

CARRIER HAVING LOCKING MECHANISM FOR HOLDING SUBSTRATES

FIELD

[0001] An embodiment of the invention is directed to a substrate carrier for processing of substrates, more specifically, a two-piece substrate carrier that is held together by a locking mechanism. Other embodiments are also described and claimed.

BACKGROUND

[0002] Camera modules are assembled by first processing the microelectronic device substrates used within the modules. Process carriers are the main tooling component used to hold the substrates during the various processing steps, in some cases, from the beginning of the manufacturing line all the way to the completed camera module. Due to the substrate's near weightless characteristic and small size, however, many of the processing steps, for example, surface-mount technology (SMT), wash and clean, flip-chip, under fill and glass attach have become challenging. Representatively, SMT and glass attach processing is done on one side of the substrate while flip-chip and under fill is done on the other side, thus a flip is required. It is difficult, however, to secure the substrate to a carrier that will allow for such processing due to the very small weight and size of the substrate. Conventional systems have tried to, for example, use an adhesive such as a double-sided adhesive tape to stick the substrate to the carrier. Adhesives, however, may wear out and therefore are unreliable. In addition, the adhesive may cover one side of the substrate and therefore not allow for processing on both sides of the substrate while the substrate is within the carrier. In such a case, a pick, flip and placement or transfer of the substrate from the carrier to, in some cases, another carrier, must occur after each processing step, so that processing may occur on both sides of the substrate. Other types of fasteners have also been used to hold the substrate between two plates of the carrier. Such fasteners, however, may protrude from a surface of one or more of the plates, causing gaps between the plates that may allow for shifting and/or movement of the substrate.

SUMMARY

[0003] An embodiment of the invention is a carrier apparatus for processing of a microelectronic device substrate. The carrier apparatus may include a first carrier plate for processing of a microelectronic device substrate, which includes a number of cantilevers (or

tabs) formed therein. Each of the cantilevers may have a first end connected to the first carrier plate and a second end that is movable between a first configuration in which the second end is within a plane of the first carrier plate and a second configuration in which the second end is outside a plane of the first carrier plate. The apparatus may further include a second carrier plate for processing of a microelectronic device substrate, which includes a number of receiving slots formed therein. Each of the receiving slots may be dimensioned to receive the second end of one of the cantilevers in the second configuration, such that the first carrier plate becomes clamped to the second carrier plate. In one embodiment, the second end of at least one of the cantilevers and the second end of another of the cantilevers may face opposite directions; in other words, the cantilevers are "pointing" in opposite directions. In addition, at least one of the cantilevers may be biased to move toward a plane of the first carrier plate. In still further embodiments, at least one of the cantilevers is integrally formed from a material of the first carrier plate. At least one of the receiving slots may include positioned therein a detent dimensioned to hold the second end of a cantilever within the receiving slot. In still further embodiments, interfacing sides of the first carrier plate and the second carrier are in contact with one another when the first carrier plate is clamped to the second carrier plate. The first carrier plate may further include a window through which a microelectronic device substrate, that is positioned between the first carrier plate and the second carrier plate and that lies within a cavity formed in the second carrier plate, which cavity is dimensioned to receive the device substrate, is exposed for processing.

[0004] Another embodiment of the invention is a carrier apparatus including a first carrier plate, having a number of beams and a number of windows formed within the first carrier plate. In one aspect, each of the beams may have a first end connected to the first carrier plate and a second end suspended within a plane of the first carrier plate and each of the beams may be operable to move (e.g., be bent) such that in a first configuration, the second end is within a plane of the first carrier plate, and in a second configuration the second end is outside the plane of the first carrier plate. The carrier apparatus may further include a second carrier plate having a number of receiving slots and a number of cavities formed therein. Each of the receiving slots are operable to receive the second end of one of the beams in the second configuration, and each of the cavities aligns with one of the windows when the second carrier plate is positioned along (e.g., abuts, while lying flat against) the first carrier plate. In one embodiment, each of the cavities that is aligned with one of the windows is dimensioned to receive a microelectronic device substrate such that at

least two opposing sides of the microelectronic device substrate are exposed for processing. The carrier apparatus may further include a support member that can be attached to the first carrier plate, which has a number of pins that are operable to move the beams between the first configuration and the second configuration. The support member may include a locking pin to lock, or otherwise attach, the support member to the first carrier plate and the first carrier plate may include an opening dimensioned to receive the locking pin. The locking pin may be operable to slide within the opening between a first position in which the support member is locked to the first carrier plate and a second position in which the support member is releasable from the first carrier plate. The apparatus may further include a base member operable to be positioned along a side of the second carrier plate which is opposite the side that abuts the first carrier plate. The base member may have a number of channels and each of the channels may be aligned with one of the receiving slots when the base member is positioned along the side of the second carrier plate.

[0005] Another embodiment of the invention is a method of assembling a carrier for processing of a microelectronic device substrate. The method may include providing a first carrier plate and a second carrier plate. The first carrier plate may have a cantilever that is biased in a direction toward a plane of the first carrier plate and a window dimensioned to expose a first side of a microelectronic device substrate positioned along the first carrier plate. The second carrier plate may have a cantilever receiving member and a cavity dimensioned to receive the second side of the microelectronic device substrate. The first carrier plate may be attached to the second carrier plate by positioning an end of the cantilever outside a plane of the first carrier plate and within the cantilever receiving member such that the end of the cantilever engages the cantilever receiving member and holds the second carrier plate against the first carrier plate. The cantilever receiving member may include a detent dimensioned to engage the end of the cantilever within a plane of the second carrier plate. In one embodiment, positioning an end of the cantilever outside a plane of the first carrier plate may be accomplished by attaching a support member having a pin dimensioned to bend the cantilever to the first carrier plate. In one aspect, the support member may be attached to the first carrier plate by aligning a locking member extending from the support member with a lock receiving member formed in the first carrier plate and sliding the support member with respect to the first carrier plate to lock the locking member within the lock receiving member. In some embodiments, prior to attaching the first carrier plate to the second carrier plate, the second carrier plate is attached to a base member, the

base member having a channel that aligns with the cantilever receiving member. In some embodiments, the cantilever is a first cantilever, and the first carrier plate includes a second cantilever, and wherein the first cantilever rotates in a first direction to position the end of the first cantilever outside the plane of the first carrier plate and the second cantilever rotates in a second direction to position an end of the second cantilever outside the plane of the first carrier plate, wherein the first direction is different from the second direction.

