



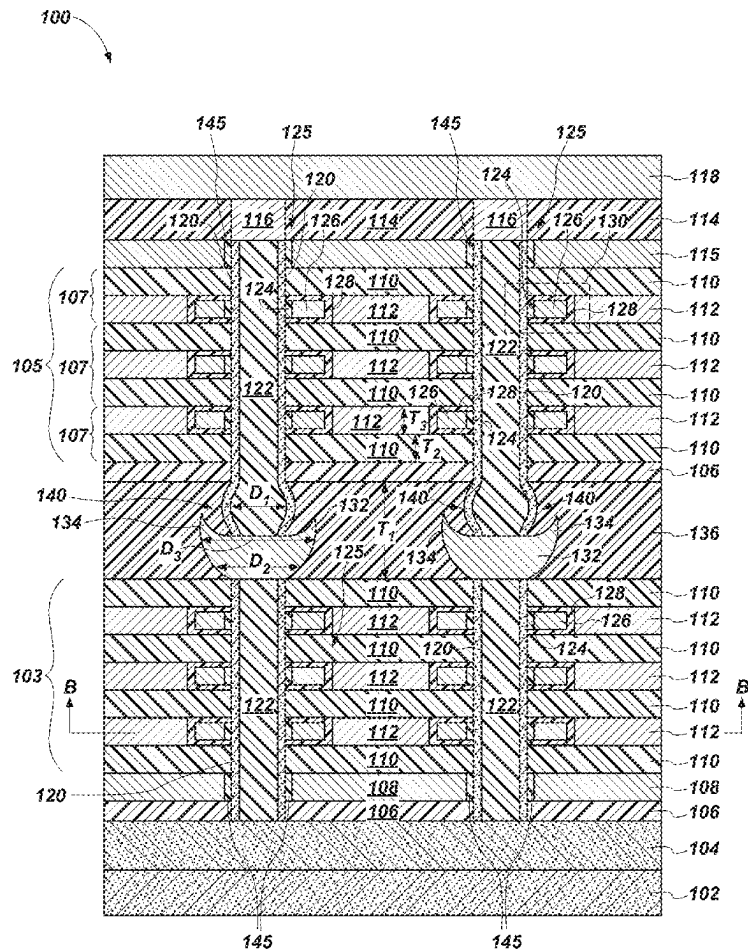
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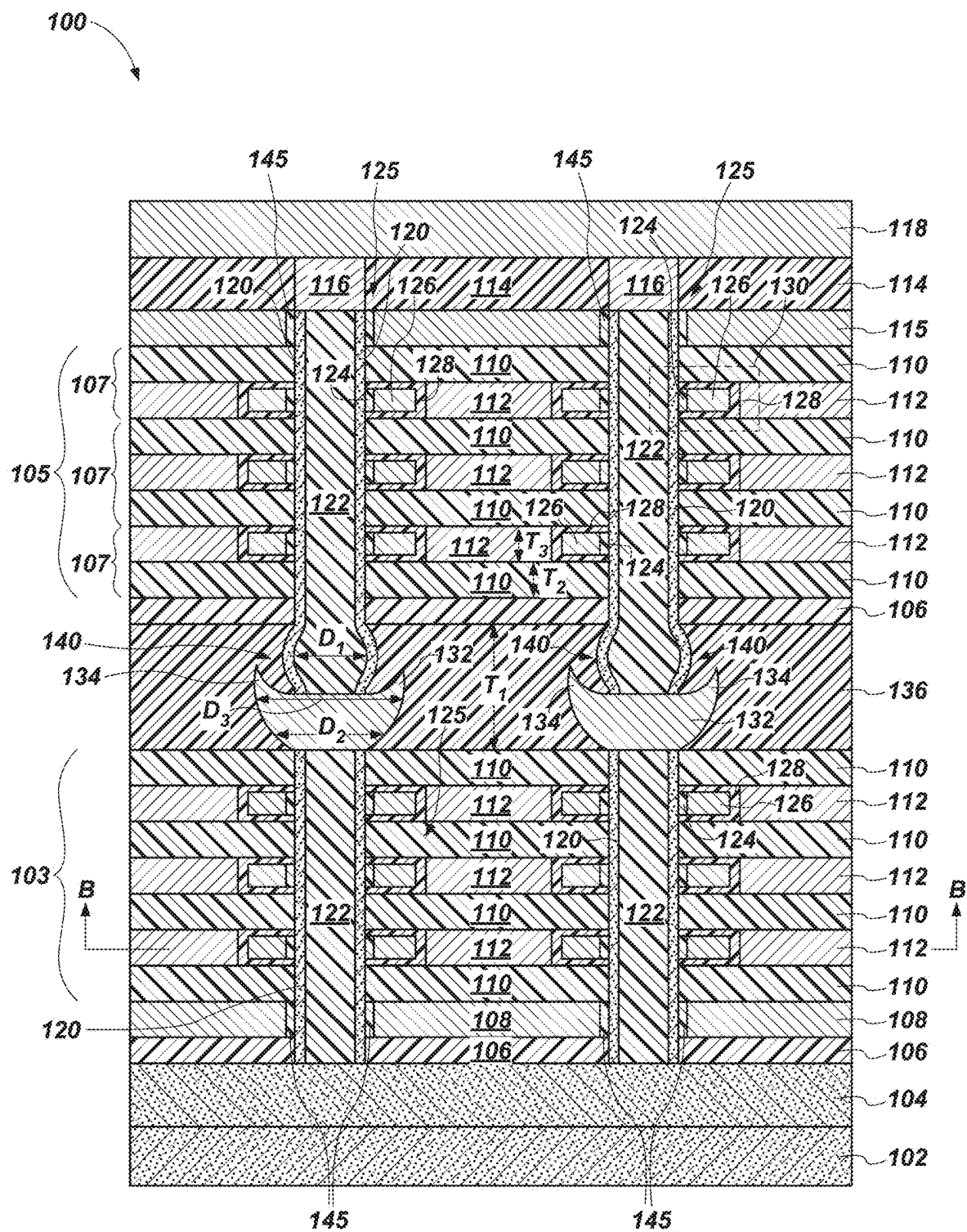
(19) **United States**(12) **Patent Application Publication**
Bicksler et al.(10) **Pub. No.: US 2025/0261373 A1**(43) **Pub. Date: Aug. 14, 2025**(54) **MEMORY DEVICES INCLUDING OXIDE
MATERIAL BETWEEN DECKS THEREOF***H01L 23/528* (2006.01)*H01L 23/535* (2006.01)*H10B 41/27* (2023.01)*H10B 41/35* (2023.01)*H10B 43/35* (2023.01)(71) Applicant: **Lodestar Licensing Group LLC**,
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C. Brighten**, Boise, ID (US)(52) **U.S. Cl.**CPC *H10B 43/27* (2023.02); *H01L 21/76805*(2013.01); *H01L 21/76895* (2013.01); *H01L**23/5283* (2013.01); *H01L 23/535* (2013.01);*H10B 41/27* (2023.02); *H10B 41/35*(2023.02); *H10B 43/35* (2023.02)(21) Appl. No.: **19/193,565**(22) Filed: **Apr. 29, 2025****Related U.S. Application Data**(60) Continuation of application No. 18/437,609, filed on
Feb. 9, 2024, now Pat. No. 12,310,024, which is a
continuation of application No. 17/661,713, filed on
May 2, 2022, now Pat. No. 11,917,825, which is a
division of application No. 16/541,944, filed on Aug.
15, 2019, now Pat. No. 11,355,514.**Publication Classification**(51) **Int. Cl.***H10B 43/27* (2023.01)*H01L 21/768* (2006.01)

(57)

ABSTRACT

A microelectronic device includes decks comprising alternating levels of a conductive material and an insulative material, the decks comprising pillars including a channel material extending through the alternating levels of the conductive material and the insulative material, a conductive contact between adjacent decks and in electrical communication with the channel material of the adjacent decks, and an oxide material between the adjacent decks, the oxide material extending between an uppermost level of a first deck and a lowermost level of a second deck adjacent to the first deck. Related electronic systems and methods of forming the microelectronic device and electronic systems are also disclosed.





