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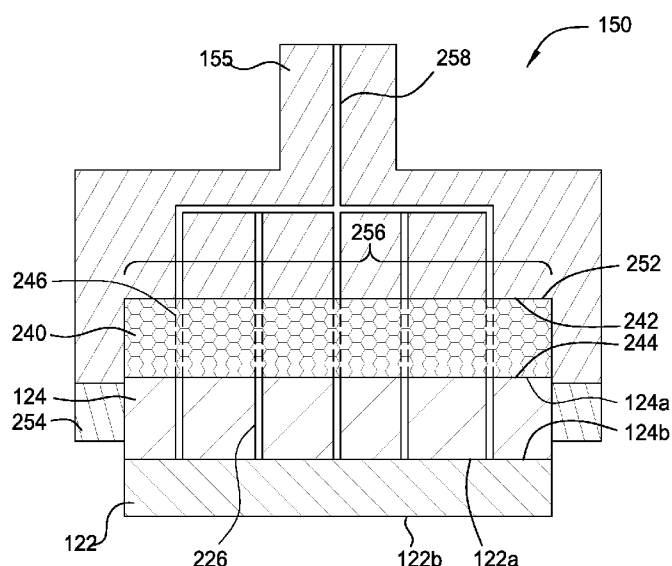


FIG. 2B

(57) Abstract: Embodiments of the disclosure relate to a system, apparatus and method for polishing thin substrates with high planarity. The apparatus comprises a chemical mechanical polishing head and a plate. The polishing head comprises a bottom surface, a retaining ring, a workpiece-receiving pocket defined between the bottom surface and the retaining ring, and at least one vacuum port adapted to provide a vacuum to the workpiece-receiving pocket through the bottom surface of the polishing head. The plate is disposed in the workpiece-receiving pocket such that the upper side of the plate faces the bottom surface of the polishing head and the lower side of the plate faces away from the bottom surface of the polishing head. The plate has a geometry or a material property configured to allow fluid to pass between the upper side and the lower side of the plate upon application of vacuum in the workpiece-receiving pocket.

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ADHESIVE-LESS CARRIERS FOR CHEMICAL MECHANICAL POLISHING

BACKGROUND

Field

[0001] Embodiments of the disclosure generally relate to a system, apparatus and method for polishing thin substrates with high planarity.

Description of the Related Art

[0002] Semiconductors and microelectronic chips are formed starting with a substrate, usually made of silicon. The chips are made on the surface of the substrate using a variety of different deposition and etch processes. In order to make the chips smaller, there are efforts to reduce the thickness of the substrate on which the active circuitry is formed. However, thinner substrates have a high risk of warping and breaking during the deposition and etching processes. In order to prevent warpage and breaking, the substrate is temporarily bonded to a thicker carrier using an adhesive. After bonding, the substrate is thinned, for example, by mechanical grinding.

[0003] The ground substrate is then polished using chemical mechanical polishing (CMP) processes to obtain good total thickness variation (TTV) and low Ra surfaces. For thin substrates having thickness in the range of 5-50 microns, the CMP processes exert a high shear force (lateral force). Adhesive-based temporarily bonded substrates can be successfully polished down to a thickness in the range of 20-50 microns. However, these adhesives are unable to tolerate temperatures greater than 180°C. Therefore, it is not possible to use thin substrates that are temporarily bonded to carriers with adhesives for subsequent substrate-to-substrate bonding at higher temperature (100-400°C) for substrate-to-substrate stacking. As a result, the thin substrate is attached to a carrier without using adhesives so it can withstand higher temperatures. This can be accomplished through electrostatic chucking. However, the high lateral forces during polishing can overcome the electrostatic chucking force and cause the substrate to slip out from under the carrier. Therefore, there is a need for an improved way to polish thin substrates

attached to a carrier without an adhesive such that it does not slip out from under the carrier or get damaged.

SUMMARY

[0004] Embodiments of the disclosure generally relate to a system, apparatus and method for polishing thin substrates with high planarity. In one embodiment, an apparatus for polishing a thin substrate includes a polishing head and a plate. The polishing head comprises a bottom surface, a retaining ring, a workpiece-receiving pocket defined between the bottom surface and the retaining ring, and at least one vacuum port adapted to provide a vacuum to the workpiece-receiving pocket through the bottom surface of the polishing head. The plate is disposed in the workpiece-receiving pocket such that the upper side of the plate faces the bottom surface of the polishing head and the lower side of the plate faces away from the bottom surface of the polishing head. The plate has a geometry or a material property configured to allow fluid to pass between the upper side and the lower side of the plate upon application of the vacuum in the workpiece-receiving pocket.

[0005] In another embodiment of the disclosure, a chemical mechanical polishing (CMP) system is provided that includes a rotatable platen, a polishing head positionable over the platen, a plate and a carrier. The polishing head is adapted to urge a substrate against a polishing pad disposed on the platen for polishing. The polishing head comprises a bottom surface, a retaining ring, a workpiece-receiving pocket defined between the bottom surface and the retaining ring and at least one vacuum port adapted to provide a vacuum to the workpiece-receiving pocket through the bottom surface. The plate is disposed in the workpiece-receiving pocket such that the upper side of the plate faces the bottom surface of the polishing head and the lower side of the plate faces away from the bottom surface of the polishing head. The plate has a geometry or a material property configured to allow fluid to pass between the upper side and the lower side of the plate upon application of a vacuum in the workpiece-receiving pocket. The carrier has an upper mounting surface and a lower mounting surface, such that the upper mounting surface is configured to mate with the plate and the lower mounting surface is configured to

secure a substrate. The carrier has a plurality of vacuum holes extending between the upper mounting surface and the lower mounting surface.

[0006] Yet another embodiment provides a method for polishing a substrate. The method includes vacuum chucking a substrate through a carrier to a polishing head by vacuum applied through a plate disposed between the head and the carrier, and polishing the substrate on a polishing pad.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] So that the manner in which the above recited features of the present disclosure can be understood in detail, a more particular description of the disclosure, briefly summarized above, may be had by reference to embodiments, some of which are illustrated in the appended drawings. It is to be noted, however, that the appended drawings illustrate only exemplary embodiments and are therefore not to be considered limiting of its scope, may admit to other equally effective embodiments.