[0006] The above summary does not include an exhaustive list of all aspects of the present invention. It is contemplated that the invention includes all systems and methods that can be practiced from all suitable combinations of the various aspects summarized above, as well as those disclosed in the Detailed Description below and particularly pointed out in the claims filed with the application. Such combinations have particular advantages not specifically recited in the above summary.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] The embodiments are illustrated by way of example and not by way of limitation in the figures of the accompanying drawings in which like references indicate similar elements. It should be noted that references to "an" or "one" embodiment in this disclosure are not necessarily to the same embodiment, and they mean at least one.

[0008] **Fig. 1** illustrates an exploded perspective view of one embodiment of a substrate carrier.

[0009] **Fig. 2A** illustrates a side view of a cantilever of the substrate carrier of **Fig. 1**.

[0010] **Fig. 2B** illustrates a side view of a cantilever of the substrate carrier of **Fig. 1**.

[0011] **Fig. 3A** illustrates one embodiment of a cross-sectional side view of a substrate carrier having a cantilever in a first configuration.

[0012] **Fig. 3B** illustrates one embodiment of a cross-sectional side view of a substrate carrier having a cantilever in a second configuration.

[0013] **Fig. 3C** illustrates one embodiment of a cross-sectional side view of a substrate carrier having a cantilever locking a first carrier plate to a second carrier plate.

[0014] **Fig. 4** illustrates an exploded perspective view of a substrate carrier and assembly tool for assembling the substrate carrier according to one embodiment.

[0015] **Fig. 5A** illustrates an exploded perspective view of a bottom side of the support member and first carrier plate of **Fig. 4**.

[0016] **Fig. 5B** illustrates a perspective view of a first carrier plate locked to the support member of **Fig. 4**.

[0017] **Fig. 6A** illustrates a perspective view of the base member and second carrier plate of **Fig. 4**.

[0018] **Fig. 6B** illustrates a perspective view of the base member attached to the second carrier plate of **Fig. 4**.

[0019] **Fig. 7** illustrates a perspective view of the substrate carrier and assembly tool of **Fig. 4**.

[0020] **Fig. 8** illustrates a cross-sectional side view through line 8-8' of **Fig. 7**.

[0021] **Fig. 9** illustrates a cross-sectional view of an assembled substrate carrier holding a substrate.

[0022] **Fig. 10** is a block diagram illustrating a process of assembling a substrate carrier.

DETAILED DESCRIPTION

[0023] In this section we shall explain several preferred embodiments of this invention with reference to the appended drawings. Whenever the shapes, relative positions and other aspects of the parts described in the embodiments are not clearly defined, the scope of the invention is not limited only to the parts shown, which are meant merely for the purpose of illustration. Also, while numerous details are set forth, it is understood that some embodiments of the invention may be practiced without these details. In other instances, well-known structures and techniques have not been shown in detail so as not to obscure the understanding of this description.

[0024] **Fig. 1** illustrates an exploded perspective view of one embodiment of a substrate carrier. Substrate carrier 100 may include a first carrier plate 102 and a second carrier plate

104. First carrier plate 102 may be a substantially planar structure having a substantially planar, or flat, top side 130 and bottom side 132. Similarly, second carrier plate 104 may be a substantially planar structure having a substantially planar, or flat, top side 134 and bottom side 136. In this aspect, when first carrier plate 102 is positioned on top of, and attached to, second carrier plate 104, the interfacing surfaces of the plates (e.g. bottom side 132 of first carrier plate 102 and top side 134 of second carrier plate 104) contact one another such that there are substantially no gaps between the plates. This is the case even when a substrate 106 is positioned between first carrier plate 102 and second carrier plate 104. This, in turn, allows for substrate 106 to be held securely in place between the plates during subsequent processing operations.

[0025] Substrate 106 may be for example, a substrate to which a microelectronic device can be mounted, and therefore also referred to herein as a microelectronic device substrate. For example, in some embodiments, substrate 106 is a ceramic substrate such as a leadless chip carrier (LCC) substrate or other similarly sized substrate that may be subjected to substrate processing techniques (e.g. SMT, ultrasonic flip-chip mounting, wash and clean, flip-chip, under fill and glass attach or ultrasonic mounting). In some embodiments, the substrate 106 may be a substrate subjected to a camera module assembly process. It is further contemplated that the substrate 106 may be any other type of micro scale structure or device that could benefit from being able to be processed simultaneously with other substrates, for example as a panel of substrates, using a carrier such as the substrate carrier 100 described herein.

[0026] In one embodiment, first carrier plate 102 and second carrier plate 104 may have substantially the same footprint. In other words, an overall size and shape of first carrier plate 102 and second carrier plate 104 may be substantially the same. First carrier plate 102 and second carrier plate 104 may be made of any material suitable for holding a microelectronic device substrate 106 throughout the substrate processing steps. Representatively, first carrier plate 102 and second carrier plate 104 may be made of a metallic material, for example, a metal alloy such as stainless steel. In one embodiment, first carrier plate 102 and second carrier plate 104 may be integrally formed from the metallic material such that the plates, as well as any features formed therein, are inseparable parts of a single integrally formed structure or unit.

