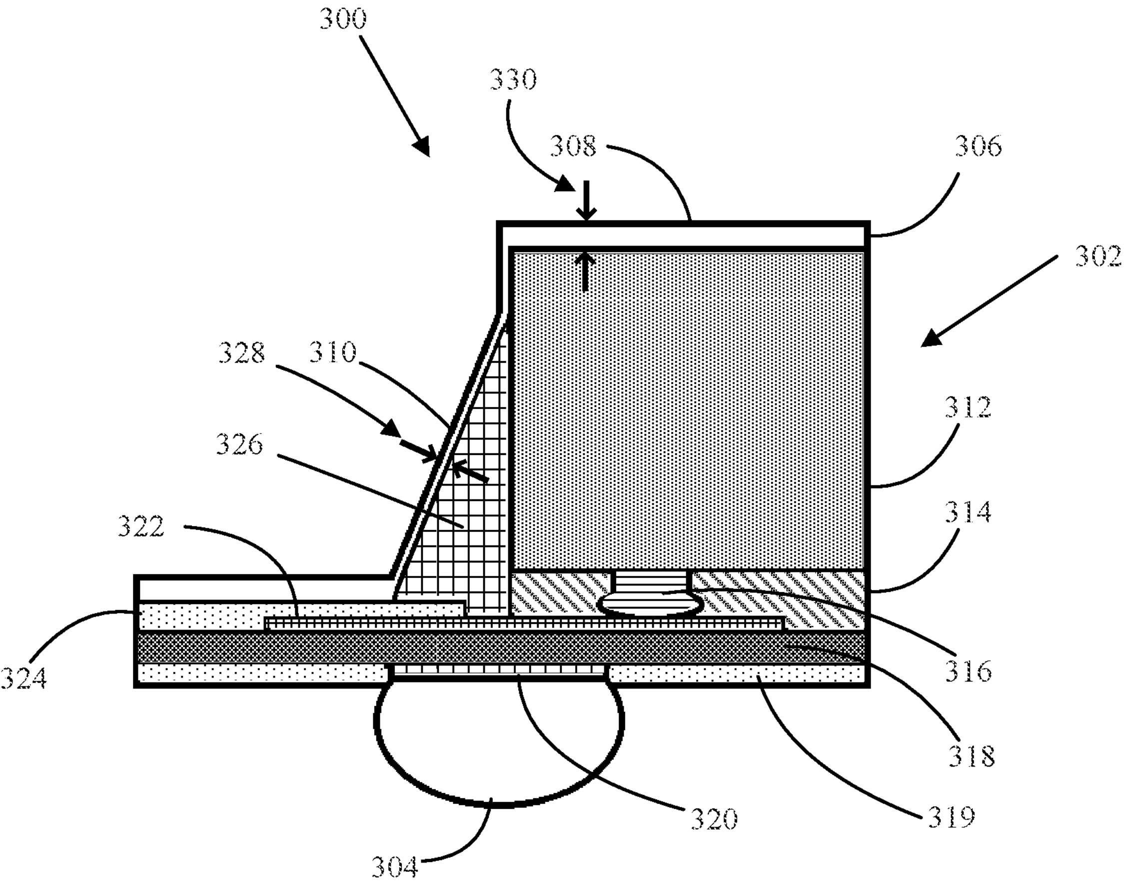


FIGURE 3

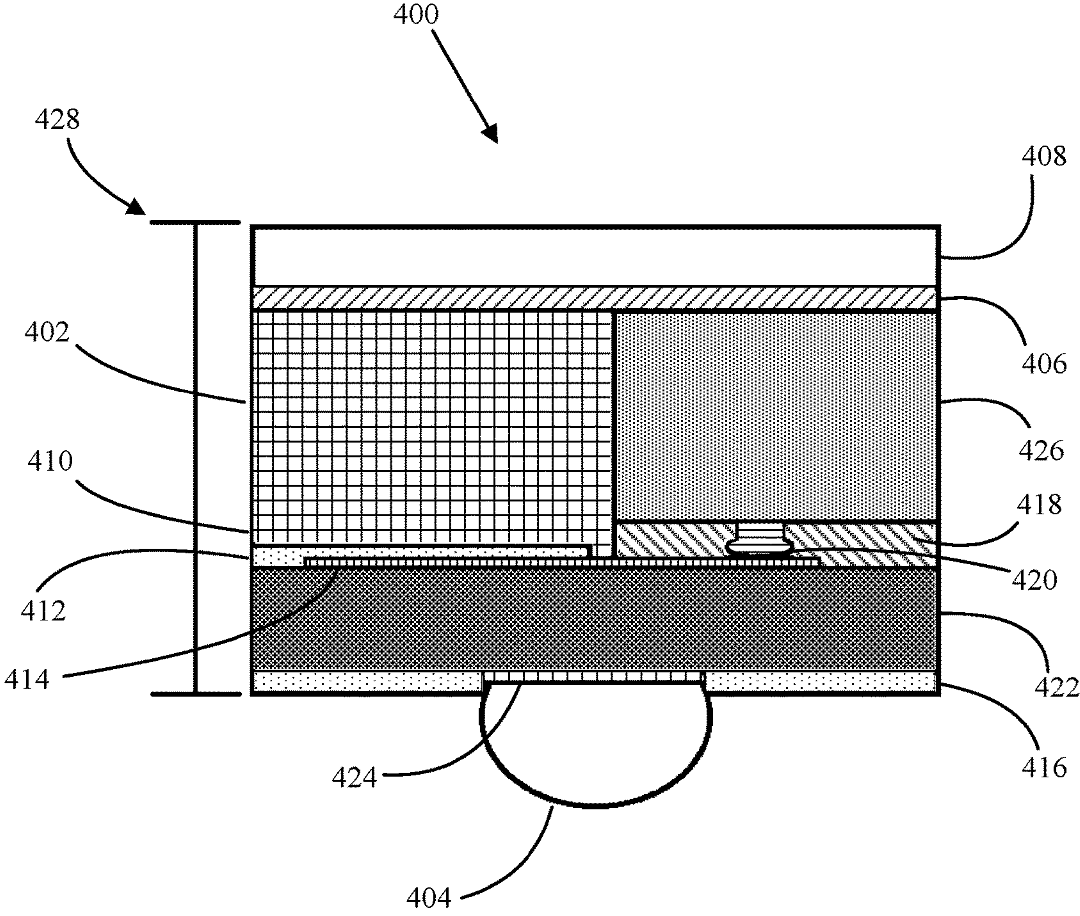


FIGURE 4

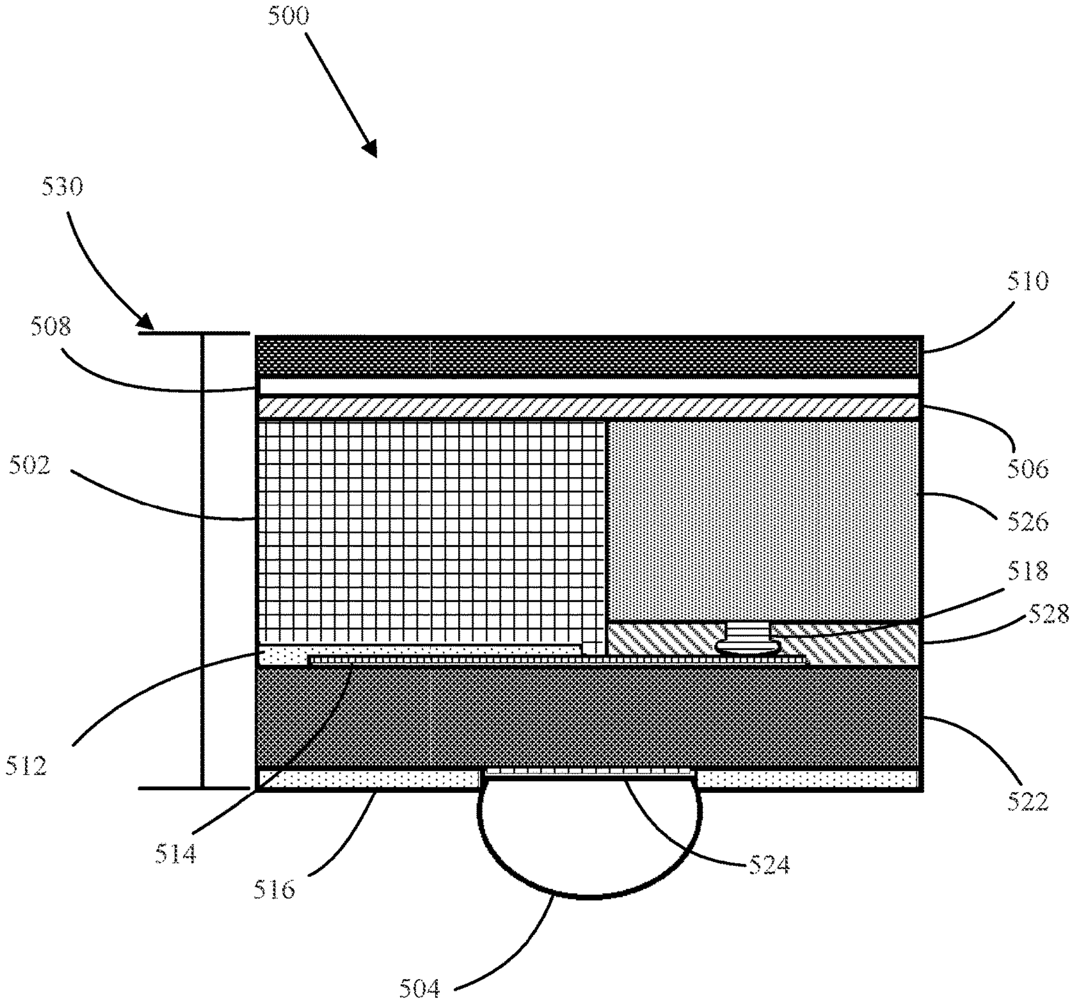


FIGURE 5

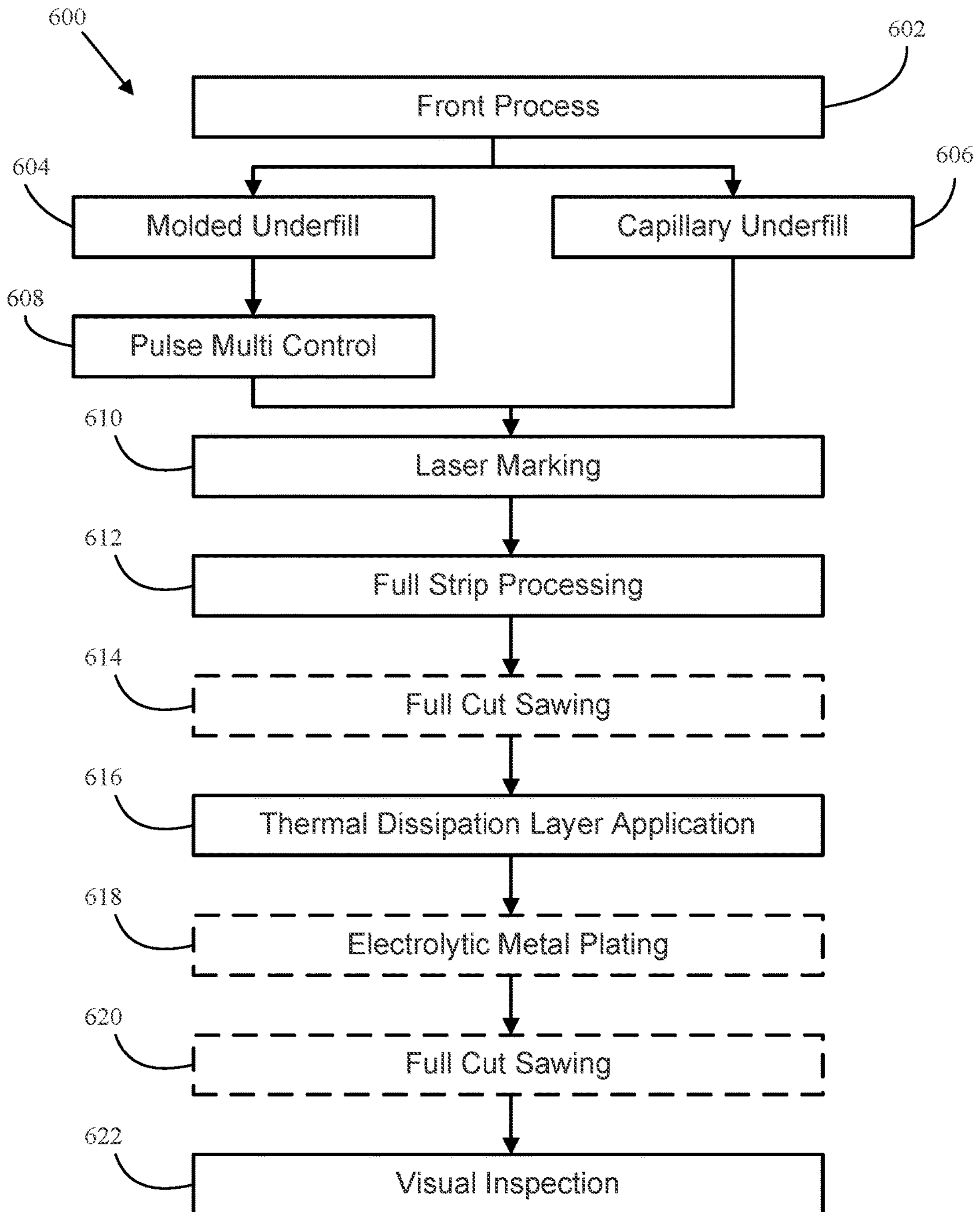


FIGURE 6

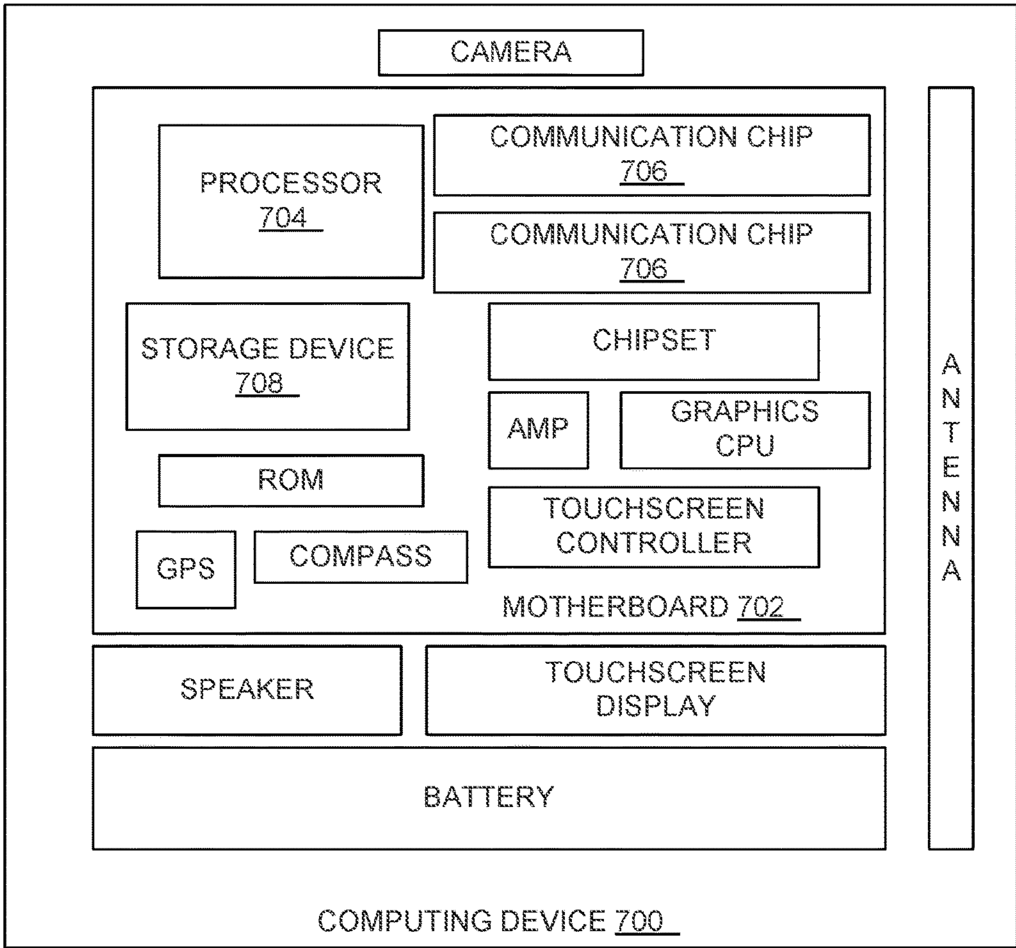


Figure 7

FLIP-CHIP PACKAGE WITH THERMAL DISSIPATION LAYER

TECHNICAL FIELD

[0001] The present disclosure relates generally to the field of flip-chip chip scale packages (FCCSPs), and more specifically to a flip-chip chip scale package with a thermal dissipation layer.

BACKGROUND

[0002] Legacy FCCSPs did not produce enough heat to require a heat spreader for dissipating heat. However, as the FCCSPs are reduced in size, the FCCSPs can generate enough heat to cause errors, failure of and/or damage to the FCCSP. In order to address these issues, it has become desirable to attach a heat spreader to the FCCSP. Legacy versions of heat spreaders for the FCCSPs include placing a contact metal slug on the FCCSP, although the process of attaching the contact metal slug is difficult and expensive, as well as increasing the overall thickness of the FCCSP.

BRIEF DESCRIPTION OF THE DRAWINGS

[0003] Embodiments will be readily understood by the following detailed description in conjunction with the accompanying drawings. To facilitate this description, like reference numerals designate like structural elements. Embodiments are illustrated by way of example, and not by way of limitation, in the figures of the accompanying drawings.

[0004] FIG. **1** is a cross-sectional view of a portion of an example FCCSP assembly that includes an FCCSP with a thermal dissipation layer, in accordance with various embodiments.