[0008] Figure 1 is a perspective view of a chemical mechanical polishing (CMP) apparatus used in semiconductor fabrication.

[0009] Figure 2A is a cross-sectional view of a carrier.

[0010] Figure 2B is a cross-sectional view of a polishing head.

[0011] Figure 3A is a schematic representation of a substrate-carrier combination to be polished.

[0012] Figure 3B is a schematic representation of the substrate being polished by a CMP apparatus.

[0013] Figure 3C is a schematic representation of the substrate slipping out from under the carrier held by the polishing head.

[0014] Figure 4A is a schematic representation of a plate disposed within the polishing head prior to attachment of the substrate-carrier combination to the polishing head.

[0015] Figure 4B is a schematic representation of a plate disposed over the substrate-carrier combination prior to attachment to the polishing head.

[0016] Figure 4C is a schematic representation of how the CMP apparatus in this disclosure prevents the substrate from slipping out from under the carrier.

[0017] Figure 5 is a block diagram of a method for polishing a substrate.

[0018] To facilitate understanding, identical reference numerals have been used, where possible, to designate identical elements that are common to the figures. It is contemplated that elements and features of one embodiment may be beneficially incorporated in other embodiments without further recitation.

DETAILED DESCRIPTION

[0019] Embodiments of the disclosure generally relate to a system, apparatus and method for polishing thin substrates with high planarity.

[0020] Chemical mechanical polishing (CMP) is a method of polishing or planarization of thin substrates used in fabrication of semiconductor devices. CMP has become a key technology for removing irregularities and achieving required planarity, layer and line width geometries of microelectronic devices, like integrated circuit chips. An important consideration in the production of microelectronic devices is process and product stability. To achieve a high yield, i.e., a low defect rate, each successive substrate is polished under similar conditions. Each substrate, in other words, is polished approximately the same amount so that each semiconductor substrate is substantially identical in planarity. Disclosed herein are apparatus and techniques that enable robust polishing of thin substrates while mitigating the potential of substrate damage due to slippage of the substrate from under the head of the polishing apparatus while polishing.

[0021] Referring to the drawings, Figure 1 is a perspective view of a chemical mechanical polishing (CMP) apparatus 100 suitable for use in semiconductor fabrication. The CMP apparatus 100 is generally composed of a polishing head 150, a polishing pad 130 mounted on a rotatable platen 160 and a fluid delivery arm 140. The fluid delivery arm 140 dispenses a stream of polishing fluid 145 on the

polishing pad 130 during polishing of a substrate 122. The polishing fluid, such as but not limited to an abrasive slurry, is supplied to the polishing surface 135 of the pad 130 to assist removal of material from the substrate 122 while the substrate 122 is processed against the polishing surface 135.

[0022] The platen 160 is operably coupled to a drive motor (not shown) that is adapted to rotate the platen 160 about a rotational axis 110 in a direction shown by the arrow. The platen 160 supports the polishing pad 130 so that the polishing surface 135 can be in contact with and process the substrate 122. In some embodiments, the polishing surface 135 is at least twice the size (i.e., diameter) of the substrate 122 that is to be processed on the polishing pad 130. The polishing pad 130 rotates due to the rotational motion of the platen 160 during polishing.

[0023] In one embodiment, the polishing material of the polishing surface 135 may be a commercially available pad material, such as polymer based pad materials utilized in CMP processes. The polymer material may be polyurethane, a polycarbonate, fluoropolymers, polytetrafluoroethylene (PTFE), polyphenylene sulfide (PPS), or combinations thereof. The polishing material may further comprise open or closed cell foamed polymers, elastomers, felt, impregnated felt, plastics, and like materials compatible with the processing chemistries. In another embodiment, the polishing material is a felt material impregnated with a porous coating. In other embodiments, the polishing material includes a material that is at least partially conductive.

[0024] The fluid delivery arm 140 delivers the polishing fluid 145, such as but not limited to an abrasive slurry, to the polishing surface 135 of the polishing pad 130 during polishing. The polishing fluid 145 may contain abrasive particles, a pH adjuster and/or chemically active components to enable chemical mechanical polishing of the substrate 122. The chemistry of the polishing fluid 145 is selected to polish substrate surfaces and may include metals, metal oxides, and semimetal oxides, among other materials. In some embodiments, the polishing fluid may be a chemical solution, water, a polishing compound, a cleaning solution, or a combination thereof.

[0025] The CMP apparatus 100 also includes a pad conditioner (not shown) that is configured to cause a pad conditioning disk (not shown) to be urged against and sweep across the polishing surface 135 at different times during the polishing process cycle to abrade and rejuvenate the polishing surface 135 of the polishing pad 130.

[0026] A carrier 124 is utilized to hold a substrate 122 against the polishing surface 135 of the polishing pad 130. The carrier 124 is retained by the polishing head 150, which is used to urge the substrate 122 against the polishing pad 130.

[0027] The polishing head 150, as shown in Figures 1 and 2B, is disposed above the polishing surface 135 of the polishing pad 130. In some embodiments, the polishing head 150 is suspended over the polishing pad 130 by a support member (not shown) which may be a carousel, circular or linear track, or other apparatus. The polishing head 150 is configured to retain the substrate 122 and controllably urge the substrate 122 towards the polishing surface 135 during polishing. As shown in Figure 2B, the polishing head 150 has a bottom surface 252, a retaining ring 254 and a workpiece-receiving pocket 256. The workpiece-receiving pocket 256 is defined as the space between the bottom surface 252 and the retaining ring 254. The workpiece-receiving pocket 256 has a diameter selected to receive a substrate having a diameter of 200mm, 300mm or 450 mm. The polishing head also has one or more vacuum ports 258 configured to provide a vacuum from a vacuum source through the workpiece-receiving pocket 256 to the bottom surface 252. As the combination of the substrate 122 and the carrier 124 is placed in connection with the bottom surface 252, it is supported by the retaining ring 254 and gets disposed within the pocket 256.