[0027] First carrier plate 102 and second carrier plate 104 may be dimensioned such that first side 108 and second side 110 of substrate 106 are exposed to the ambient environment when microelectronic device substrate 106 is positioned between first carrier plate 102 and second carrier plate 104. In this aspect, first carrier plate 102 may include windows 112, which align with cavities 114 formed in second carrier plate 104. Representatively, in one embodiment, first carrier plate 102 may include windows 112A, 112B, 112C, 112D and 112E, which align with cavities 114A, 114B, 114C, 114D and 114E, respectively, formed in second carrier plate 104. In this aspect, when a substrate such as substrate 106 is positioned between first carrier plate 102 and second carrier plate 104 within windows 112A-112E and the corresponding cavities 114A-114E, both the first side 108 and the second side 110 are exposed so that processing steps can be performed on both sides of the substrate 106 without having to remove it from substrate carrier 100.

[0028] Each of windows 112A-112E and cavities 114A-114E may have any size and dimension suitable for holding a substrate 106 and exposing both sides 108 and 110 of the substrate 106 to the ambient environment during subsequent processing operations. In one embodiment, each of windows 112A-112E and cavities 114A-114E may have substantially the same dimensions such that they are substantially mirror images of one another. Still further, the dimensions of windows 112A-112E and cavities 114A-114E may be such that interfacing surfaces of first carrier plate 102 and second carrier plate 104 (e.g. side 132 and side 134) may be in contact and flush with one another when a substrate 106 is positioned within each of the aligned windows 112A-112E and 114A-114E. Representatively, windows 112A-112E and cavities 114A-114E may each have recessed regions such that the first side 108 and/or the second side 110 of substrate 106 is recessed within a thickness of first carrier plate 102 and second carrier plate 104 when the plates are attached together. It should also be understood that although a single substrate 106 is illustrated, it is contemplated that a substrate such as substrate 106 can be positioned within each of windows 112A-112E and corresponding cavities 114A-114E, such that a panel of substrates are formed within substrate carrier 100 for subsequent processing.

[0029] It is further to be understood that although five windows 112 and five cavities 114 are illustrated within each of first carrier plate 102 and second carrier plate 104, respectively, it is contemplated that any number of windows 112 and cavities 114 suitable for holding a desired number of substrates may be included. For example, in some embodiments, as many

as 20-30 windows 112 and 20-30 cavities 114, or more, may be formed within each of plates 102, 104, respectively. In addition, a pattern of windows 112 and cavities 114 within first carrier plate 102 and second carrier plate 104, respectively, may be substantially the same such that when first carrier plate 102 is positioned on second carrier plate 104, each of windows 112 align with a single one of cavities 114.

[0030] In one embodiment, to help align windows 112 with cavities 114, second carrier plate 104 may include optional alignment members 124A, 124B and first carrier plate 102 may include optional alignment openings 126A, 126B. Alignment openings 126A, 126B may be dimensioned to receive alignment members 124A, 124B, respectively. Alignment members 124A, 124B may be, in one embodiment, slightly raised structures which are dimensioned to fit within alignment openings 126A, 126B. When alignment members 124A, 124B are positioned within alignment openings 126A, 126B, respectively, each of windows 112 are, in turn, aligned with a respective one of cavities 114.

[0031] First carrier plate 102 may be attached to second carrier plate 104 using cantilevers 116, or tabs, formed from first carrier plate 102. Cantilevers 116 are dimensioned to be inserted within receiving slots 118, also referred to herein as cantilever receiving members, formed within second carrier plate 104. Cantilevers 116 may be formed by, for example, beams 116A, 116B, 116C, 116D, 116E, 116F, 116G, 116H, which are cut out of the material of first carrier plate 102 such that they are integrally formed with first carrier plate 102. Each of beams 116A-116H may have a first end 120 and a second end 122. The first end 120 may be attached to, and integrally formed with, first carrier plate 102 and second end 122 may be considered a “free end” in that it is suspended within first carrier plate 102 and free to move. In other words, the second end 122 is not directly attached to first carrier plate 102 and may therefore move outside a plane of first carrier plate 102, for example, above or below a surface of first carrier plate 102. Cantilevers 116 and/or each second end 122 may therefore be considered to have, for example, a first configuration in which the second end 122 is within a plane of first carrier plate 102 and a second configuration in which the second end 122 is outside a plane of the first carrier plate 102. It should be understood that the second end 122 of cantilevers 116 is considered to be within “a plane” of first carrier plate 102 (or second carrier plate 104) when it is between, or level with, the top side 130 (or surface) and the bottom side 132 (or surface) of the plate. For example, “a plane” or “the

plane” of first carrier plate 102 could be any plane along a line drawn between and parallel to the surfaces of first carrier plate 102.

[0032] Representatively, in the first configuration beams 116A-116H may be in a first position, also referred to as a resting or natural position, in which no external forces are applied and therefore the second end 122 is within a plane of the first carrier plate 102. This first position of second end 122 may also be referred to herein as a planar position because the entire cantilever 116, including second end 122, is within a plane of first carrier plate 102. The first configuration is illustrated by, for example, beams 116B and 116D-116H. In the second configuration, the second end 122 of beams 116A-116H may be in a second or biased position in which the second end 122 is outside a plane of first carrier plate 102. The second configuration is illustrated by, for example, beams 116A and 116C. As can be seen from beams 116A and 116C, in this second configuration, beams 116A and 116C may be considered sloped or at an angle with respect to the plane of first carrier plate 102. The position of second end 122 of beams 116A and 116C in the second configuration may be referred to as “biased” or a “biased position” because in this position, cantilevers 116, and more specifically, beams 116A and 116C are biased and want to move in a direction toward a plane of first carrier plate 102 (i.e. back to their natural or resting position). Said another way, when beams 116A and 116C are moved such that the second end 122 is outside a plane of first carrier plate 102, they have a tendency to want to spring back toward the plane of first carrier plate 102, much like a diving board. In other words, once an external force used to move beams 116A and 116C outside of a plane of first carrier plate 102 is removed, the biasing force of the cantilever forces the second end 122 of beams 116A and 116C to move back to the resting position (or first configuration) in which it is within a plane of first carrier plate 102.