[0005] FIG. **2** is an example sputter coating process of applying the thermal dissipation layer to a portion of an FCCSP, in accordance with various embodiments.

[0006] FIG. **3** is a cross-sectional view of another portion of an example FCCSP assembly that includes an FCCSP with a thermal dissipation layer, in accordance with various embodiments.

[0007] FIG. **4** is a cross-sectional view of a portion of an example FCCSP assembly that includes an FCCSP with an electrolytic plating layer, in accordance with various embodiments.

[0008] FIG. **5** is a cross-sectional view of a portion of an example FCCSP assembly that includes an FCCSP with a flash coat layer and a protective layer, in accordance with various embodiments.

[0009] FIG. **6** is an example process for making an FCCSP assembly that includes an FCCSP with a thermal dissipation layer, in accordance with various embodiments.

[0010] FIG. **7** is an example computing device, in accordance with various embodiments.

DETAILED DESCRIPTION

[0011] Embodiments herein may relate to achieving desired heat dissipation of an FCCSP within a limited FCCSP thickness requirement by applying a thermal dissipation layer to a surface of the FCCSP. The thermal dissipation layer may be applied to the surface of the FCCSP through a sputter coating process or a polymer spray coating process, where the thermal dissipation layer provides adequate thermal dissipation while limiting an increase in the thickness of the FCCSP due to the thermal dissipation layer.

[0012] Legacy heat spreaders may have included a contact metal slug affixed to an FCCSP to dissipate heat created by the FCCSP during operation. However, the contact metal slug may have a relatively large thickness and, as a result, the total thickness of the contact metal slug and the FCCSP may be increased by a relatively large amount, such that the FCCSP may not fit within a desired installation location due to the thickness of the FCCSP. Embodiments herein may allow for application of a thermal dissipation layer that acts as a heat spreader with characteristics similar to legacy heat spreaders, although having a fraction of the thickness of the legacy heat spreaders.

[0013] In the following detailed description, reference is made to the accompanying drawings that form a part hereof, wherein like numerals designate like parts throughout, and in which is shown by way of illustration embodiments in which the subject matter of the present disclosure may be practiced. It is to be understood that other embodiments may be utilized and structural or logical changes may be made without departing from the scope of the present disclosure. Therefore, the following detailed description is not to be taken in a limiting sense, and the scope of embodiments is defined by the appended claims and their equivalents.

[0014] For the purposes of the present disclosure, the phrase “A and/or B” means (A), (B), or (A and B). For the purposes of the present disclosure, the phrase “A, B, and/or C” means (A), (B), (C), (A and B), (A and C), (B and C), or (A, B and C).

[0015] The description may use the phrases “in an embodiment,” “in some embodiments,” or “in embodiments,” which may each refer to one or more of the same or different embodiments. Furthermore, the terms “comprising,” “including,” “having,” and the like, as used with respect to embodiments of the present disclosure, are synonymous.

[0016] The term “coupled with,” along with its derivatives, may be used herein. “Coupled” may mean one or more of the following. “Coupled” may mean that two or more elements are in direct physical or electrical contact. However, “coupled” may also mean that two or more elements indirectly contact each other, but yet still cooperate or interact with each other, and may mean that one or more other elements are coupled or connected between the elements that are said to be coupled with each other.

[0017] FIG. **1** depicts a portion of an example flip-chip chip scale package (FCCSP) assembly **100** that includes an FCCSP **104** with a thermal dissipation layer **102**. The FCCSP **104** may include some type of flip-chip package design, including package designs produced through the use of a capillary underfill process, a molded underfill process, some other process, or some combination thereof. The FCCSP **104** may be designed and/or utilized for certain operations, such as broadband use or digital use.

[0018] The FCCSP **104** may be manufactured through some known manufacturing technique and/or process for producing a chip package. In examples, the process of producing the FCCSP **104** may include laser marking the FCCSP **104** prior to application of the thermal dissipation layer **102**. The laser marking may be utilized for identifying the FCCSP **104**, indicating characteristics of the FCCSP **104**, other elements that may be indicated by a laser mark-

ing, and/or some combination thereof. The laser marking applied to the FCCSP **104** may be visible through and/or on the thermal dissipation layer **102**. In examples, the FCCSP **104** and/or the thermal dissipation layer **102** may be marked after application of the thermal dissipation layer **102**, such as by using ink, laser marking, other known forms of marking chips, or some combination thereof.

[0019] The FCCSP **104** may include one or more components, substrates, layers, or some combination thereof. The FCCSP **104** may include a chip **108** abutted on a side by an underfill material **110**. The chip **108** may be electrically coupled to a substrate layer **122** by first level interconnects **118**. The substrate layer **122** may include one or more pre-preg layers, core layers, electrically conductive inner layers, via structures, or some combination thereof.

[0020] The first level interconnects **118** may extend through the underfill material **110** and may contact an electrically conductive trace **114**, the electrically conductive trace **114** at least partially located intermediate to underfill material **110** and the substrate layer **122**. Solder resist **116** may be affixed to a surface of the substrate layer **122**. Additionally, the FCCSP may include an encapsulation material **126** and a solder resist **112**, the solder resist located intermediate to the encapsulation material **126** and the electrically conductive trace **114**.

[0021] A solder ball **106** may be affixed to a surface of the FCCSP **104**. The surface of the FCCSP **104** to which the solder ball **106** is affixed may include thermally conductive traces and ball pads **124**. In some embodiments, the solder ball **106** may also be referred to as a solder "bump." Generally, as used herein, a solder ball or solder bump may refer to the solder material itself, either in its pre- or post-reflow state. The surface of the FCCSP **104** to which the solder ball **106** is affixed may be orientated toward a circuit board when the FCCSP **104** is mounted to the circuit board. When mounting the circuit board, the solder ball **106** may be subjected to a reflow process for affixing the FCCSP **104** to the circuit board.