[0028] The polishing head 150 is rotated by a shaft 155 coupled to an actuator or a motor (not shown). The rotating polishing head 150 in concert with the rotating polishing pad 130 applies a lateral force to the substrate 122 as it is urged against the polishing pad 130. In other embodiments, the polishing head 150 may have a linear motion relative to the polishing pad 130. In addition, the polishing head 150 may be used to move the substrate 122 vertically towards and against the polishing

pad 130. The polishing head 150 may also be moved in a sweeping motion to generate relative motion between the substrate 122 and the polishing surface 135.

[0029] The polishing head 150 provides a controllable load, i.e., pressure, on the substrate 122 to push it vertically down against the polishing pad 130. In addition, the polishing head 150 rotates to provide additional motion between the substrate 122 and the polishing pad 130. The polishing rate (i.e., the rate of removal of the material from the substrate) is affected by the pressure applied to the substrate 122 against the polishing pad 130, the velocity of the polishing pad 130 relative to the substrate 122, the amount of polishing fluid 145 introduced to the polishing surface 135, and the condition of the polishing pad 130.

[0030] The thin substrate 122 may be composed of a variety of different types of materials, such as but not limited to silicon, gallium arsenide, lithium niobate, etc. The substrate 122 may have a diameter of 200mm, 300mm, 450mm or other diameter. The substrate 122 may have a thickness of less than 100 microns. The substrate 122 is attached to a carrier 124 during the chemical mechanical polishing process.

[0031] The carrier 124 has the shape of a cylindrical disk and has a diameter substantially equal to that of the substrate 122 to be polished. The carrier 124 is positionable in the workpiece-receiving pocket 256 of the polishing head 150. The diameter of the pocket 256 is greater than the diameter of the carrier 124 so that the carrier 124 can be positioned within the pocket 256. In some embodiments, the carrier 124 may have a diameter substantially similar to a 200mm substrate, a 300mm substrate or a 450mm substrate. The carrier 124 may have a thickness between 400 microns and 1500 microns. The carrier 124 may be made of a ceramic material, using a rigid dielectric substrate with conducting electrodes embedded within. Since thin substrates that are temporarily bonded to carriers with adhesives cannot be used for subsequent processing at higher temperature (100-400°C), the substrate 122 and the carrier 124 are held together by electrostatic chucking force. The carrier 124 has a plurality of vacuum holes 226 extending between the upper mounting surface 124a and the lower mounting surface 124b. The substrate 122 can be more robustly secured to the carrier 124 while in the polishing head 150

during polishing by applying vacuum to the substrate 122 through the vacuum holes 226.

[0032] Figure 2A shows a cross-sectional view of the carrier 124 that holds the substrate 122 while in the polishing head 150. The carrier 124 has an upper mounting surface 124a and a lower mounting surface 124b. The upper mounting surface 124a is configured to mate with the lower side 244 of a plate 240. The lower mounting surface 124b is configured to secure an upper surface 122a of the substrate 122, while a lower surface 122b of the substrate 122 is polished. The lower mounting surface 124b is exposed below the retaining ring 254 (as shown in Figure 2B).

[0033] In some embodiments, the carrier 124 is an electrostatic chuck. For example, the carrier 124 may be a bipolar electrostatic chuck. In the example depicted in Figure 2A, the carrier 124 has two chucking electrodes 228a and 228b that can be electrically coupled to a power source 225 located outside the carrier 124 via the terminals 227a and 227b respectively. The power source 225 is configured to provide chucking power to the electrodes 228a, 228b, such that the substrate 122 can be electrostatically chucked to the carrier 124, as shown in Figure 3A. The chucking electrodes 228a, 228b may be an interdigitated mesh that maintains a chucking force after power is removed from the electrodes 228a, 228b. For example, when the terminals 227a, 227b are disconnected from the power source 225, the carrier 124 can freely transport the substrate 122 chucked thereon without the connection to the power source 225. In an alternative embodiment, a battery power source 229 embedded within the carrier 124 may be used instead of the power source 225.

[0034] Figure 3A shows the substrate 122 and the carrier 124 electrostatically chucked together. The carrier 124 is electrically charged by a power source 225 through the application of voltages across the embedded chucking electrodes 228a and 228b (shown in Figure 2A). The applied voltage from the power source 225 create localized bipolar electrostatic attraction between the substrate 122 and the carrier 124, resulting in a stacked combination 120 of the substrate 122 and the carrier 124. The carrier 124 is able to retain sufficient electrostatic force to process

the substrate 122, after the power source 225 is disconnected. The electrostatic attraction between the carrier 124 and the substrate 122 can be released electrically by neutralizing the electrostatic charge that holds them together. The combination 120 of the carrier 124 and the substrate 122 has a combined thickness of between 500 microns and 1500 microns.

[0035] Figure 2B shows a plate 240 disposed within the workpiece-receiving pocket 256. An upper side 242 of the plate 240 contacts the bottom surface 252 of the polishing head 150. A lower side 244 of the plate 240 is configured to abut a substrate or a substrate-carrier combination, as described above. The plate 240 may be made of a ceramic material and has a geometry or a material property that allows fluid passage between the upper side 242 and the lower side 244 upon application of vacuum in the workpiece-receiving pocket 256. The pressure drop between the upper side 242 and the lower side 244 of the plate 240 (i.e., across the thickness of the plate 240) is less than about 50% at a nominal superficial velocity of between one and two meters per second. In one example, the pressure drop between the upper side 242 and the lower side 244 of the plate 240 is less than about 10% at a nominal superficial velocity of between one and two meters per second. In some embodiments, the plate 240 may be porous in nature so that the upper side 242 of the plate and the lower side 244 are fluidly coupled. In other embodiments, the plate 240 may be a porous ceramic disk with about 30-70% open porosity and has a pore size of less than 200 microns—for example, ranging between 0.25 to 90 microns. Monolithic, single-grade, aluminum oxide porous ceramic may have pore sizes of 6, 15, 30, 50, 60 and 120 microns and can be used for the plate 240. In some alternative embodiments, the plate 240 may also have a predetermined pattern of a plurality of fine holes 246 (shown in Figure 2B), having an open area sufficient to apply the vacuum force to the substrate 122. In those embodiments, the plurality of fine holes 246 is distributed across the bottom surface of the plate 240 and each hole has a diameter in the range of 10-50 microns. In those embodiments, the plate 240 may be made from a conducting or semi-conducting material.