[0033] It is in turn this tendency of the second end 122 of beams 116A-116H to want to spring back to the planar position that locks cantilevers 116 within receiving slots 118 of second carrier plate 104. Representatively, second carrier plate 104 includes receiving slots 118A, 118B, 118C, 118D, 118E, 118F, 118G, 118H, which align with a respective one of beams 116A-116H. The receiving slots 118A-118H are dimensioned to engage and retain the second end 122 of each of beams 116A-116H. In this aspect, each of receiving slots 118A-118H may be elongated cut-outs formed through second carrier plate 104. Receiving slots 118A-118H are dimensioned so that the second end 122 of a respective one of beams

116A-116H in the second or biased position (outside the plane of first carrier plate 102) can be inserted within one of receiving slots 118A-118H and engage the receiving slots 118A-118H as the second end 122 springs back toward the first or planar position. This, in turn, clamps first carrier plate 102 and second carrier plate 104 together, with a force sufficient to hold one or more of a substrate 106 securely between the plates 102, 104.

[0034] Cantilevers 116A-116H may be arranged around first carrier plate 102 in a pattern that allows for the clamping force to be evenly distributed across each of first carrier plate 102 and second carrier plate 104. For example, cantilevers 116A-116H may be arranged in a lengthwise direction in rows extending from one end of first carrier plate 102 to another end of first carrier plate 102 as shown in **Fig. 1**. Representatively, cantilevers 116A, 116B may be arranged in one row along one edge of first carrier plate 102, cantilevers 116C and 116D may be arranged in another row, cantilevers 116E and 116F in another row and cantilevers 116G and 116H may be arranged in a row along the other edge of first carrier plate 102. In this aspect, cantilevers 116A-116H are evenly spread across the entire first carrier plate 102 to allow for an even distribution of the clamping force between the plates. Still further, it should be understood that cantilevers 116A-116H are arranged such that they clamp first carrier plate 102 and second carrier plate 104 together, but do not contact, or otherwise directly clamp onto, any one or more of a substrate 106 that may be positioned between the plates. Rather, first carrier plate 102 and second carrier plate 104 contact portions of the top side 108 and the bottom side 110 of substrate 106 to hold the substrate between the plates.

[0035] In addition, in some embodiments, at least two of cantilevers 116A-116H may face different directions to help prevent shifting between first carrier plate 102 and second carrier plate 104. Representatively, cantilevers 116A, 116B, 116G and 116H may face one direction and cantilevers 116C, 116D, 116E and 116F may face another direction, for example, an opposite direction. The opposite orientation of cantilevers 116A-116H helps to provide a more secure attachment between first carrier plate 102 and second carrier plate 104 and reduce shifting between the plates.

[0036] Representatively, **Fig. 2A** and **Fig. 2B** illustrate the opposite orientation of cantilevers 116A and 116C in more detail. In particular, **Fig. 2A** illustrates a side view of cantilever 116A and **Fig. 2B** illustrates a side view of cantilever 116C. It can be seen from these views that the second end 122 of cantilever 116A (**Fig. 2A**) faces or points in one direction while the second end 122 of cantilever 116C (**Fig. 2B**) faces or points in a second,

different, direction. For example, according to the view illustrated by **Fig. 2A** and **Fig. 2B**, second end 122 of cantilever 116A may face to the right, which would be toward one end of first carrier plate 102, and second end 122 of cantilever 116C may face to the left, which would be toward another end of first carrier plate 102. Each of cantilever 116A and cantilever 116C, in turn, may be considered to rotate, with respect to the first carrier plate 102, in different directions in response to the external force used to move the respective second end 122 outside a plane of first carrier plate 102. For example, cantilever 116A rotates in a first direction illustrated by arrow 202 and cantilever 116C rotates in a second direction illustrated by arrow 204. The first direction 202 may be a clockwise direction while the second direction 204 may be a counter-clockwise direction.

[0037] In addition, when the external force is applied to cantilevers 116A, 116C in a direction of arrow 206, the second end 122 of each of cantilevers 116A, 116C move outside of, and in this case, below a plane of first carrier plate 102. As previously discussed, however, in this position, the second end 122 has a tendency to want to spring back toward the plane of first carrier plate 102, in a direction of arrow 208. Thus, in this position, the cantilevers 116A, 116C may be considered to be in a second configuration, and more specifically second end 122 may be considered to be in a biased position in which it is biased in a direction of arrow 208.

[0038] The attachment of first carrier plate 102 to second carrier plate 104 using this biasing force of cantilevers 116 may be better understood in reference to **Figs. 3A, 3B** and **3C**. In particular, **Fig. 3A** illustrates a cross-sectional side view of a first carrier plate 102 and a second carrier plate 104 of a substrate carrier with a cantilever in the first configuration. From this view, it can be seen that in the first configuration, the second end 122 of cantilever 116 is within a plane of first carrier plate 102. As previously discussed, in this configuration, the second end 122 may be considered to be in a first or planar position. Second carrier plate 104 is shown positioned below first carrier plate 102 such that receiving slot 118 is aligned with cantilever 116. From this view, it can be seen that receiving slot 118 includes a detent 310 positioned therein. For example, detent 310 may be a recess formed within a sidewall of receiving slot 118. Detent 310 is dimensioned to engage and hold cantilever 116 within receiving slot 118 as will be described in more detail in reference to **Fig. 3C**. In addition, both a top side 130 and a bottom side 132 of first carrier plate 102 and a top side 134 and a bottom side 136 of second carrier plate 104 are shown as substantially flat, planar surfaces.