[0022] The thermal dissipation layer **102** may be affixed to another surface of the FCCSP **104**. As shown, the thermal dissipation layer **102** may be affixed to a surface of the FCCSP **104** opposing the solder ball **106**. In embodiments, the thermal dissipation layer **102** may be affixed to a single surface to which the solder ball **106** is not affixed or some combination of the surfaces to which the solder ball **106** is not affixed. Further, in embodiments, the thermal dissipation layer **102** may be affixed to the same surface as the solder ball **106** and may extend across the surface surrounding the solder ball **106** without contacting the solder ball **106**. The thermal dissipation layer **102** may be affixed in a configuration such that the thermal dissipation layer **102** is electrically isolated from a ground of the FCCSP **104**, signals of the FCCSP **104**, circuitry of the FCCSP **104**, or some combination thereof.

[0023] The thermal dissipation layer **102** may be affixed to the surface of the FCCSP **104** through a sputter coating process. The sputter coating process may include some sputter coating process now known or later developed, including the simplified example sputter coating process described in more detail below.

[0024] The thermal dissipation layer **102** may include a metallic element or combination of metallic elements that may be subjected to the sputter coating process. The thermal dissipation layer **102** may be a type of metal with a high thermal conductivity, including silver, copper, aluminum, zinc, iron, tin, or some combination thereof. For example, the thermal dissipation layer **102** may be copper applied to the surface of the FCCSP **104** through the sputter coating process.

[0025] In other examples, the thermal dissipation layer **102** may be affixed to the surface of the FCCSP **104** through a polymer spray coating process. In these examples, the thermal dissipation layer **102** may be a type of polymer with a high thermal conductivity, including graphite, thermally conductive plastics, polymers with high molecular weight polyethylene nanofibers, polymers with vapor grown carbon fiber, or some combination thereof.

[0026] In some examples, the thermal dissipation layer **102** may be affixed to the surface of the FCCSP **104** through a laminating process. In these examples, the thermal dissipation layer **104** may include a thermally conductive material. The thermally conductive material may include materials with high thermal conductivity including some type of metallic material (such as silver, copper, aluminum, zinc, iron, tin, or some combination thereof), graphite, thermally conductive plastics, polymers with high molecular weight polyethylene nanofibers, polymers with vapor grown carbon fiber, or some combination thereof.

[0027] The thermal dissipation layer **102** may operate as a heat spreader during operation of the FCCSP **104**, thereby dissipating heat produced by the FCCSP **104** during operation. The thermal dissipation may increase or decrease based on the thickness of the thermal dissipation layer **102**, the type of metal and/or polymer comprising the thermal dissipation layer **102**, the density of the thermal dissipation layer **102**, some other factor, and/or some combination thereof.

[0028] A thickness of the thermal dissipation layer **102** may be selected based on one or more factors, including a desired heat dissipation achieved by the thermal dissipation layer **102**, a desired maximum combined thickness of the FCCSP and the thermal dissipation layer **128**, a desired thickness of the thermal dissipation layer **130**, some other factor and/or some combination thereof. In an embodiment, the thickness of the thermal dissipation layer **102** may be selected such that the combined thickness of the FCCSP and the thermal dissipation layer **128** is approximately, or less than, 800 micrometers. In an embodiment, the thickness of the thermal dissipation layer **130** may be limited to a maximum of 20 micrometers. A thickness of the thermal dissipation layer **102** may vary across the surface and/or surfaces of the FCCSP **104** based on the sputter coating process utilized, a direction from which the thermal dissipation layer **102** was applied during the sputter coating process, an angle that the surface to which the thermal dissipation layer **102** was applied was toward a target material utilized for applying the thermal dissipation layer **102** during the sputter coating process, varying desired heat dissipation amounts along different portions of the surface or surfaces, some other factor, or some combination thereof.

[0029] FIG. **2** depicts an example sputter coating process of applying a thermal dissipation layer, such as thermal dissipation layer **102** of FIG. **1**, to a portion of an FCCSP **202**, such as FCCSP **104** of FIG. **1**. The FCCSP **202** may include a solder ball **204**, such as solder ball **106** of FIG. **1**, affixed to a surface of the FCCSP **202**.

[0030] A target material **206** may be placed in a vacuum chamber (not shown). The target material **206** may include a material to be applied to the FCCSP **202** as a thermal

dissipation layer (e.g., thermal dissipation layer **102**), as discussed throughout this disclosure, including silver, copper, aluminum, zinc, iron, tin, or some combination thereof.

[0031] During the sputter coating process, the target material **206** may be bombarded with gas atoms **208**, such as argon atoms, oxygen atoms, other heavy gas atoms, or some combination thereof. The gas atoms **208** may be directed toward the target material **206** in a direction **210**.

[0032] In response to the gas atoms **208** contacting the target material **206**, target ions **212** may be ejected from the target material **206**. The target ions **212** may be ejected in a direction **214** toward the FCCSP **202**. Upon contact with the FCCSP **202**, the target ions **212** may become affixed to the FCCSP **202**, to other target ions **212** already affixed to the FCCSP **202**, some other material residing on the surface of the FCCSP, or some combination thereof. As an increasing amount of the target ions **212** become affixed to the FCCSP **202** and/or the other target ions **212**, a thermal dissipation layer, such as the thermal dissipation layer **102** of FIG. **1**, may be produced on a surface of the FCCSP **202**.

[0033] FIG. **3** depicts a cross-sectional view of another portion of an example FCCSP assembly **300** that includes an FCCSP **302** with a thermal dissipation layer **306**. The FCCSP assembly **300** may include one or more features to the similar features of the FCCSP assembly **100** of FIG. **1**.

[0034] The FCCSP **302** may include one or more components, substrates, layers, or some combination thereof. The FCCSP **302** may include a chip **312** abutted on a side by an underfill material **314**. The chip **312** may be electrically coupled to a substrate layer **318** by first level interconnects **316**. The substrate layer **318** may include one or more pre-preg layers, core layers, electrically conductive inner layers, via structures, or some combination thereof.

[0035] The first level interconnects **316** may extend through the underfill layer **314** and may contact an electrically conductive trace **322**, the electrically conductive trace **322** at least partially located intermediate to the under fill layer **314** and the substrate layer **318**. Solder resist **319** may be affixed to a surface of the substrate layer **318**. Additionally, the FCCSP **302** may include an encapsulation material **326** and a solder resist **324**, the solder resist **324** located intermediate to the encapsulation material **326** and the substrate layer **318**.