[0036] The diameter of the plate 240 is substantially similar to a 200mm substrate, 300mm substrate or a 450mm substrate. The thickness of the plate 240 may be between 250 microns and 1000 microns.

[0037] Figure 3B is a schematic representation of the substrate 122 being polished while held in the polishing head 150. The polishing head 150 rotates and pushes down the substrate 122 on the rotating polishing pad 130. The lower surface 122b of the substrate 122 is urged against the polishing surface 135 on the polishing pad 130, thus polishing the substrate 122. While polishing the substrate 122, the shear force at the interface between the substrate 122 and the polishing surface 135 may be overcome by the frictional force holding the substrate 122 to the carrier 124. As a result, the substrate 122 may slip out from under the carrier 124 and be damaged. Figure 3C is a schematic representation of the substrate 122 slipping out from under the carrier 124. The frictional force at the interface between the substrate 122 and the carrier 124 is a function of the product of the electrostatic chucking force and the coefficient of friction. The frictional force remains a constant for a constant chucking voltage. The shear force at the interface of the substrate 122 and the polishing surface 135 is inversely proportional to the thickness of the substrate 122. Therefore, the surface shear force is higher for thinner substrates than for thicker substrates, which causes the substrate 122 to be more likely to slip out from under the carrier 124.

[0038] Advantageously, the CMP apparatus 100 mitigates the aforementioned problem of the slippage of thin substrates from under the carrier. The plate 240 disposed within the polishing head 150 with vacuum ports 258 enables active coupling of the substrate 122 through the vacuum holes 226 in the carrier 124 by application of vacuum. The vacuum force supplements the electrostatic force between the substrate 122 and the carrier 124, and allows the combination 120 to successfully withstand the higher shear force during the polishing process. After the polishing process is complete, the vacuum is turned off, which releases the combination 120 from the plate 240 and the polishing head 150. The combination 120 is subsequently de-chucked to separate the substrate 122 from the carrier 124. De-chucking is the process of draining the accumulated electrostatic charge that

holds the substrate 122 to the carrier 124 by applying a voltage of reverse polarities from the power source 225 to the chucking electrodes 228a and 228b (shown in Figure 2A). The absence of electrostatic force causes the substrate 122 to be de-chucked from the carrier 124.

[0039] In some embodiments, the plate 240 is first disposed under the polishing head 150 by a fastener or clamp or by application of vacuum. The polishing head 150 is moved over the combination 120 and the combination 120 is then secured in the pocket 256 under the plate 240 by the application of vacuum through the vacuum ports 258 and the holes in the plate 240. The vacuum provides sufficient suction force to hold the combination 120 to the polishing head 150. The vacuum through the vacuum holes 226 in the carrier 124 also enhances the force holding the substrate 122 to the carrier 124 in addition to the electrostatic chucking force between them.

[0040] Figure 4A is a schematic representation of the plate 240 disposed within the polishing head 150 with the combination 120 under the polishing head 150. If the plate 240 is disposed under the polishing head 150 by application of vacuum, both the combination 120 and the plate 240 are released when the vacuum is turned off, after the polishing process is complete. In that case, the plate 240 is already separated from the combination 120 and a collection mechanism, such as but not limited to a robot, collects both the plate 240 and the combination 120. The substrate 122 is retrieved by de-chucking the electrostatic force between the carrier 124 and the substrate 122. The plate 240 and/or the carrier 124 may be utilized with subsequent substrates processed in the CMP apparatus. If the plate 240 is unitarily attached to the polishing head 150 by a means other than vacuum, only the combination 120 is released when the vacuum is turned off after the polishing process is complete. That is, the plate 240 remains attached to the polishing head 150 after the combination 120 is released and is utilized in the polishing head 150 to secure the next combination 120 to be polished. The substrate 122 is subsequently retrieved by de-chucking the electrostatic force between the carrier 124 and the substrate 122.

[0041] In other embodiments, the plate 240 is disposed over the combination 120 prior to attachment to the polishing head 150. Application of vacuum through the vacuum ports 258 provides sufficient suction force to hold the plate 240 and the combination 120 to the polishing head 150. The holes 246 and/or porosity of the plate 240 and the vacuum holes 226 in the carrier 124 secure the plate 240 and the combination 120 to the polishing head 150.

[0042] Figure 4B is a schematic representation of the plate 240 disposed over the combination 120 prior to attachment to the polishing head 150. After the polishing process is complete, the vacuum is turned off to release both the combination 120 and the plate 240. The plate 240 is already separated from the combination 120 and a collection mechanism collects both the plate 240 and the combination 120. The substrate 122 is retrieved by de-chucking the electrostatic force between the carrier 124 and the substrate 122.

[0043] During the polishing process using the CMP apparatus 100, the substrate 122 is urged against the polishing pad 130 and rotated about a longitudinal axis 110 (shown in Figure 1). The shear force between the substrate 122 and the moving polishing surface 135 cannot overcome the sum of the electrostatic and frictional forces at the interface between the substrate 122 and the carrier 124, and the suction force due to the vacuum between the substrate 122 and the carrier 124. This prevents the substrate 122 from slipping out from under the carrier 124. Figure 4C is a schematic representation of how the CMP apparatus 100 in this disclosure prevents the substrate 122 from slipping out from under the carrier 124.

[0044] Figure 5 is a block diagram of a method for polishing a substrate described in the embodiments above. The method 500 begins at block 505 by chucking the substrate 122 to the carrier 124 to form a substrate-carrier combination. In one example, the substrate 122 is electrostatically chucked to the carrier 124. As mentioned above, the voltage applied from the power source 225 via terminals 227a and 227b to the chucking electrodes 228a and 228b respectively in the carrier 124 creates localized bipolar electrostatic attraction across the substrate 122 and the carrier 124, resulting in a stacked combination 120 of the substrate 122 and the carrier 124 (shown in Figure 2A). The power source 225 is disconnected

from the terminals 227a and 227b and the residual electrostatic force retains the substrate 122 to the carrier 124 as the combination 120.