In this aspect, when the interfacing surfaces or sides of first carrier plate 102 and second carrier plate 104, in other words bottom side 132 and top side 134, are placed in contact with one another as shown in **Fig. 3C**, there are no gaps between first carrier plate 102 and second carrier plate 104, even when a substrate is positioned between them.

[0039] **Fig. 3B** illustrates a cross-sectional side view of the first carrier plate and the second carrier plate of **Fig. 3A** with the cantilever in the second configuration. To move cantilever 116, and more specifically the second end 122 outside a plane of first carrier plate 102, an external force in a direction of arrow 312 is applied to cantilever 116. In this case, the external force is applied in a downward direction, as illustrated by arrow 312, so that the second end 122 of cantilever 116 is below a plane of first carrier plate 102. It should be understood, however, that the force may be in any direction so long as it causes the second end 122 of cantilever 116 to move out of the plane of first carrier plate 102 and in a direction of second carrier plate 104. With the application of the external force, the second end 122 of cantilever 116 is now in a second or biased position in which it is outside a plane of first carrier plate 102, but biased in a direction of the plane of first carrier plate 102. Said another way, if the external force were removed, the second end 122 of cantilever 116 would move or spring back toward the plane of first carrier plate 102 to the position shown in **Fig. 3A**.

[0040] While the cantilever 116 is in the second or biased position as illustrated in **Fig. 3B**, first carrier plate 102 and second carrier plate 104 are moved toward one another so that the second end 122 of cantilever 116 is positioned within receiving slot 118. Once second end 122 is within receiving slot 118, the external force may be removed so that the second end 122 of cantilever 116 catches on detent 310 of second carrier plate 104 as it springs back toward first carrier plate 102. This configuration is shown in **Fig. 3C**.

[0041] Representatively, **Fig. 3C** illustrates a cross-sectional side view of the first carrier plate and the second carrier plate of **Fig. 3C** with the cantilever engaging the receiving slot. In particular, the second end 122 of cantilever 116 is biased, or wants to move or bend, in a direction of first carrier plate 102 as illustrated by arrow 314. As such, when the external force is removed, the second end 122 moves toward first carrier plate 102 in a direction of arrow 214. The detent 310 within receiving slot 118, however, catches on and engages the second end 122 to prevent it from moving all the way back to the first position, within the plane of first carrier plate 102. The detent 310, for example, may be a recessed region formed within the bottom side 134 of the second carrier plate 104, near the edge of the

receiving slot 118. When the second end 122 is held by the detent 310 in a biased position as shown in **Fig. 3C**, it pulls (i.e. in a direction of arrow 314) second carrier plate 104 against first carrier plate 102 and clamps the plates together. First carrier plate 102 will therefore remain clamped or attached to second carrier plate 104 until an external downward force (i.e. in a direction of arrow 312) is applied to cantilever 116 to release the second end 122 from detent 310.

[0042] Any suitable mechanism may be used to apply the external forces and assemble substrate carrier 100. **Fig. 4** illustrates an exploded perspective view of a substrate carrier and assembly tool for assembling the substrate carrier according to one embodiment. Substrate carrier 100 includes a first carrier plate 102 and a second carrier plate 104 having the same features and operation as described in reference to **Figs. 1-3C**. Assembly tool 400 may include a support member 402 and a base member 404. Support member 402 may attach to first carrier plate 102 and base member 404 may attach to second carrier plate 104. The support member 402 and base member 404, with respective carrier plates attached, may be drawn together to attach first carrier plate 102 to second carrier plate 104 as previously discussed.

[0043] More specifically, support member 402 may be formed by a substantially planar panel 406 with a similar footprint to that of first carrier plate 102. Panel 406 may have a first side 408 (or top side) and a second side 410 (or bottom side). Push pins 412 may extend from a side of panel 406 facing the first carrier plate 102, in this case, from the second side 410 of panel 406. Push pins 412 may be dimensioned to apply the previously discussed external force needed to move the second end 122 of one or more of cantilevers 116 to the biased position, outside a plane of first carrier plate 102. In this aspect, push pins 412 may be positioned along the second side 410 of support member 402 so that they align with each of cantilevers 116 formed in first carrier plate 102. Push pins 412 may have any size and shape suitable for applying the desired external force to cantilevers 116. Representatively, in one embodiment, push pins 412 are cylindrical structures having a similar width to that of cantilevers 116 such that they can extend through the cantilever cut-outs 436 within first carrier plate 102. Push pins 412 may have any length sufficient to push the second end 122 of the cantilevers 116 to the desired biased position. The number of push pins 412 extending from support member 402 may correspond to the number of cantilevers 116 such that there is one pin 412 aligned with each of cantilevers 116. Push pins 412 may be integrally formed

with the second side 410 of support member 402, or separate structures which are mounted (such as by chemical bonding or mechanical fasteners) to second side 410. In this aspect, support member 402 and push pins 412 may be made of the same or different material, for example, a plastic material or a metal material, or a combination of materials.

[0044] In one embodiment, support member 402 may further include a handle 414 attached to first side 408. Handle 414 may have any size and shape suitable for allowing a user or robotic mechanism to move support member 402 to a desired position. Handle 414 may be integrally formed as part of support member 402, or may be a separate structure mounted (such as by chemical bonding or mechanical fasteners) to first side 408. In this aspect, support member 402 and handle 414 may be made of the same or different material, for example, a plastic material or a metal material, or a combination of materials.