[0036] The thermal dissipation layer **306** may be affixed to the FCCSP **302** on a surface of the FCCSP **302** opposite a solder ball **304** affixed to the FCCSP **302**. The solder ball **304** may be affixed to a surface of the FCCSP **302** that includes thermally conductive traces and ball pads **320**. In embodiments, the thermal dissipation layer **306** may be affixed to one surface or a combination of the surfaces of the FCCSP **302**.

[0037] The thermal dissipation layer **306** may extend across a flat portion **308** and a slanted portion **310** of the surface of the FCCSP **302**. The thickness of the thermal dissipation layer **306** may differ between the flat portion **308** and the slanted portion **310** of the FCCSP **302**. The thickness of the flat portion **330** of the thermal dissipation layer **306** may be approximately 20 micrometers, while the thickness of the slanted portion **328** may be approximately 10 micrometers. The difference in the thickness between the flat portion **308** and the slanted portion **310** may be based on the process used for applying the thermal dissipation layer **306**, the orientation of the FCCSP **302** toward a target material during a sputter coating process, or some combination thereof.

[0038] In embodiments, the thermal dissipation layer **306** may be substantially the same thickness on the flat portion **308** and the slanted portion **310**. In order to achieve the same thickness on the flat portion **308** and the slanted portion **310**, the orientation of the FCCSP **302** toward the target material during the sputter coating process may be changed, such that a greater portion of the target ions, such as target ions **212** of FIG. **2**, are directed toward the flat portion **308** in a first orientation and a greater portion of the target ions are directed to the slanted portion **310** in a second orientation.

[0039] FIG. **4** depicts a cross-sectional view of a portion of an example FCCSP assembly **400** that includes an FCCSP **402** with an electrolytic plating layer **408**. The FCCSP assembly **400** may include one or more features similar to the features of the FCCSP assembly **100** of FIG. **1** and/or the FCCSP assembly **300** of FIG. **3**.

[0040] A thermal dissipation layer **406** may be affixed to the FCCSP **402** on a surface opposite a solder ball **404** affixed to the FCCSP **402**. In embodiments, the thermal dissipation layer **406** may be affixed to one surface or a combination of the surfaces of the FCCSP **402**.

[0041] The electrolytic plating layer **408** may be affixed to the thermal dissipation layer **406** on a surface of the thermal dissipation layer **406** opposite the surface of the thermal dissipation layer **406** affixed to the FCCSP **402**. In embodiments, the electrolytic plating layer **408** may be affixed to one or more of the surfaces of the thermal dissipation layer **406** that are not affixed to the FCCSP **402**. The electrolytic plating layer **408** may be affixed to an entirety or a portion of the one or more of the surfaces of the thermal dissipation layer **406**. The electrolytic plating layer **408** may be affixed to the thermal dissipation layer through an electrolytic plating process.

[0042] The electrolytic plating layer **408** may be a type of material having a high thermal conductivity, such as silver, copper, aluminum, zinc, iron, tin, or some combination thereof. Affixing the electrolytic plating layer **408** may increase the thermal dissipation of the FCCSP assembly **400** during operation of the FCCSP **402**.

[0043] A thickness of the electrolytic plating layer **408** may be selected based on a desired amount of heat dissipation of the FCCSP assembly **400** during the operation of the FCCSP **402**. In other embodiments, the thickness of the electrolytic plating layer **408** may be selected based on a desired maximum thickness of the FCCSP assembly **400**. The thickness of the FCCSP assembly **428**, including the FCCSP **402**, the thermal dissipation layer **406**, and the electrolytic plating layer **408** may be approximately, or less than, 800 micrometers.

[0044] FIG. **5** depicts a cross-sectional view of a portion of an example FCCSP assembly **500** that includes an FCCSP **502** with a flash coat layer **508** and a protective layer **510**. The FCCSP assembly **500** may include one or more features similar to the features of the FCCSP assembly **100** of FIG. **1**, the FCCSP assembly **300** of FIG. **3**, and/or the FCCSP assembly **400** of FIG. **4**.

[0045] A thermal dissipation layer **506** may be affixed to the FCCSP **502** on a surface opposite a solder ball **504** affixed to the FCCSP **502**. In embodiments, the thermal dissipation layer **506** may be affixed to one or a combination of the surfaces of the FCCSP **502**.

[0046] The flash coat layer **508** may be affixed to a surface of the thermal dissipation layer **506** opposite a surface of the thermal dissipation layer **506** affixed to the FCCSP **502**. The flash coat layer **508** may be affixed to an entirety or a portion of the thermal dissipation layer **506** not affixed to the FCCSP **502**. The flash coat layer **508** may be applied to the thermal dissipation layer **506** through a flash coating process.

[0047] The flash coat layer **508** may be applied to the thermal dissipation layer **506** to protect the thermal dissipation layer **506** from oxidization. The flash coat layer **508** may comprise a metal, including nickel, zinc, or some combination thereof.

[0048] The protective layer **510** may be affixed to a surface of the flash coat layer **508** opposite the surface of the flash coat layer **508** affixed to the thermal dissipation layer **506**. The protective layer **510** may be affixed to an entirety or a portion of the flash coat layer **508** not affixed to the thermal dissipation layer **506**.

[0049] The protective layer **510** may protect the flash coat layer **508**, the thermal dissipation layer **506**, the FCCSP **502**, or some combination thereof from physical damage. The protective layer **510** may be a metal, including stainless steel, steel, iron, silver, or some combination thereof. In some embodiments, the protective layer **510** may be forgone, leaving the FCCSP **502** with the flash coat layer **508**.

[0050] Thicknesses of the flash coat layer **508** and/or the protective layer **510** may be selected based on a maximum desired thickness of the FCCSP assembly **500**. The thicknesses of the flash coat layer **508** and the protective layer **510** may be selected such that a thickness of the FCCSP assembly **530**, including the FCCSP **502**, the thermal dissipation layer **506**, the flash coat layer **508** and the protective layer **510**, is approximately, or less than, 800 micrometers. In embodiments where the protective layer **510** has been forgone, the FCCSP assembly **500**, including the FCCSP **502**, the thermal dissipation layer **506** and the flash coat layer **508**, may have a combined thickness of approximately, or less than, 800 micrometers.