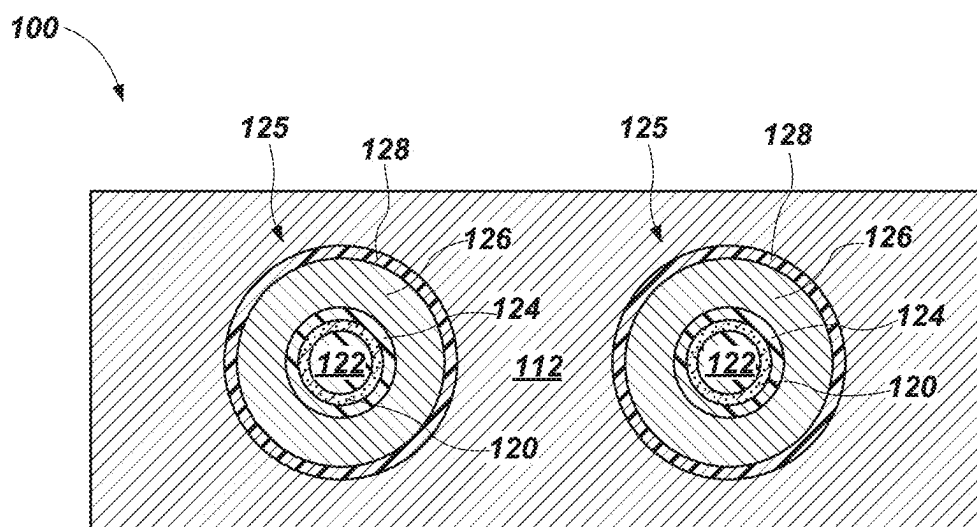


FIG. 1B

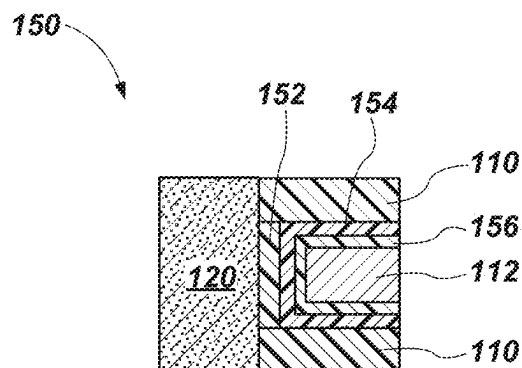
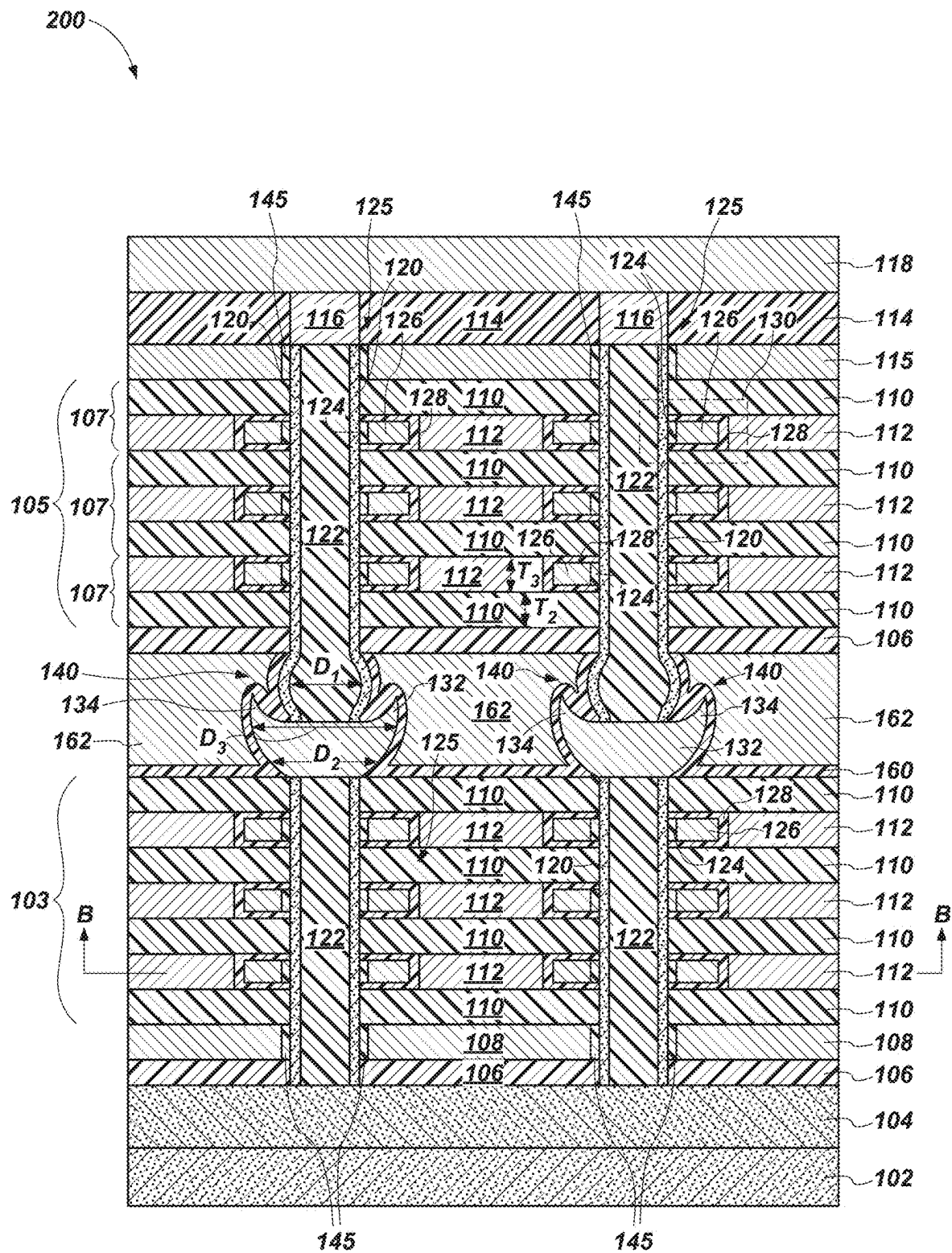