[0045] The second side 410 of support member 402 may be attached to first carrier plate 102 using one or more of a locking pin 416. Locking pin 416 may be dimensioned to be inserted within, and engage with, a locking pin opening 418 within first carrier plate 102 as will be described in more detail in reference to **Fig. 5A** and **Fig. 5B**.

[0046] Base member 404 may be formed by a substantially planar panel upon which second carrier plate 104 may be positioned. Base member 404 may, in one embodiment, have a slightly larger footprint to that of second carrier plate 104 and include recessed regions 434A and 434B at each end to facilitate removal of substrate carrier 100 once assembly is complete. Panel 406 may have a first side 422 (or top side) and a second side 424 (or bottom side). Channels 426A, 426B, 426C and 426D may be formed within the side of panel 406 facing second carrier plate 104, in this case the first side 422. Channels 426A-426D may be aligned with each row of receiving slots 118 so that cantilevers 116 can be pushed through receiving slots 118, below a plane of second carrier plate 104 during the attachment operation. In this aspect, channels 426A-426D may have a depth and width sufficient to receive the second end 122 of each of cantilevers 116. In addition, channels 426A-426D may extend in a same direction as receiving slots 118, for example, in a lengthwise direction along base member 404, and from one end to another end of base member 404.

[0047] To help align channels 426A-426D with receiving slots 118, base member 404 may further include locating pins 430A and 430B and alignment pins 428A, 428B, 428C and 428D extending from the first side 422. Locating pins 430A and 430B may be dimensioned

to fit within openings 432A and 432B, respectively, formed within second carrier plate 104 to help position second carrier plate 104 on base member 404. Alignment pins 428A-428D may be positioned along edges of base member 404 and define a receiving area for second carrier plate 104. In this aspect, when second carrier plate 104 is positioned between alignment pins 428A-428D, it will be centered on base member 404 and each of receiving slots 118 aligned with one of channels 426A-426D.

[0048] **Fig. 5A** illustrates an exploded perspective view of a bottom side of the support member and first carrier plate of **Fig. 4**. From this view, it can be seen that the second side 410 (bottom side) of support member 402 includes push pins 412 and locking pins 416 arranged around its surface. The number of push pins 412 may correspond to the number of cantilevers 116 and the number of locking pins 416 may correspond to the number of locking pin openings 418 formed in first carrier plate 102. Representatively, in one embodiment where first carrier plate 102 includes cantilevers 116A-116H, support member 402 may include push pins 412A, 412B, 412C, 412D, 412E, 412F, 412G, 412H, which each correspond to one of cantilever beams 116A-116H. In this aspect, each of push pins 412A-412H may be arranged along support member 402 such that they align with one of cantilever beams 116A-116H. In some cases, each of push pins 412A-412H are arranged so that they align with a second end 122 of each of cantilevers 116.

[0049] As previously discussed, push pins 412A-412H are dimensioned to push, or otherwise move, a respective one of cantilever beams 116A-116H outside a plane of first carrier plate 102 when the second side 410 of support member 402 is positioned along a surface of first carrier plate 102, for example a top side 130 of first carrier plate 102. Representatively, as can be seen from the magnified view of push pin 412B, which is highlighted in dashed lines, in one embodiment, one or more of push pins 412, in this case push pin 412B, may be a cylindrical structure that is perpendicular to second side 410. In some embodiments, the end of push pin 412B may be closed, and in some cases, rounded to provide a sufficient contact with cantilever 116B. It is contemplated, however, that push pins 412 may be any size and shape suitable for pushing a respective one of cantilevers 116 outside a plane of first carrier plate 102.

[0050] Locking pins 416 may further be of any size and shape suitable for locking support member 402 to first carrier plate 102 using locking pin openings 418. Representatively, as can be seen from the magnified view of locking pin 416A, highlighted

by dashed lines, locking pin 416A may have a shaft portion 502 and a head portion 504. The head portion 504 may be raised above the surface of first side 410 of support member 402 by shaft portion 502. In addition, head portion 504 may be wider than shaft portion 502. The corresponding locking pin opening 418A may have an insertion portion 506 which is large enough to receive the head portion 504 and a locking portion 508 which is wide enough to receive the shaft portion 502 but narrower than the head portion 504. In this aspect, locking pin 416A can be locked within locking pin opening 418A by inserting locking pin 416A within the insertion portion 506 and then sliding the locking pin 416A into the locking portion 508. Because the head portion 504 is larger than the opening of locking portion 508, the locking portion 508 prevents head portion 504 from being pulled out of the locking portion 508, which in turn locks support member 402 to first carrier plate 102. It should be understood that, although not specifically described, each of the locking pins 416B, 416C and 416D and locking pin openings 418B, 418C and 418D may have the same dimensions and operate in a similar manner as locking pin 416A and locking pin opening 418A. In addition, each of locking pin openings 418A-418D may be oriented in the same direction along first carrier plate 102 such that each of the locking pins 416A-416D may be locked within a respective one of the locking pin openings 418A-418D simultaneously by sliding support member 402 with respect to first carrier plate 102.

[0051] Representatively, this sliding operation can be seen from **Fig. 5B**, which illustrates a perspective view of a first carrier plate 102 locked to support member 402. In one embodiment, locking pins 416B and 416D are first inserted into respective locking pin openings 418B and 418D. Once within the openings 418B and 418D, first carrier plate 102 may be slid in a direction of arrow 510 while support member 402 remains stationary to lock the locking pins 416B and 416D within locking pin openings 418B and 418D. This in turn, locks first carrier plate 102 to support member 402. First carrier plate 102 may be unlocked from support member 402 by sliding first carrier plate 102 in a direction opposite arrow 510. It should further be understood that in some embodiments, instead of sliding first carrier plate 102, support member 402 may slide while first carrier plate 102 remains stationary, or both the first carrier plate 102 and support member 402 may be slid in opposite directions to accomplish locking and unlocking of first carrier plate 102 to support member 402.