[0051] FIG. **6** depicts an example process **600** for making an FCCSP assembly that includes an FCCSP with thermal dissipation layer. The example process **600** may be utilized to produce the FCCSP assembly **100** of FIG. **1**, the FCCSP assembly **300** of FIG. **3**, the FCCSP assembly **400** of FIG. **4**, and/or the FCCSP assembly **500** of FIG. **5**.

[0052] The example process **600** may be similar to known processes for producing an FCCSP, with the exception of the additional thermal dissipation layer application block. The process **600** may begin with a front process block **602** for producing a base die of the FCCSP. The front process block **602** may include an incoming wafer. The incoming wafer may be subjected to a process of back-grinding and dicing. A die may be attached to the processed wafer and a substrate may be reflowed on to the wafer. The substrate may be subjected to a process of de-fluxing and cleaning to produce the base die.

[0053] The process **600** may alternatively continue to either a molded underfill block **604** or a capillary underfill block **606** for underfilling the base die. In the molded underfill block **604**, a mold compound is forced under the base die. The mold compound is subjected to a post mold cure process to fully cross link the mold compound material. If the molded underfill block **604** is used, the process **600** continues to a pulse multi control block **608**.

[0054] After completion of the underfill blocks, the process **600** continues to a laser marking block **610**. A laser marking may be applied to the top surface of the FCCSP for identification. The FCCSP is laser marked with identification information or information identifying characteristics of the FCCSP. The laser mark generated by the laser marking block **610** may be visible through or on the thermal dissipation layer of the completed FCCSP.

[0055] The process continues to a full strip processing block **612**. The full strip processing block **612** may indicate that the process **600** is being applied to a substrate strip of FCCSPs. In some embodiments, the process **600** may continue to a full cut sawing block **614**. In other embodiments, the full cut sawing block **614** is forgone until a later stage in the process **600**.

[0056] In block **616**, the thermal dissipation layer is applied. The thermal dissipation layer may be applied by the techniques and/or the configurations described in this disclosure, including the sputter metal coating process and/or the polymer spray coating process.

[0057] In some embodiments, the process **600** continues to an electrolytic metal plating block **618** in order to add an electrolytic plating layer, such as electrolytic plating layer **408** of FIG. **4**. The electrolytic metal plating block **618** may include a plating process, where additional metal may be plated to a surface of the FCCSP. The additional metal may include any thermally conductive metal, including silver, copper, aluminum, zinc, iron, tin, or some combination thereof. The electrolytic player layer block **618** may be forgone in some of the embodiments where the thermal dissipation layer is only desired to be affixed to the FCCSP.

[0058] The process **600** may then continue to a full cut sawing block **620** in some embodiments. The full cut sawing block **614** and the full cut sawing block **620** may be utilized in different embodiments of the process **600** from each other. For instance, some of the embodiments of the process **600** may include full cut sawing block **614**, which other embodiments of the process **600** may include full cut sawing block **620**. The full cut sawing block **614** and/or the full cut sawing block **620** may be performed when there is a substrate strip of FCCSPs and may involve cutting the substrate strip into individual packages.

[0059] The process **600** ends with a visual inspection block **622** of the resulting FCCSP verifying that the desired results were achieved.

[0060] Embodiments of the present disclosure may be implemented into a system using the packages and manufacturing techniques disclosed herein. FIG. **7** schematically illustrates a computing device **700**, in accordance with some implementations, which may include one or more FCCSP assemblies, such as the FCCSP assemblies **100**, **300**, **400**, **500**, etc., described herein. For instance, chip packages mounted to a motherboard **702** of the computing device **700**, such as processor **704**, communication chip **706**, and storage device **708**, may include an FCCSP assembly.

[0061] The computing device **700** may be, for example, a mobile communication device or a desktop or rack-based computing device. The computing device **700** may house a board such as the motherboard **702**. The motherboard **702** may include a number of components, including (but not limited to) a processor **704** and at least one communication chip **706**. Any of the components discussed herein with reference to the computing device **700** may include a heat removal assembly as described above.

[0062] The computing device **700** may include a storage device **708**. In some embodiments, the storage device **708** may include one or more solid state drives. Examples of storage devices that may be included in the storage device **708** include volatile memory (e.g., dynamic random access memory (DRAM)), non-volatile memory (e.g., read-only memory, ROM), flash memory, and mass storage devices (such as hard disk drives, compact discs (CDs), digital versatile discs (DVDs), and so forth).

[0063] Depending on its applications, the computing device **700** may include other components that may or may not be physically and electrically coupled to the motherboard **702**. These other components may include, but are not limited to, a graphics processor, a digital signal processor, a crypto processor, a chipset, an antenna, a display, a touchscreen display, a touchscreen controller, a battery, an audio codec, a video codec, a power amplifier, a global positioning system (GPS) device, a compass, a Geiger counter, an accelerometer, a gyroscope, a speaker, and a camera.

[0064] The communication chip **706** and the antenna may enable wireless communications for the transfer of data to and from the computing device **700**. The term "wireless" and its derivatives may be used to describe circuits, devices, systems, methods, techniques, communications channels, etc., that may communicate data through the use of modulated electromagnetic radiation through a non-solid medium. The term does not imply that the associated devices do not contain any wires, although in some embodiments they might not. The communication chip **706** may implement any of a number of wireless standards or protocols, including but not limited to Institute for Electrical and Electronic Engineers (IEEE) standards including Wi-Fi (IEEE 802.11 family), IEEE 802.16 standards (e.g., IEEE 802.16-2005 Amendment), Long-Term Evolution (LTE) project along with any amendments, updates, and/or revisions (e.g., advanced LTE project, ultra mobile broadband (UMB) project (also referred to as "3GPP2"), etc.). IEEE 802.16 compatible broadband wide region (BWA) networks are generally referred to as WiMAX networks, an acronym that stands for Worldwide Interoperability for Microwave Access, which is a certification mark for products that pass conformity and interoperability tests for the IEEE 802.16 standards. The communication chip **706** may operate in accordance with a Global System for Mobile Communications (GSM), General Packet Radio Service (GPRS), Universal Mobile Telecommunications System (UMTS), High Speed Packet Access (HSPA), Evolved HSPA (E-HSPA), or LTE network. The communication chip **706** may operate in accordance with Enhanced Data for GSM Evolution (EDGE), GSM EDGE Radio Access Network (GERAN), Universal Terrestrial Radio Access Network (UTRAN), or Evolved UTRAN (E-UTRAN). The communication chip **706** may operate in accordance with Code Division Multiple Access (CDMA), Time Division Multiple Access (TDMA), Digital Enhanced Cordless Telecommunications (DECT), Evolution-Data Optimized (EV-DO), derivatives thereof, as well as any other wireless protocols that are designated as 3G, 4G, 5G, and beyond. The communication chip **706** may operate in accordance with other wireless protocols in other embodiments.