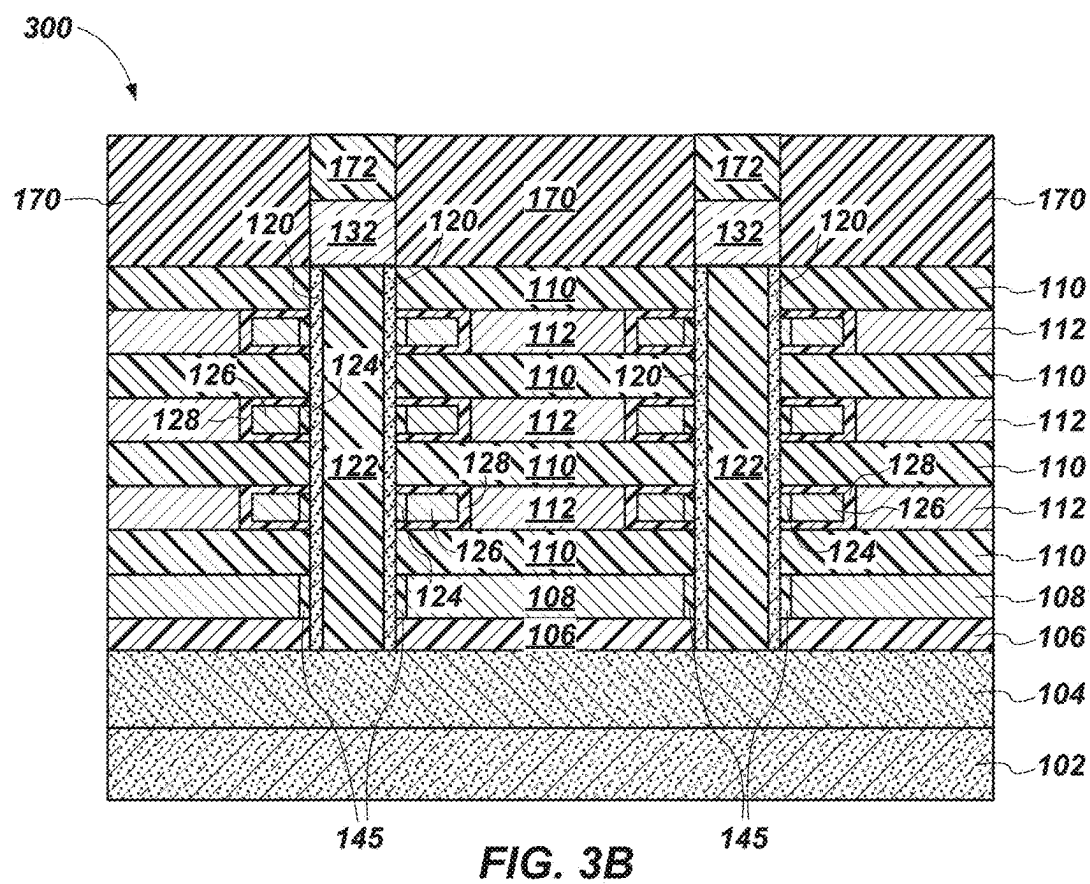
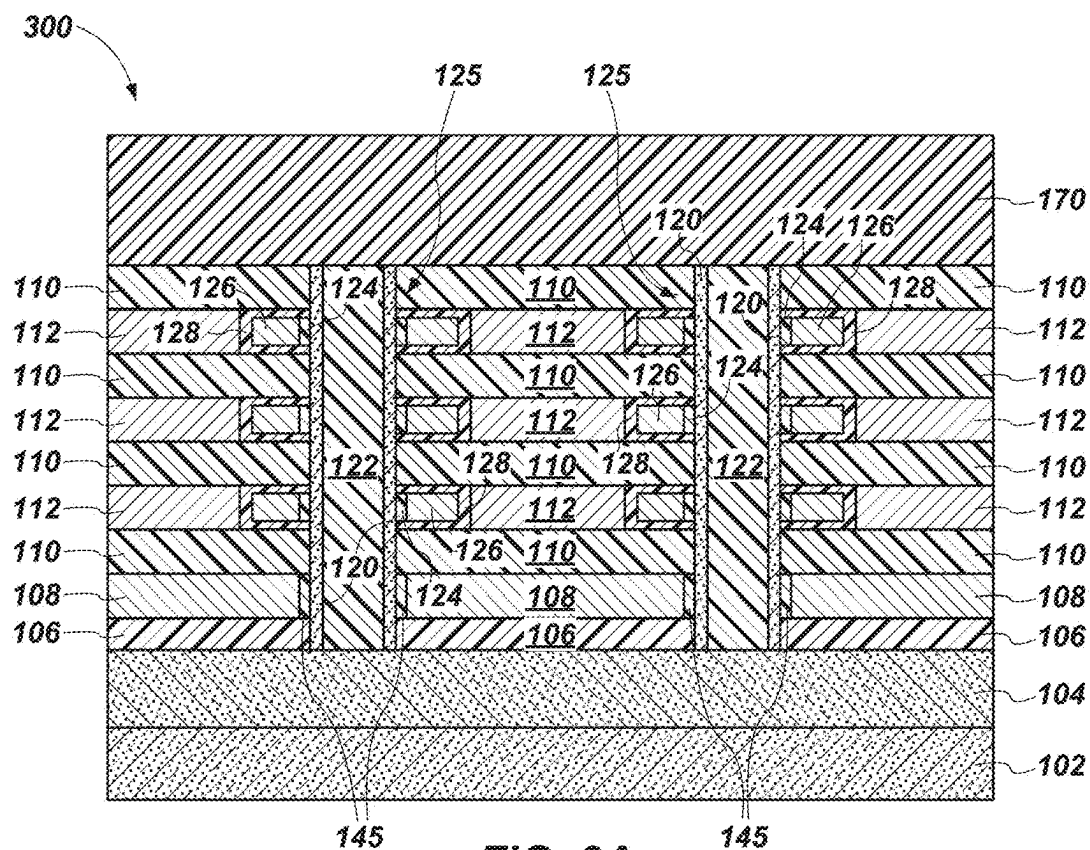