[0045] At block 510, the combination 120 is chucked to a polishing head 150 by applying vacuum through the plate 240 disposed over the combination 120. As described above, the plate 240 has a geometry or material property which allows fluid to pass between the upper side 242 and the lower side 244 of the plate 240 upon application of a vacuum. In one example, as in Figure 4A, the plate 240 is first disposed under the polishing head 150 by a means of attachment or by application of vacuum. The combination 120 is then disposed under the plate 240 by the application of vacuum through the vacuum ports 258 and the plate 240, which provides sufficient suction force to hold the plate 240 and the combination 120 to the polishing head 150. In another example, the plate 240 is disposed over the combination 120 prior to attachment to the polishing head 150. Application of vacuum through the vacuum ports 258 provides sufficient suction force to hold the plate 240 and the combination 120 to the polishing head 150.

[0046] At block 515, the substrate 122 is polished on a polishing pad, while the combination 120 is disposed within the polishing head 150. The exposed surface of the substrate 122 is placed against the rotating polishing pad 130. The polishing head 150 pushes down the bonded combination 120 onto the polishing pad 130 with a lateral pressure in the range of 0.8-4psi (equivalent to a force of 110-440 lbf or 50-200 kgf on a 300mm substrate).

[0047] At block 520, the vacuum is turned off to release the combination 120. In some embodiments, when the vacuum is turned off, the plate 240 is retained in the polishing head and is ready to attach another substrate-carrier combination. In other embodiments, both the plate 240 and the combination 120 are released when the vacuum is turned off. A collection mechanism picks up both the plate 240 and the combination 120. In either case, the substrate 122 is retrieved by de-chucking the electrostatic force between the carrier 124 and the substrate 122. De-chucking is accomplished by applying a voltage of reverse polarities to drain the accumulated electrostatic charge that holds the substrate 122 to the carrier 124.

[0048] The method and apparatus described above enables polishing of thin substrates by preventing slippage of the substrate from under the carrier and any damage that may be caused to the substrate subsequently. This method also allows the thin substrate to endure higher temperature since adhesives, which typically fail at elevated temperatures are not used for holding the substrate and the carrier together. Therefore, the processed thin substrates may have better total thickness variation (TTV) and planarity to enable successful circuitry design on them. These thin substrates are expected to meet the future requirements for high-density 3D Dynamic Random Access Memory (DRAM) applications, image sensors and emerging market segments.

[0049] While the foregoing is directed to particular embodiments of the present disclosure, it is to be understood that these embodiments are merely illustrative of the principles and applications of the present invention. It is therefore to be understood that numerous modifications may be made to the illustrative embodiments to arrive at other embodiments without departing from the spirit and scope of the present inventions, as defined by the appended claims.

What is claimed is:

1. An apparatus for polishing a substrate, the apparatus comprising:
 - a chemical mechanical polishing (CMP) head comprising:
 - a bottom surface;
 - a retaining ring;
 - a workpiece-receiving pocket defined between the bottom surface and the retaining ring; and
 - at least one vacuum port adapted to provide a vacuum to the workpiece-receiving pocket through the bottom surface; and
 - a plate disposed in the workpiece-receiving pocket, an upper side of the plate facing the bottom surface of the polishing head and a lower side facing away from the bottom surface of the polishing head, the plate having a geometry or a material property configured to allow fluid to pass between the upper side and the lower side of the plate upon application of the vacuum in the workpiece-receiving pocket.
2. The apparatus of claim 1, wherein the pressure drop between the upper side and the lower side of the plate is less than 50% at a nominal superficial velocity of between one and two meters per second.
3. The apparatus of claim 1, wherein the plate has porosity between 30-70% and pores less than 200 microns in size.
4. The apparatus of claim 1, wherein the plate has a plurality of holes fluidly coupling the upper side and the lower side of the plate.
5. The apparatus of claim 1, wherein the plate has a diameter substantially similar to a 200mm semiconductor substrate, 300mm semiconductor substrate or a 450mm semiconductor substrate.

6. The apparatus of claim 1, wherein the plate is fabricated from at least one of a ceramic material, a conducting material and a semi-conducting material, the plate comprising a plurality of fine holes formed therethrough.
7. The apparatus of claim 1, wherein the plate has a thickness of between 250 microns and 1000 microns.
8. A chemical mechanical polishing (CMP) system comprising:
a rotatable platen;
a chemical mechanical polishing (CMP) head positionable over the platen, the polishing head adapted to urge a substrate against a polishing pad disposed on the platen for polishing, the polishing head comprising:
a bottom surface;
a retaining ring;
a workpiece-receiving pocket defined between the bottom surface and the retaining ring; and
at least one vacuum port adapted to provide a vacuum to the workpiece-receiving pocket through the bottom surface;
a plate positionable in the workpiece-receiving pocket, an upper side of the plate facing the bottom surface of the polishing head and a lower side facing away from the bottom surface of the polishing head, the plate having a geometry or a material property configured to allow fluid to pass between the upper side and the lower side of the plate upon application of a vacuum in the workpiece-receiving pocket; and
a carrier having an upper mounting surface and a lower mounting surface, the upper mounting surface configured to mate with the plate and the lower mounting surface configured secure a substrate, the carrier having a plurality of vacuum holes extending between the upper mounting surface and the lower mounting surface.
9. The system of claim 8, wherein the carrier is fabricated from a ceramic material.

10. The system of claim 8, wherein the carrier is positionable in the workpiece-receiving pocket below the plate.

11. The system of claim 8, wherein the pressure drop between the upper side and the lower side of the plate is less than 50% at a nominal superficial velocity of between one and two meters per second.

12. The system of claim 8, wherein the plate has porosity between 30-70% and pores less than 200 microns in size.

13. The system of claim 8, wherein the plate is fabricated from at least one of a ceramic material, a conducting material and a semi-conducting material, the plate comprising a plurality of fine holes formed therethrough.

14. The system of claim 8, wherein the plate and the carrier have a combined thickness of between 500 microns and 1500 microns.

15. A method of polishing a substrate, the method comprising:

vacuum chucking a substrate through a carrier to a chemical mechanical polishing (CMP) head by vacuum applied through a plate disposed between the head and the carrier;

applying vacuum to the substrate through pores formed through the plate;
and

polishing the substrate chucked to the head on a polishing pad.