[0052] Referring now in more detail to the second carrier plate 104 and base member 404, **Fig. 6A** and **Fig. 6B** are perspective views illustrating the positioning of second carrier

plate 104 on base member 404. Representatively, to position second carrier plate 104 on base member 404, locating pins 430A, 430B extending from a top side 602 of base member 404 are aligned with locating pin openings 432A, 432B, respectively, formed in second carrier plate 104. In addition, second carrier plate 104 is aligned within the area between alignment pins 428A- 428D. Once aligned second carrier plate 104 is positioned on the top side 422 of base member as shown in **Fig. 6B**. Positioning of second carrier plate 104 with respect to base member 404 in this manner, further aligns each of receiving slots 118 with one of channels 426A-426D so that when the first carrier plate 102 is attached to the second carrier plate 104, the cantilevers 116 (see, for example, **Fig. 1**) can be inserted within a respective one of the receiving slots 118 as previously discussed. In addition, it can be seen from **Fig. 6B** that the edges of second carrier plate 104 extend beyond the recessed regions 434A and 434B cut into the end edges of base member 404 to facilitate removal of substrate carrier 100 once assembly is complete.

[0053] **Fig. 7** illustrates a perspective view of the substrate carrier and assembly tool of **Fig. 4**. More specifically, **Fig. 7** shows support member 402, first carrier plate 102 attached, second carrier plate 104 and base member 404 aligned with one another to complete the assembly of substrate carrier 100. Representatively, in one embodiment, support member 402 is attached to first carrier plate 102 so that cantilevers 116 are held outside a plane of first carrier plate 102 as previously discussed. Second carrier plate 104 is positioned on base member 404 as described in reference to **Figs. 6A-6B**. One or more of a substrate 106 described in **Fig. 1**, for example, a microelectronic device substrate, is then positioned within cavities 114 of second carrier plate 104 as described in reference to **Fig. 1**. Support member 402 having first carrier plate 102 attached thereto is then positioned on base member 404 so that each of cantilevers 116 of first carrier plate 102 are positioned within receiving slots 118 of second carrier plate 104. In addition, the alignment members 124A, 124B of second carrier plate 104 are positioned within the alignment openings 126A, 126B of first carrier plate 102, as previously discussed in reference to **Fig. 1**. With the first carrier plate 102 and second carrier plate 104 properly aligned and unable to slide with respect to one another due to the alignment members 124A, 124B being within alignment openings 126A, 126B, support member 402 is released from first carrier plate 102. Support member 402 may be released from first carrier plate 102 by sliding the locking pins 416 out of respective openings 418 as previously discussed in reference to **Fig. 5A** and **Fig. 5B**. Once support member 402 is released, the cantilevers 116 of first carrier plate spring back toward the plane of first carrier

plate 102 and engage the receiving slots 118 of second carrier plate 104 as previously discussed in reference to **Figs. 3A-3C**. With first carrier plate 102 clamped to second carrier plate 104, and a substrate 106 sandwiched in between, assembly of the substrate carrier 100 is complete and the substrate carrier 100 can be removed from base member 404, such as by lifting it off of base member 404.

[0054] **Fig. 8** illustrates a cross-sectional side view through line 8-8' of **Fig. 7**. From this view, it can be seen that when support member 402 and base member 404 are assembled as previously discussed, one or more of a substrate 106 is held between first carrier plate 102 and second carrier plate 104 of the substrate carrier 100. In addition, it can be seen that substrate 106 is within the aligned cavity 114 and window 112 of first carrier plate 102 and second carrier plate 104. One or more of the window 112 and the cavity 114 may further include recessed regions 702, 704, respectively, that help to hold the substrate 106 within the first carrier plate 102 and the second carrier plate 104 so that it does not create a gap between the plates.

[0055] Once the substrate 106 is in place, support member 402 and base member 404 may be removed as previously discussed, leaving behind the completed substrate carrier 100. A cross-sectional view of an assembled substrate carrier holding a substrate is shown in **Fig. 9**. Representatively, **Fig. 9** illustrates substrates 106 positioned between first carrier plate 102 and second carrier plate 104.

[0056] **Fig. 10** is a block diagram illustrating one embodiment of a process of assembling a substrate carrier. Representatively, in one embodiment, process 1000 includes providing a first carrier plate (block 1002). The first carrier plate may be a first carrier plate such as first carrier plate 102 described in reference to **Fig. 1**, which includes a cantilever that is biased in a direction toward a plane of the first carrier plate and a window dimensioned to expose a first side of a microelectronic device substrate positioned along the first carrier plate. The process may further include providing a second carrier plate (block 1004). The second carrier plate may be a second carrier plate such as second carrier plate 104 described in reference to **Fig. 1**, which includes a cantilever receiving member or slot and a cavity dimensioned to receive the second side of the microelectronic device substrate. The first carrier plate may be attached to the second carrier plate using the cantilevers of the first carrier plate (block 1006). Representatively, the first carrier plate may be attached to the second plate by positioning an end of one or more of the cantilevers outside a plane of the

first carrier plate and within the cantilever receiving member of the second carrier plate such that the end of the cantilever engages the cantilever receiving member and clamps the second carrier plate against the first carrier plate. In addition, it is contemplated that prior to attaching the first carrier plate to the second carrier plate a microelectronic device substrate may be positioned on either the first carrier plate or the second carrier plate such that when assembly is complete, the substrate is held between the plates for further processing operations. In addition, it should be understood that in any of the embodiments disclosed herein, any number of substrates may be held within the substrate carrier so that a panel of substrates that can be simultaneously processed is formed.