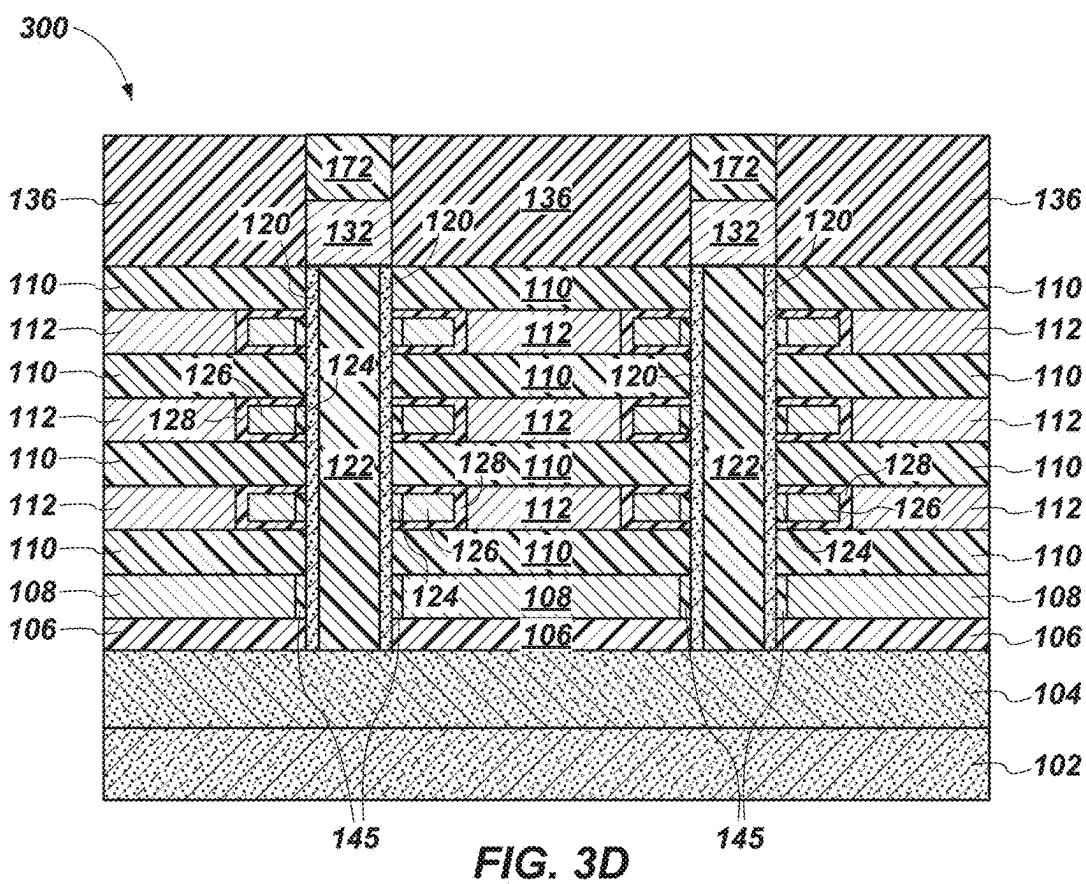
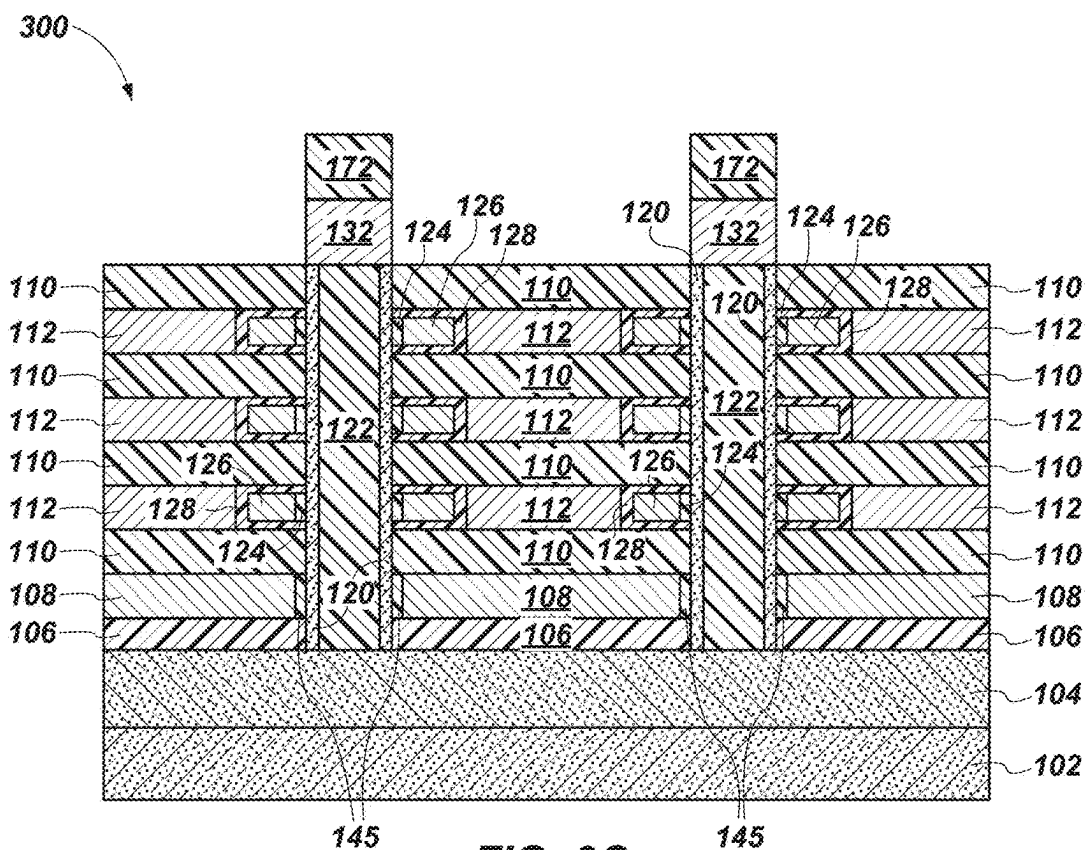
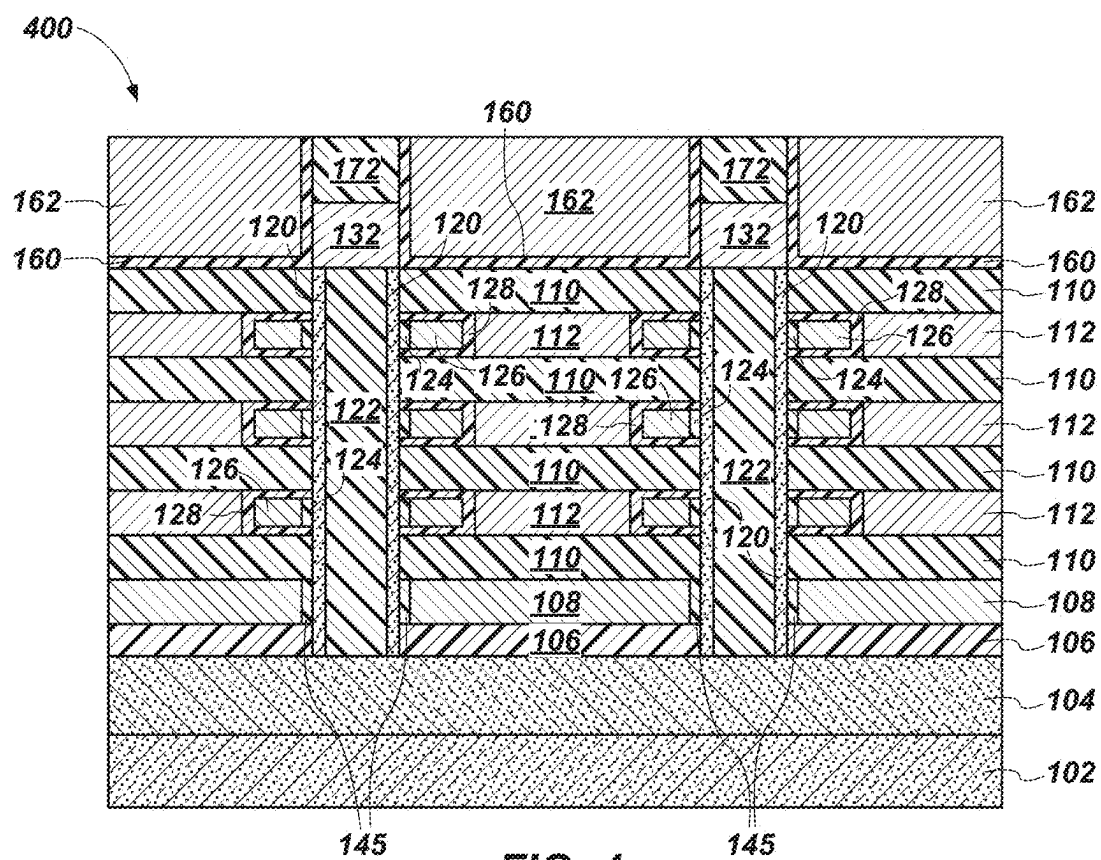