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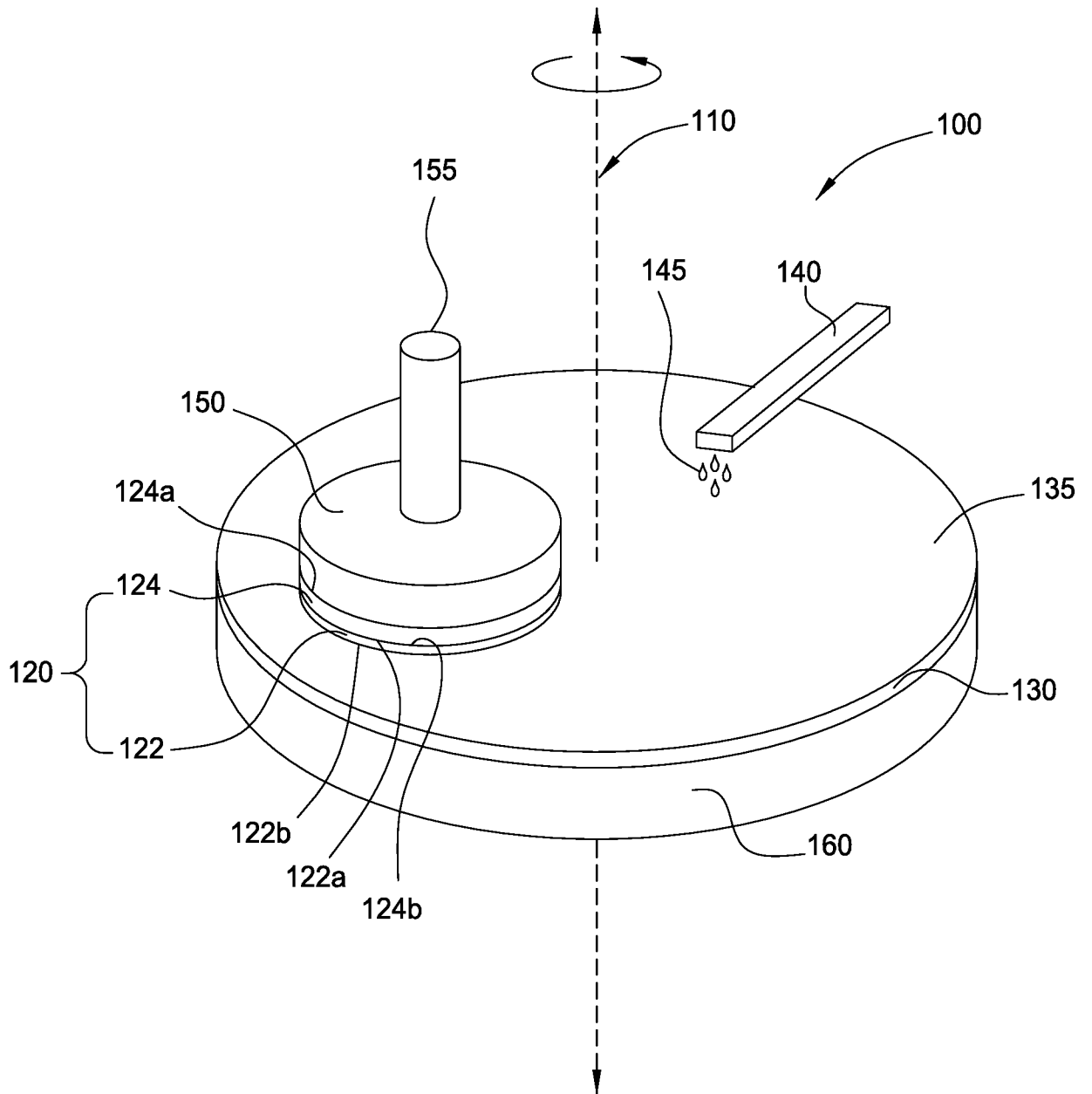


FIG. 1

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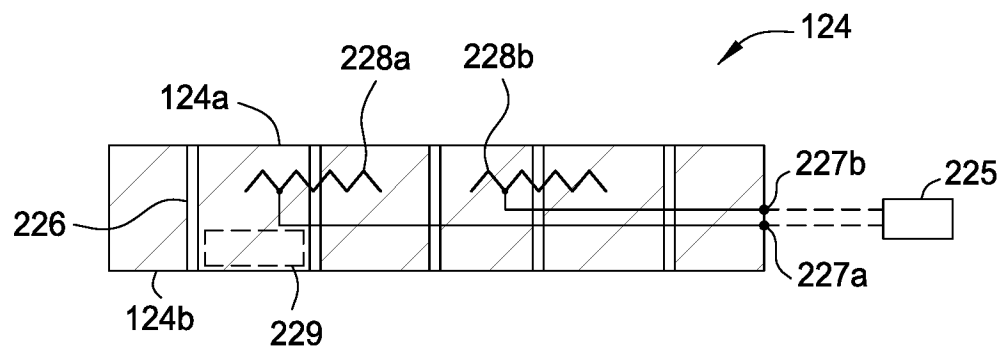