[0057] While certain embodiments have been described and shown in the accompanying drawings, it is to be understood that such embodiments are merely illustrative of and not restrictive on the broad invention, and that the invention is not limited to the specific constructions and arrangements shown and described, since various other modifications may occur to those of ordinary skill in the art. For example, in some embodiments, the substrate carrier assembly process may be automated by a robotic system which performs each of the previously discussed assembly operations with, or without, the presence of a support member and base member such as those previously discussed. The description is thus to be regarded as illustrative instead of limiting.

Claims

1. A carrier apparatus for processing of a microelectronic device substrate, the apparatus comprising:
 - a first carrier plate for processing of a microelectronic device substrate, the first carrier plate having a plurality of cantilevers formed therein, each of the plurality of cantilevers having a first end connected to the first carrier plate and a second end that is movable between a first configuration in which the second end is within a plane of the first carrier plate and a second configuration in which the second end is outside a plane of the first carrier plate; and
 - a second carrier plate for processing of a microelectronic device substrate, the second carrier plate having a plurality of receiving slots formed therein, each of the plurality of receiving slots dimensioned to receive the second end of one of the plurality of cantilevers in the second configuration such that the first carrier plate is clamped to the second carrier plate, and at least one receiving slot of the plurality of receiving slots comprises a recess formed within a sidewall defining the receiving slot, and the recess is dimensioned to receive and hold the second end of one of the plurality of cantilevers within the receiving slot.
2. The carrier apparatus of claim 1 wherein the second end of at least one of the plurality of cantilevers and the second end of another of the plurality of cantilevers face opposite directions.
3. The carrier apparatus of claim 1 wherein at least one of the plurality of cantilevers is biased to move toward a plane of the first carrier plate when it is in the second configuration.
4. The carrier apparatus of claim 1 wherein at least one of the plurality of cantilevers is integrally formed from a material of the first carrier plate.
5. The carrier apparatus of claim 1 wherein interfacing sides of the first carrier plate and the second carrier contact one another when the first carrier plate is clamped to the second carrier plate.
6. The carrier apparatus of claim 1 wherein the first carrier plate further comprises:
 - a window through which a microelectronic device substrate positioned between the first carrier plate and the second carrier plate is exposed for processing.

7. The carrier apparatus of claim 1 wherein the second carrier plate further comprises:
a cavity dimensioned to receive a microelectronic device substrate.

8. A carrier apparatus for processing of a microelectronic device substrate, the apparatus comprising:

a first carrier plate having a plurality of beams and a plurality of windows formed within the first carrier plate, each of the plurality of beams having a first end connected to the first carrier plate and a second end suspended within a plane of the first carrier plate, and wherein each of the plurality of beams is operable to move such that the second end is within a plane of the first carrier plate in a first configuration and outside the plane of the first carrier plate in a second configuration; and

a second carrier plate having a plurality of receiving slots and a plurality of cavities formed therein, wherein each of the plurality of receiving slots is operable to receive the second end of one of the plurality of beams in the second configuration and the one of the plurality of beams clamps the first carrier plate to the second carrier plate such that interfacing sides of the first carrier plate and the second carrier plate contact one another, and wherein each of the plurality of cavities aligns with one of the plurality of windows when the second carrier plate is clamped to the first carrier plate.

9. The carrier apparatus of claim 8 wherein each of the plurality of cavities aligned with one of the plurality of windows is dimensioned to receive a microelectronic device substrate such that at least two sides of the microelectronic device substrate are exposed for processing.

10. The carrier apparatus of claim 8 further comprising:

a base member operable to be positioned along a side of the second carrier plate opposite the first carrier plate, the base member having a plurality of channels, wherein each of the plurality of channels are aligned with one of the plurality of receiving slots when the base member is positioned along the side of the second carrier plate.

11. The carrier apparatus of claim 8 further comprising:

a support member attached to the first carrier plate, the support member having a plurality of pins operable to move the plurality of beams between the first configuration and the second configuration.

12. The carrier apparatus of claim 11 wherein the support member further comprises:
a locking pin to lock the support member to the first carrier plate.
13. The carrier apparatus of claim 12 wherein the first carrier plate further comprises:
an opening dimensioned to receive the locking pin, wherein the locking pin is operable to slide within the opening between a first position in which the support member is locked to the first carrier plate and a second position in which the support member is releasable from the first carrier plate.
14. A method of assembling a carrier for processing of a microelectronic device substrate, the method comprising:
providing a first carrier plate, the first carrier plate having a cantilever that is operable to be biased to move in a direction toward a plane of the first carrier plate and a window dimensioned to expose a first side of a microelectronic device substrate positioned along the first carrier plate;
providing a second carrier plate, the second carrier plate having a cantilever receiving member and a cavity dimensioned to receive the second side of the microelectronic device substrate; and
attaching the first carrier plate to the second carrier plate by positioning an end of the cantilever outside a plane of the first carrier plate and within the cantilever receiving member such that the end of the cantilever engages the cantilever receiving member and holds the second carrier plate against the first carrier plate, and wherein positioning an end of the cantilever outside a plane of the first carrier plate comprises attaching a support member to the first carrier plate, the support member having a pin dimensioned to bend the cantilever.
15. The method of claim 14 wherein the cantilever receiving member comprises a detent dimensioned to engage the end of the cantilever within a plane of the second carrier plate.
16. The method of claim 14 further comprising:
prior to attaching the first carrier plate to the second carrier plate, attaching the second carrier plate to a base member, the base member having a channel that aligns with the cantilever receiving member.

17. The method of claim 14 wherein the cantilever is a first cantilever, the first carrier plate further comprising a second cantilever, and wherein the first cantilever rotates in a first direction to position the end of the first cantilever outside the plane of the first carrier plate and the second cantilever rotates in a second direction to position an end of the second cantilever outside the plane of the first carrier plate, wherein the first direction is different from the second direction.