FIG. 1C









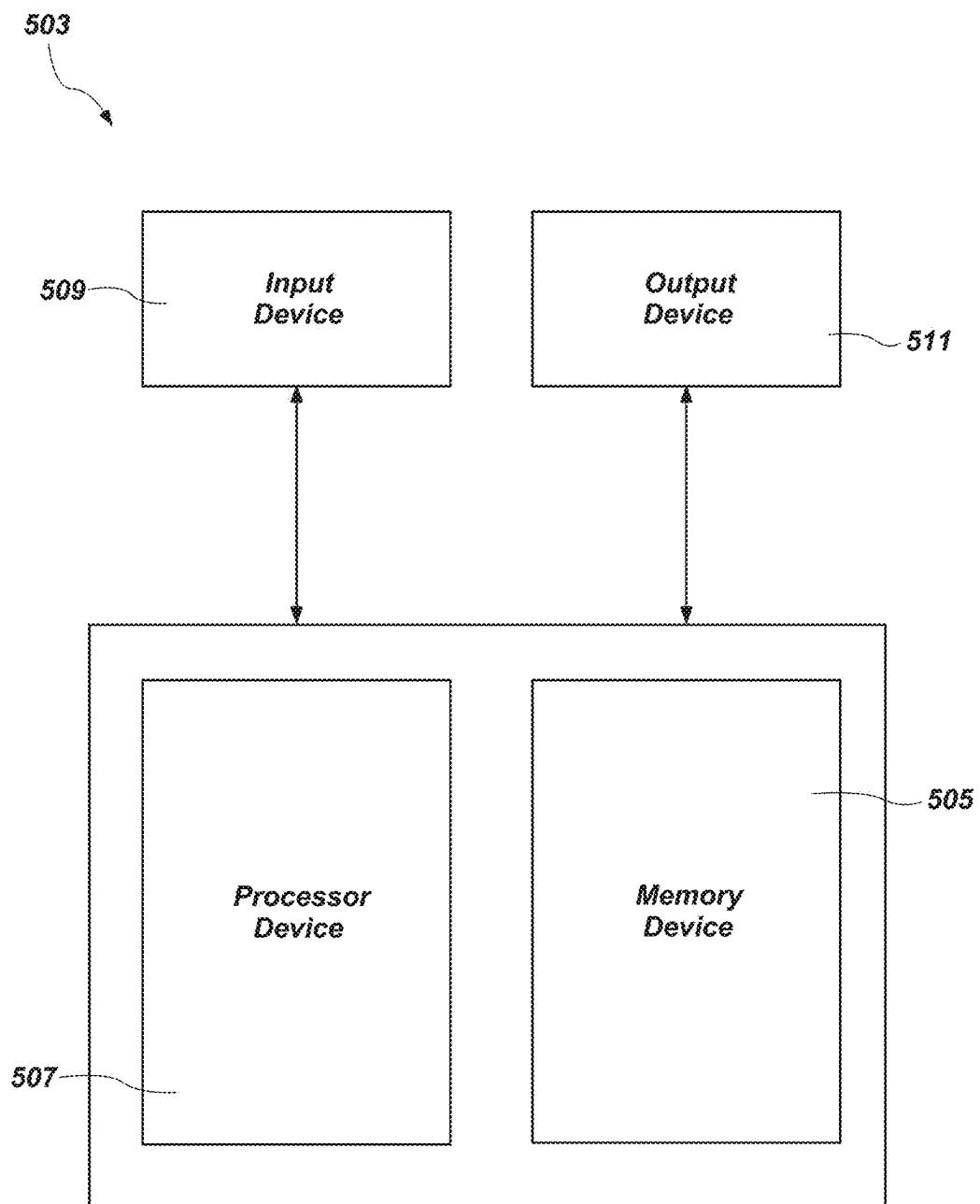


FIG. 5

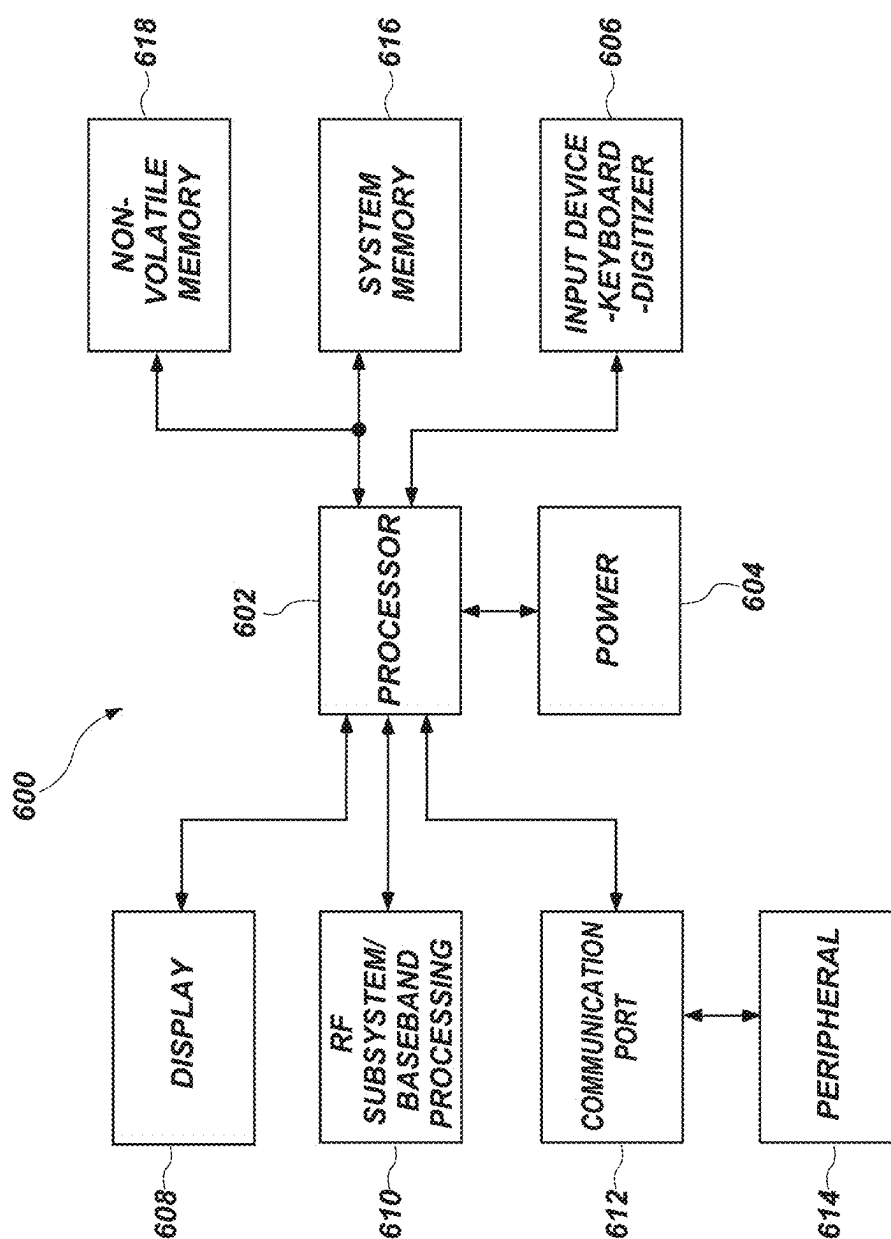


FIG. 6

MEMORY DEVICES INCLUDING OXIDE MATERIAL BETWEEN DECKS THEREOF

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation of U.S. patent application Ser. No. 18/437,609, filed Feb. 9, 2024, which is a continuation of U.S. patent application Ser. No. 17/661,713, filed May 2, 2022, now U.S. Pat. No. 11,917,825, issued Feb. 27, 2024, which is a divisional of U.S. patent application Ser. No. 16/541,944, filed Aug. 15, 2019, now U.S. Pat. No. 11,355,514, issued Jun. 7, 2022, the disclosure of each of which is hereby incorporated herein in its entirety by this reference.

TECHNICAL FIELD

[0002] Embodiments disclosed herein relate to microelectronic devices and electronic systems including an oxide material between decks of alternating levels of insulative material and conductive material, and to related methods. More particularly, embodiments of the disclosure relate to microelectronic devices and electronic systems comprising memory strings extending through decks of alternating levels of insulative material and conductive material and including an oxide material that does not exhibit charge trapping characteristics, and to related methods of forming the microelectronic devices and electronic systems.