FIG. 2A

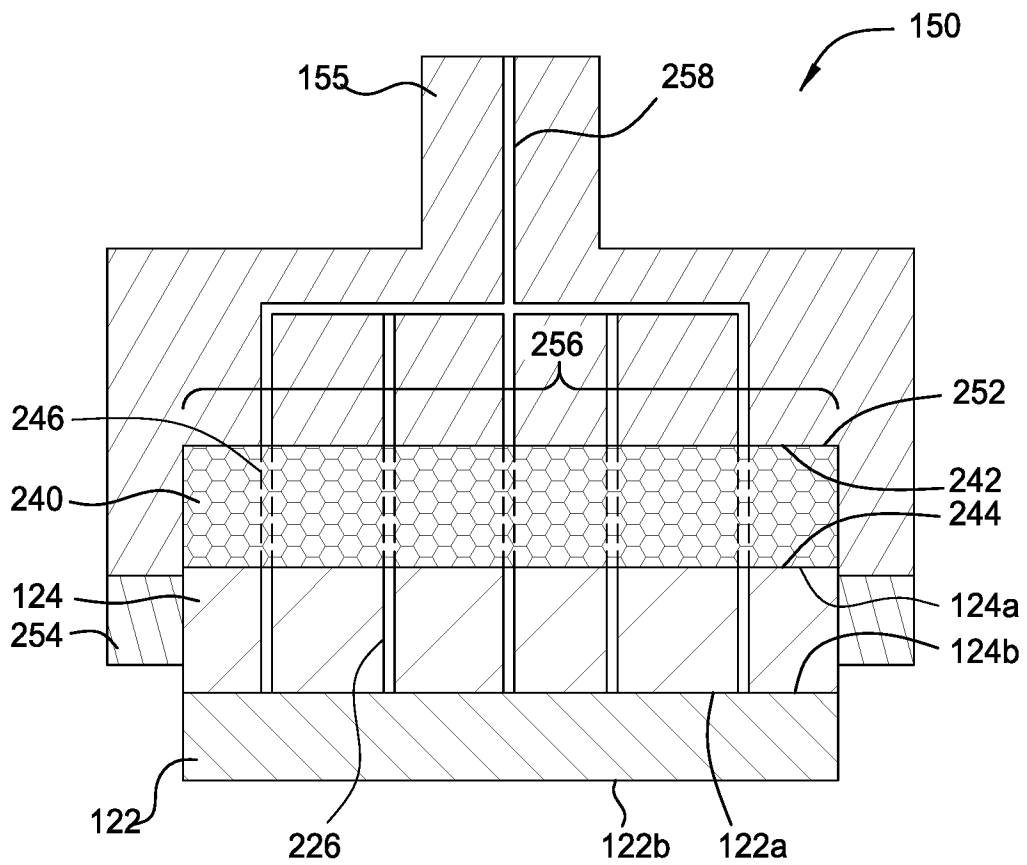


FIG. 2B

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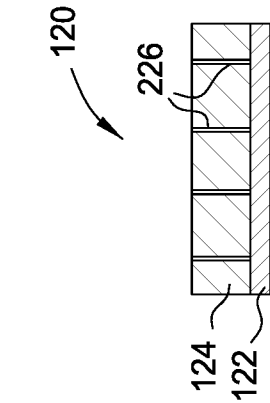