[0065] The computing device **700** may include a plurality of communication chips **706**. For instance, a first communication chip **706** may be dedicated to shorter range wireless communications such as Wi-Fi and Bluetooth, and a second communication chip **706** may be dedicated to longer range wireless communications such as GPS, EDGE, GPRS, CDMA, WiMAX, LTE, EV-DO, and others. In some embodiments, the communication chip **706** may support wired communications. For example, the computing device **700** may include one or more wired servers.

[0066] The processor **704** and/or the communication chip **706** of the computing device **700** may include one or more dies or other components in an IC package. Such an IC package may be coupled with an interposer or another package using any of the techniques disclosed herein. The term "processor" may refer to any device or portion of a device that processes electronic data from registers and/or memory to transform that electronic data into other electronic data that may be stored in registers and/or memory.

[0067] In various implementations, the computing device **700** may be a laptop, a netbook, a notebook, an ultrabook, a smartphone, a tablet, a personal digital assistant (PDA), an ultra mobile PC, a mobile phone, a desktop computer, a server, a printer, a scanner, a monitor, a set-top box, an entertainment control unit, a digital camera, a portable music player, or a digital video recorder. In further implementations, the computing device **700** may be any other electronic device that processes data. In some embodiments, the recessed conductive contacts disclosed herein may be implemented in a high-performance computing device.

[0068] It will be apparent to those skilled in the art that various modifications and variations can be made in the disclosed embodiments of the disclosed device and associated methods without departing from the spirit or scope of the disclosure. Thus, it is intended that the present disclosure covers the modifications and variations of the embodiments disclosed above provided that the modifications and variations come within the scope of any claims and their equivalents.

1. An apparatus, comprising:

a flip-chip chip scale package (FCCSP); and

a thermal dissipation layer, applied to a surface of the FCCSP through a sputter coating process, to dissipate heat produced by the FCCSP during operation of the FCCSP.

2. The apparatus of claim **1**, wherein the thermal dissipation layer includes a copper layer applied to the surface of the FCCSP through the sputter coating process.

3. The apparatus of claim **1**, further comprising a flash coat layer applied to a surface of the thermal dissipation layer opposite the FCCSP, wherein the flash coat layer is to protect the thermal dissipation layer from oxidization.

4. The apparatus of claim **1**, further comprising an electrolytic plate layer applied to a surface of the thermal dissipation layer opposite the FCCSP, the electrolytic plate layer to increase thermal dissipation of the apparatus.

5. The apparatus of claim **4**, wherein a thickness, measured perpendicularly to the surface of the FCCSP, of the electrolytic plate layer is selected based on a desired amount of thermal conductivity of the thermal dissipation layer.

6. The apparatus of claim **4**, wherein a combined thickness, measured perpendicularly to the surface of the FCCSP, of the FCCSP, the thermal dissipation layer and the electrolytic plate layer is less than approximately 800 micrometers.

7. The apparatus of claim **1**, wherein the FCCSP is for broadband or digital use.

8. The apparatus of claim **1**, wherein a combined height of the FCCSP and the thermal dissipation layer is less than approximately 800 micrometers.

9. The apparatus of claim **1**, wherein a maximum thickness of the thermal dissipation layer is approximately 20 micrometers.

10. The apparatus of claim **1**, wherein the thermal dissipation layer is electrically isolated from a ground of the FCCSP.

11. The apparatus of claim **1**, wherein the thermal dissipation layer extends across an entirety of the surface of the FCCSP.

12. The apparatus of claim **1**, wherein the FCCSP includes a capillary underfill material or a molded underfill material.

13. A system, comprising:

a circuit board;

a flip-chip chip scale package (FCCSP) mounted to the circuit board; and

a thermal dissipation layer for dissipation of heat produced by the FCCSP and applied to a surface of the FCCSP by a sputter coating process.

14. The system of claim **13**, wherein the FCCSP includes a capillary underfill material.

15. The system of claim **13**, wherein the FCCSP includes a molded underfill material.

16. The system of claim **13**, wherein the thermal dissipation layer extends across an entirety of the surface of the FCCSP.

17. The system of claim **13**, further comprising a ground connection coupled to the FCCSP, wherein the thermal dissipation layer is electrically isolated from the ground connection.

18. The system of claim **13**, wherein the FCCSP is for broadband or digital use.

19. The system of claim **13**, wherein a combined thickness, measured perpendicularly to the surface of the FCCSP, of the FCCSP and the thermal dissipation layer is less than approximately 800 micrometers.

20. The system of claim **13**, further comprising an electrolytic plate layer applied, through an electrolytic plating process, to a surface of the thermal dissipation layer opposite the FCCSP, wherein a thickness, measured perpendicularly to the surface of the FCCSP, of the electrolytic plate layer is selected based on a desired amount of thermal conductivity of the thermal dissipation layer.

21. The system of claim **20**, wherein a combined thickness, measured perpendicularly to the surface of the FCCSP, of the FCCSP, the thermal dissipation layer, and the electrolytic plate layer is less than approximately 800 micrometers.

22. The system of claim **13**, further comprising a flash coat layer applied to a surface of the thermal dissipation layer opposite the FCCSP, the flash coat layer to protect the thermal dissipation layer from oxidization.

23. The system of claim **13**, wherein the thermal dissipation layer includes a copper layer applied to the surface of the FCCSP by the sputter coating process.

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