BACKGROUND

[0003] A continuing goal of the semiconductor industry has been to increase the memory density (e.g., the number of memory cells per memory die) of memory devices, such as non-volatile memory devices (e.g., NAND Flash memory devices). To meet demands for higher capacity memories, designers continue to strive for increasing memory density, (i.e., the number of memory cells for a given area of an integrated circuit die). One way to increase memory density is to reduce the feature size of individual memory cells. However, as the feature size decreases, the thickness of different portions of the memory cell, such as a tunnel dielectric material, may also exhibit a similar decrease in size. A tunnel dielectric material having a low thickness may result in an increased risk of failure of the tunnel dielectric material and charge leakage from a storage node of the memory cell.

[0004] Another proposal for increasing memory density in non-volatile memory devices is to utilize vertical memory array (also referred to as a “three-dimensional (3D) memory array”) architectures. A conventional vertical memory array includes semiconductor pillars extending through openings in tiers of conductive structures (e.g., word lines, control gates) and dielectric materials at each junction of the semiconductor pillars and the conductive structures. Such a configuration permits a greater number of transistors to be located in a unit of die area by building the array upwards (e.g., longitudinally, vertically) on a die, as compared to structures with conventional planar (e.g., two-dimensional) arrangements of transistors. As the demand for higher densities of memory cells increases, the semiconductor pillars are patterned to have a smaller pitch between adjacent pillars. In addition, multiple decks comprising the tiers of conductive structures and dielectric materials may be pat-

terned one over the other to facilitate an increased number of memory cells in the device.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] FIG. 1A is a simplified cross-sectional view of a microelectronic device, in accordance with embodiments of the disclosure;

[0006] FIG. 1B is a simplified cross-sectional view of the microelectronic device taken along section line B-B of FIG. 1A;

[0007] FIG. 1C is a simplified cross-sectional view of a memory cell, in accordance with embodiments of the disclosure;

[0008] FIG. 2 is a simplified cross-sectional view of a microelectronic device, in accordance with embodiments of the disclosure;

[0009] FIG. 3A through FIG. 3D are simplified cross-sectional views illustrating a method of forming a microelectronic device, in accordance with embodiments of the disclosure;

[0010] FIG. 4 is a simplified cross-sectional view illustrating a method of forming a microelectronic device, in accordance with other embodiments of the disclosure;

[0011] FIG. 5 is a block diagram of an electronic system, in accordance with embodiments of the disclosure; and

[0012] FIG. 6 is a processor-based system, in accordance with embodiments of the disclosure.

DETAILED DESCRIPTION

[0013] The illustrations included herewith are not meant to be actual views of any particular systems, microelectronic devices, electronic systems, or memory cells, but are merely idealized representations that are employed to describe embodiments herein. Elements and features common between figures may retain the same numerical designation except that, for ease of following the description, reference numerals begin with the number of the drawing on which the elements are introduced or most fully described.

[0014] The following description provides specific details, such as material types, material thicknesses, and processing conditions in order to provide a thorough description of embodiments described herein. However, a person of ordinary skill in the art will understand that the embodiments disclosed herein may be practiced without employing these specific details. Indeed, the embodiments may be practiced in conjunction with conventional fabrication techniques employed in the semiconductor industry. In addition, the description provided herein does not form a complete description of a microelectronic device or an electronic system, or a complete description of a process flow for fabricating the microelectronic device or electronic system. The structures described below do not form complete microelectronic devices or electronic systems. Only those process acts and structures necessary to understand the embodiments described herein are described in detail below. Additional acts to form a complete microelectronic device or electronic system may be performed by conventional techniques.

[0015] The materials described herein may be formed by conventional techniques including, but not limited to, spin coating, blanket coating, chemical vapor deposition (CVD), atomic layer deposition (ALD), plasma-enhanced ALD, physical vapor deposition (PVD), plasma-enhanced chemical vapor deposition (PECVD), or low-pressure chemical

vapor deposition (LPCVD). Alternatively, the materials may be grown in situ. Depending on the specific material to be formed, the technique for depositing or growing the material may be selected by a person of ordinary skill in the art. The removal of materials may be accomplished by any suitable technique including, but not limited to, etching, abrasive planarization (e.g., chemical-mechanical planarization), or other known methods unless the context indicates otherwise.

[0016] As used herein, the terms “longitudinal,” “vertical,” “lateral,” and “horizontal” are in reference to a major plane of a substrate (e.g., base material, base structure, base construction, etc.) in or on which one or more structures and/or features are formed and are not necessarily defined by Earth’s gravitational field. A “lateral” or “horizontal” direction is a direction that is substantially parallel to the major plane of the substrate, while a “longitudinal” or “vertical” direction is a direction that is substantially perpendicular to the major plane of the substrate. The major plane of the substrate is defined by a surface of the substrate having a relatively large area compared to other surfaces of the substrate.

[0017] As used herein, the term “substantially” in reference to a given parameter, property, or condition means and includes to a degree that one of ordinary skill in the art would understand that the given parameter, property, or condition is met with a degree of variance, such as within acceptable tolerances. By way of example, depending on the particular parameter, property, or condition that is substantially met, the parameter, property, or condition may be at least 90.0 percent met, at least 95.0 percent met, at least 99.0 percent met, at least 99.9 percent met, or even 100.0 percent met.

[0018] As used herein, “about” or “approximately” in reference to a numerical value for a particular parameter is inclusive of the numerical value and a degree of variance from the numerical value that one of ordinary skill in the art would understand is within acceptable tolerances for the particular parameter. For example, “about” or “approximately” in reference to a numerical value may include additional numerical values within a range of from 90.0 percent to 110.0 percent of the numerical value, such as within a range of from 95.0 percent to 105.0 percent of the numerical value, within a range of from 97.5 percent to 102.5 percent of the numerical value, within a range of from 99.0 percent to 101.0 percent of the numerical value, within a range of from 99.5 percent to 100.5 percent of the numerical value, or within a range of from 99.9 percent to 100.1 percent of the numerical value.

[0019] As used herein, spatially relative terms, such as “beneath,” “below,” “lower,” “bottom,” “above,” “upper,” “top,” “front,” “rear,” “left,” “right,” and the like, may be used for ease of description to describe one element’s or feature’s relationship to another element(s) or feature(s) as illustrated in the figures. Unless otherwise specified, the spatially relative terms are intended to encompass different orientations of the materials in addition to the orientation depicted in the figures. For example, if materials in the figures are inverted, elements described as “below” or “beneath” or “under” or “on bottom of” other elements or features would then be oriented “above” or “on top of” the other elements or features. Thus, the term “below” can encompass both an orientation of above and below, depending on the context in which the term is used, which will be evident to one of ordinary skill in the art. The materials may

be otherwise oriented (e.g., rotated 90 degrees, inverted, flipped, etc.) and the spatially relative descriptors used herein interpreted accordingly.

[0020] As used herein, an “electrically conductive material” may refer to one or more of a metal, such as tungsten, titanium, nickel, platinum, palladium, ruthenium, aluminum, copper, molybdenum, gold, a metal alloy, a metal-containing material (e.g., metal nitrides, metal silicides (tantalum silicides, tungsten silicides, nickel silicides, titanium silicides), metal carbides, metal oxides), a conductively doped semiconductor material (e.g., conductively doped silicon, conductively doped germanium, conductively doped silicon germanium, etc.), polysilicon, other materials exhibiting electrical conductivity, or combinations thereof. Electrically conductive materials may include at least one of titanium nitride (TiN), tantalum nitride (TaN), tungsten nitride (WN), titanium aluminum nitride (TiAlN), elemental titanium (Ti), elemental platinum (Pt), elemental rhodium (Rh), elemental ruthenium (Ru), elemental molybdenum (Mo), elemental iridium (Ir), iridium oxide (IrOx), elemental ruthenium (Ru), ruthenium oxide (RuOx), elemental tungsten (W), elemental aluminum (Al), elemental copper (Cu), elemental gold (Au), elemental silver (Ag), polysilicon, alloys thereof, or combinations thereof. The terms “electrically conductive material” and “conductive material” may be used interchangeably herein.