FIG. 3A

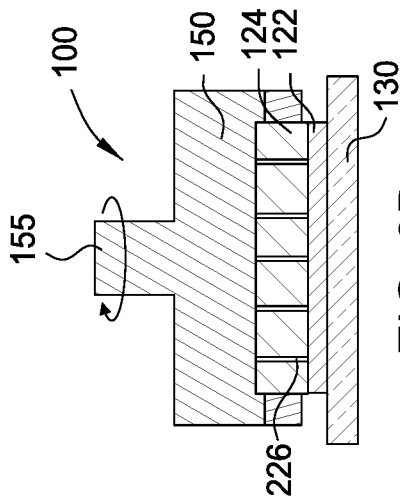


FIG. 3B

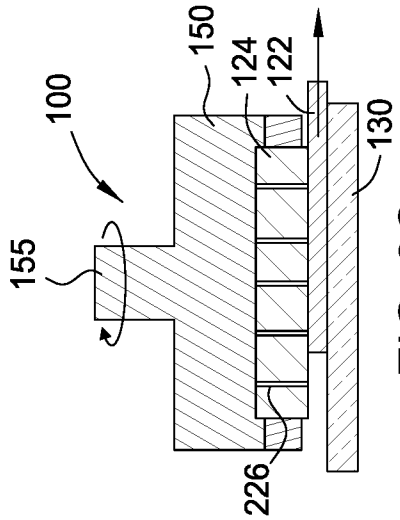


FIG. 3C

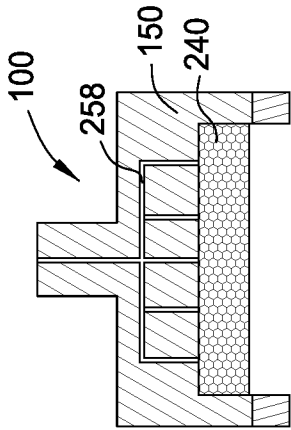


FIG. 4A

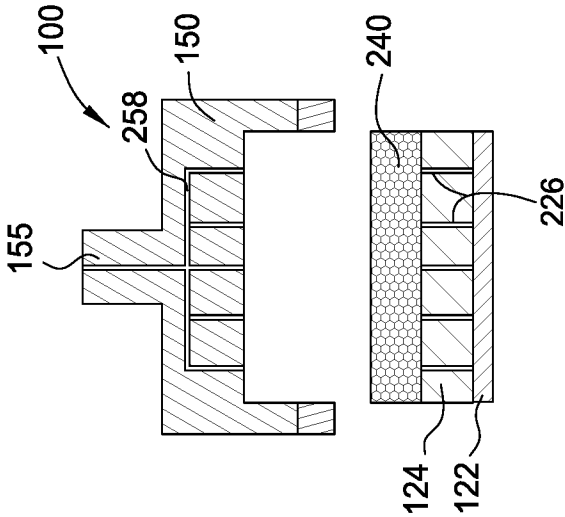


FIG. 4B

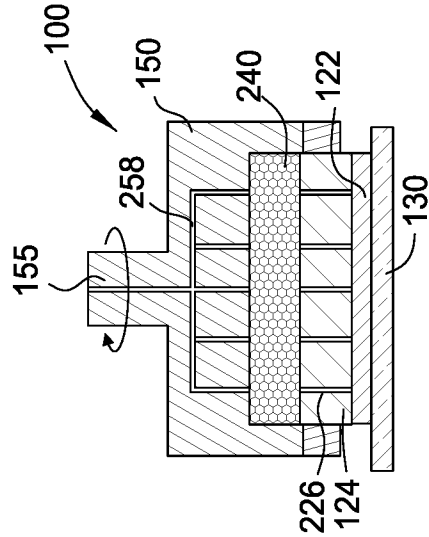


FIG. 4C

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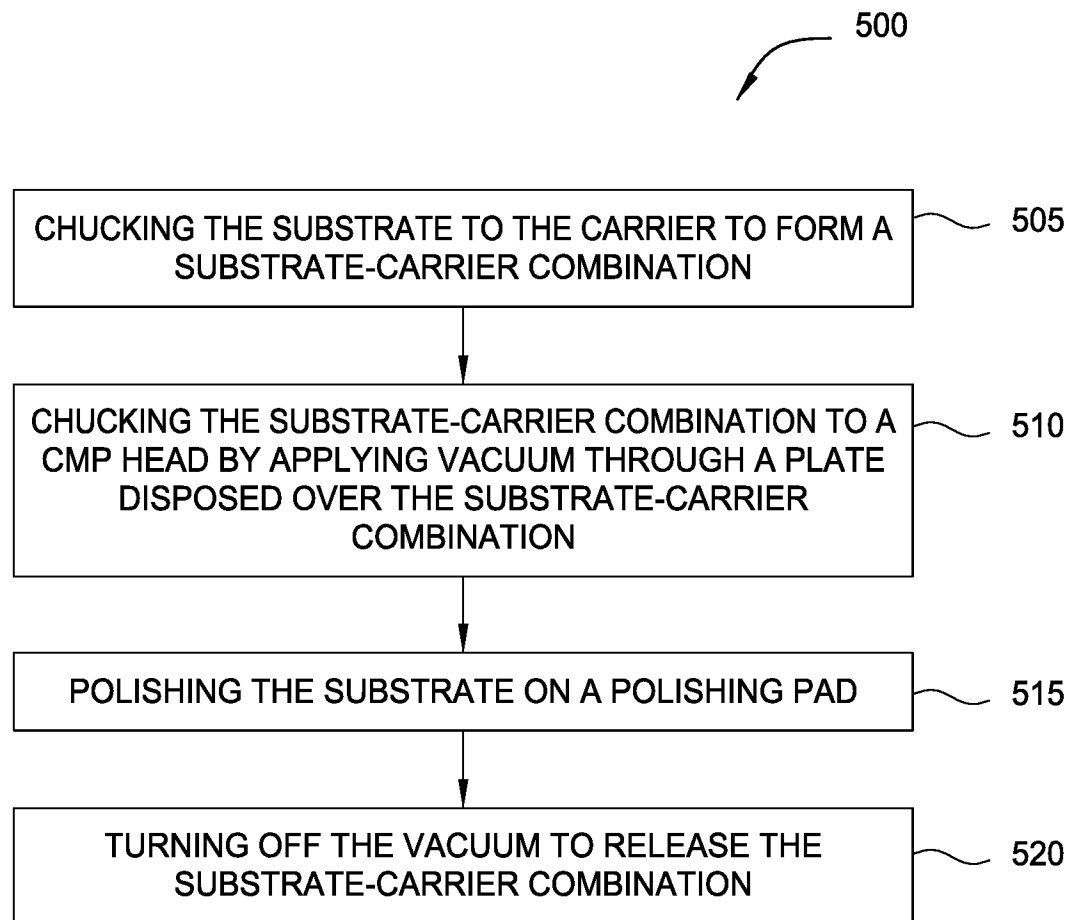


FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2018/021561**A. CLASSIFICATION OF SUBJECT MATTER****B24B 37/30(2012.01)i, B24B 37/04(2006.01)i, H01L 21/304(2006.01)i, H01L 21/306(2006.01)i, H01L 21/67(2006.01)i, H01L 21/673(2006.01)i, H01L 21/683(2006.01)i**

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B24B 37/30; H01L 21/304; B24B 7/22; B24B 37/00; H01T 23/00; B24B 41/06; C23F 1/02; B24B 37/04; H01L 21/306; H01L 21/67; H01L 21/673; H01L 21/683

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & keywords: chemical mechanical polishing head, CMP, vacuum port, workpiece-receiving pocket, plate, and ceramic

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2006-0245138 A1 (KOH et al.) 02 November 2006 See paragraphs [0002]-[0003], [0035], [0049]-[0060] and figures 1-6.	1-15
A	US 5938512 A (TAKEI et al.) 17 August 1999 See column 3, lines 51-64, column 4, line 63 - column 5, line 9 and figures 1-2.	1-15
A	JP 07-290355 A (NIPPON STEEL CORP. et al.) 07 November 1995 See paragraph [0026] and figures 1-4.	1-15
A	EP 1125686 A1 (SHIN-ETSU HANDOTAI CO., LTD.) 22 August 2001 See paragraphs [0023]-[0026] and figure 2.	1-15
A	US 6030488 A (IZUMI et al.) 29 February 2000 See column 6, line 41 - column 7, line 28 and figure 1.	1-15



Further documents are listed in the continuation of Box C.



See patent family annex.

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

19 June 2018 (19.06.2018)

Date of mailing of the international search report

19 June 2018 (19.06.2018)

Name and mailing address of the ISA/KR

International Application Division

Korean Intellectual Property Office

189 Cheongsa-ro, Seo-gu, Daejeon, 35208, Republic of Korea



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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2018/021561

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2006-0245138 A1	02/11/2006	AU 2003-248610 A1 TW 200504918 A WO 2005-005096 A1	28/01/2005 01/02/2005 20/01/2005
US 5938512 A	17/08/1999	EP 0850723 A1 EP 0850723 B1 JP 10-193260 A TW 387110 B	01/07/1998 20/11/2002 28/07/1998 11/04/2000
JP 07-290355 A	07/11/1995	None	
EP 1125686 A1	22/08/2001	DE 60007273 T2 EP 1125686 A4 EP 1125686 B1 JP 2000-233366 A JP 3623122 B2 KR 10-0701340 B1 TW 426585 B US 6422922 B1 WO 00-47368 A1	23/09/2004 24/04/2002 17/12/2003 29/08/2000 23/02/2005 29/03/2007 21/03/2001 23/07/2002 17/08/2000
US 6030488 A	29/02/2000	EP 0857541 A2 EP 0857541 A3 JP 10-217112 A KR 10-1998-0071123 A	12/08/1998 03/02/1999 18/08/1998 26/10/1998