[0021] According to embodiments described herein, a microelectronic device includes decks comprising alternating levels of a conductive material (which may also be characterized as access lines (e.g., word lines) or gate electrodes) and an insulative material (e.g., a dielectric material). Pillars of a channel material may extend through the decks and may form strings of memory cells. For example, memory cells may be located at an intersection proximate the channel material and at least some of the levels of the conductive material. One or more of a dielectric material (e.g., one or more of a tunnel dielectric material, a charge trapping material, a charge blocking material, or another material) may be located between the channel material and at least some of the levels of the conductive material. Another conductive material (e.g., an electrode material) may be located proximate to some of the dielectric materials. In some embodiments, the electrode material is located between dielectric materials. Memory cells associated with different levels of the conductive material may be isolated from one another at least by the intervening level of the insulative material.

[0022] A conductive contact electrically couples the channel material of one deck to the channel material of an adjacent deck. In some embodiments, the volume between the adjacent decks is free of charge trapping materials, such as silicon nitride. For example, an insulative material, such as an oxide material (e.g., silicon dioxide), may be located between the adjacent decks. The oxide material may facilitate decoupling between the channel material between adjacent pillars. The oxide material may extend from one deck to an adjacent deck and may electrically isolate the conductive contacts electrically coupling the channel materials of the adjacent decks. In some embodiments, the oxide material substantially fills the volume between the adjacent decks and between conductive contacts of adjacent pillars. In other embodiments, the oxide material lines the conductive contacts and at least a portion of one of the decks (e.g., an insulative material of at least one of the decks). Another

electrically conductive material is adjacent to the oxide material and fills the remaining volume between the adjacent decks and between the oxide material lining adjacent conductive contacts.

[0023] The oxide material may reduce or prevent electrical coupling between adjacent pillars proximate a location between the adjacent decks. The oxide material may comprise a material that is not prone to charge trapping (e.g., electron trapping) and associated de-trapping of charges. Due, at least in part, to the presence of the oxide material, the pillars including the strings of memory cells may exhibit improved device performance, such as reduced read write bias and an increased operating window compared to conventional memory cells. In some embodiments including the conductive material adjacent to the oxide material, the conductive material may reduce or prevent interactions between the channel materials of adjacent pillars. In some embodiments, the conductive material may improve string current of the string of memory cells and may also improve gate induced drain leakage (GIDL).

[0024] FIG. 1A is a simplified cross-sectional view of a microelectronic device **100**, in accordance with embodiments of the disclosure. The microelectronic device **100** may include a first deck **103** adjacent to (e.g., over) a base material **102** and a second deck **105** adjacent to (e.g., over) the first deck **103**. The base material **102** may comprise a substrate or a construction upon which additional materials are formed. The base material **102** may be a semiconductor substrate, a base semiconductor layer on a supporting structure, a metal electrode, or a metal electrode on a semiconductor substrate having one or more layers, structures or regions formed thereon. The base material **102** may be a conventional silicon substrate or other bulk substrate comprising a layer of semiconductive material. As used herein, the term “bulk substrate” means and includes not only silicon wafers, but also silicon-on-insulator (“SOI”) substrates, such as silicon-on-sapphire (“SOS”) substrates and silicon-on-glass (“SOG”) substrates, epitaxial layers of silicon on a base semiconductor foundation, and other semiconductor or optoelectronic materials, such as silicon-germanium, germanium, gallium arsenide, gallium nitride, and indium phosphide. The base material **102** may be doped or undoped.

[0025] The first deck **103** and the second deck **105** may each independently comprise alternating levels of an insulative material **110** and a conductive material **112**. For example, the microelectronic device **100** may include tiers **107**, each tier **107** comprising an insulative material **110** and a conductive material **112**.

[0026] Although FIG. 1A illustrates that the microelectronic device **100** includes only two decks **103**, **105**, the disclosure is not so limited. In other embodiments, the microelectronic device **100** includes more than two decks **103**, **105**, such as three decks, four decks, six deck, eight decks, or another number of decks. In addition, although FIG. 1A illustrates that the first deck **103** and the second deck **105** include three tiers **107**, the disclosure is not so limited. In other embodiments, the first deck **103** and the second deck **105** may each individually comprise more than at least about 32 tiers **107** or alternating levels of conductive material **112** and insulative material **110**, such as at least about 64 tiers **107**, at least about 128 tiers **107**, or even at least about 256 tiers **107**. In some embodiments, the first deck **103** and the second deck **105** comprise the same

number of tiers **107**. In other embodiments, the first deck **103** includes a different number of tiers **107** than the second deck **105**.

[0027] A source **104**, such as a source region, may be located between the base material **102** and the first deck **103**. An etch stop material **106** may be adjacent to the source **104** and a conductive material **108** may be adjacent to the etch stop material **106**.

[0028] The source **104** may include, for example, a semiconductor material doped with one of P-type conductivity materials or N-type conductivity materials. As used herein, an N-type conductivity material may include, for example, polysilicon doped with at least one N-type dopant (e.g., arsenic ions, phosphorous ions, antimony ions). As used herein, a P-type conductivity material may include, for example, polysilicon doped with at least one P-type dopant (e.g., boron ions). In some embodiments, the source **104** includes N-type conductivity materials. In other embodiments, the source **104** comprises tungsten, tungsten silicide, or another material.

[0029] The etch stop material **106** may comprise, for example, one or more of aluminum oxide (Al_2O_3), titanium dioxide (TiO_2), silicon carbide doped with nitrogen (SiCN), aluminum nitride, aluminum oxynitride, silicon carbide, or another material. In some embodiments, the etch stop material **106** comprises aluminum oxide. The etch stop material **106** may be formulated and configured to exhibit an etch selectivity with respect to the materials of the first deck **103** and the second deck **105** (e.g., with respect to the insulative materials **110** and the conductive materials **112**). During formation of the first deck **103** and the second deck **105**, portions of the insulative material **110** and the conductive material **112** of the respective first deck **103** and second deck **105** may be removed without substantially removing the etch stop material **106**.

[0030] The conductive material **108** may comprise a so-called select gate source material. The conductive material **108** may include an electrically conductive material, such as one or more of a metal, such as tungsten, titanium, nickel, chromium, cobalt, platinum, palladium, ruthenium, rhodium, iridium, tantalum, aluminum, copper, molybdenum, gold, silver, a metal alloy, a conductive metal-containing material, (e.g., a conductive metal nitride (titanium nitride (TiN), tantalum nitride (TaN), tungsten nitride (WN), titanium aluminum nitride (TiAlN)), a conductive metal oxide (iridium oxide (IrOx), ruthenium oxide (RuOx), titanium dioxide), a conductive metal silicide (tantalum silicides, tungsten silicides, nickel silicides, titanium silicides)), a conductively doped semiconductor material (e.g., conductively doped silicon, conductively doped germanium, conductively doped silicon germanium, etc.), polysilicon, other materials exhibiting electrical conductivity, alloys thereof, or combinations thereof. In some embodiments, the conductive material **108** comprises polysilicon (e.g., P-type polysilicon), or another material.

[0031] The insulative material **110** may comprise a dielectric material, such as, for example, silicon dioxide, or other dielectric materials.

[0032] The conductive material **112** may comprise an electrically conductive material, such as one or more of the materials described above with reference to the conductive material **108**. In some embodiments, the conductive material **112** comprises polysilicon. In some embodiments, the conductive material **112** has the same composition as the

conductive material **108**. The conductive material **112** may also be referred to herein as access lines (e.g., word lines) or gate electrodes.

[0033] With continued reference to FIG. 1A, pillars **125** comprising a channel material **120** may extend through the first deck **103** and the second deck **105**. The channel material **120** may be in electrical communication with the source **104**. The channel material **120** may include a semiconductor material, such as, for example, polysilicon. In some embodiments, the channel material **120** comprises P-type polysilicon. In other embodiments, the channel material **120** comprises a metal oxide semiconductor material. In some embodiments, the channel material **120** comprises polysilicon. The channel material **120** may be electrically isolated from the conductive material **108** and the conductive material **115** by an insulative material **145**. The insulative material **145** may comprise a dielectric material. For example, the insulative material **145** may comprise one or more of phosphosilicate glass, borosilicate glass, borophosphosilicate glass (BPSG), fluorosilicate glass, silicon dioxide, titanium dioxide, zirconium dioxide, hafnium dioxide, tantalum oxide, magnesium oxide, aluminum oxide, niobium oxide, molybdenum oxide, strontium oxide, barium oxide, yttrium oxide, a nitride material, (e.g., silicon nitride (Si_3N_4)), an oxynitride (e.g., silicon oxynitride), another gate dielectric material, a dielectric carbon nitride material (e.g., silicon carbon nitride (SiCN)), or a dielectric carboxynitride material (e.g., silicon carboxynitride (SiOCN)).

[0034] In some embodiments, the pillars **125** further include an electrically insulative material **122** between portions of the channel material **120**. The electrically insulative material **122** may include, for example, phosphosilicate glass, borosilicate glass, borophosphosilicate glass (BPSG), fluorosilicate glass, silicon dioxide, titanium dioxide, zirconium dioxide, hafnium dioxide, tantalum oxide, magnesium oxide, aluminum oxide, niobium oxide, molybdenum oxide, strontium oxide, barium oxide, yttrium oxide, a nitride material, (e.g., silicon nitride (Si_3N_4)), an oxynitride (e.g., silicon oxynitride), another gate dielectric material, a dielectric carbon nitride material (e.g., silicon carbon nitride (SiCN)), a dielectric carboxynitride material (e.g., silicon carboxynitride (SiOCN)), or combinations thereof. In some embodiments, the electrically insulative material **122** comprises silicon dioxide.

[0035] Memory cells **130** may be located at intersections between the channel material **120** and the conductive materials **112**. The memory cells **130** may comprise, for example, a dielectric material **124** (which may also be referred to as a tunnel dielectric material) between the channel material **120** and an electrode material **126** (which may also be referred to as a gate electrode, a floating gate, or a gate), and an other dielectric material **128** (which may also be referred to as a charge storage material) around at least a portion of the electrode material **126**. In some embodiments, the memory cell **130** may be referred to herein as a “floating gate” memory cell. As will be described with reference to FIG. 1C, the memory cells **130** may include other materials and may be referred to herein as “charge trapping” memory cells.

[0036] The electrode material **126** may include an electrically conductive material. By way of nonlimiting example, the electrode material **126** may include a conductively doped semiconductor material (e.g., conductively doped silicon, conductively doped germanium, conductively doped silicon

germanium, etc.), polysilicon, one or more of a metal such as tungsten, titanium, nickel, chromium, cobalt, platinum, palladium, ruthenium, rhodium, iridium, tantalum, aluminum, copper, molybdenum, gold, silver, or combinations thereof, a metal alloy a conductive metal-containing material, (e.g., a conductive metal nitride (titanium nitride (TiN), tantalum nitride (TaN), tungsten nitride (WN), titanium aluminum nitride (TiAlN)), a conductive metal oxide (iridium oxide (IrOx), ruthenium oxide (RuOx), titanium dioxide), a conductive metal silicide (tantalum silicides, tungsten silicides, nickel silicides, titanium silicides)), alloys thereof, or combinations thereof. In some embodiments, the electrode material **126** comprises tungsten. In other embodiments, the electrode material **126** comprises polysilicon. In some such embodiments, the polysilicon may be doped and may comprise, for example, n-doped polysilicon or p-doped polysilicon.

[0037] The dielectric material **124** may include, for example, a tunnel oxide material. In some embodiments, the dielectric material **124** comprises silicon dioxide. However, the disclosure is not so limited and the dielectric material **124** may comprise another material, such as one or more of the materials described above with reference to the insulative material **145**. In some embodiments, the dielectric material **124** comprises the same material composition as the insulative material **145**. Although FIG. 1A illustrates the dielectric material **124** only on sides proximate the conductive materials **112** and not in contact with or located on sides of the insulative materials **110**, the disclosure is not so limited. In other embodiments, the dielectric material **124** extends continuously through the entire first deck **103** and the entire second deck **105** to the conductive contact **132**. In some embodiments, the dielectric material **124** may be grown on the electrode material **126**, such as by an in-situ steam generation (ISSG) process to selectively oxidize exposed portions of the electrode material **126**.

[0038] The other dielectric material **128** may include a charge trapping material, such as an oxide-nitride-oxide (ONO) structure. For example, the other dielectric material **128** may comprise a first oxide material, a silicon nitride material adjacent to the first oxide material, and a second oxide material adjacent to the silicon nitride material. The first oxide material and the second oxide material may include silicon dioxide, hafnium oxide, zirconium oxide, or another material. In some embodiments, the first oxide material and the second oxide material have the same material composition. In some embodiments, the first oxide material and the second oxide material comprise silicon dioxide. In some embodiments, the other dielectric material **128** may also be referred to as an interpoly dielectric (IPD) material.

[0039] FIG. 1B is a simplified cross-sectional view of the microelectronic device **100** taken along section line B-B of FIG. 1A. The pillars **125** may include a circular cross-sectional shape. In some embodiments, the channel material **120** may surround the electrically insulative material **122** and may exhibit a circular cross-sectional shape. The dielectric material **124** may surround the channel material **120** and may be located between the channel material **120** and the electrode material **126**. The other dielectric material **128** may be located between the electrode material **126** and the conductive material **112**.

[0040] Referring back to FIG. 1A, another conductive material **115** may be formed adjacent to the insulative

material 110 of the uppermost tier 107. The conductive material 115 may comprise a so-called select gate drain (SGD) material. The conductive material 115 may comprise one or more of the materials described above with reference to the conductive material 108. In some embodiments, the conductive material 115 has the same material composition as the conductive material 108. An insulative material 114 may be formed adjacent to the conductive material 115. The insulative material 114 may be patterned and conductive contacts 116 (which may also be referred to herein as conductive plugs) may be adjacent to and in electrical communication with the channel material 120. A conductive line 118 (e.g., data line, bit line) may be adjacent to and in electrical communication with the conductive contacts 116.

[0041] In some embodiments, the channel material 120 may exhibit a bulge 140 at a location between the first deck 103 and the second deck 105. A distance D_1 between opposing portions of the bulge 140 (e.g., the diameter of the channel material 120 at the bulge 140) may be greater than a distance between opposing portions of the channel material 120 at other portions of the channel material 120. In other words, the channel material 120 may have a larger diameter proximate the bulge 140 relative to other locations of the channel material 120.

[0042] The bulge 140 may be a result of the method of forming the microelectronic device 100, such as the method of forming the channel materials 120 to extend through the first deck 103 and the second deck 105 and forming the conductive contacts 132 between the first deck 103 and the second deck 105.

[0043] The conductive contacts 132 may electrically couple the channel material 120 of a pillar 125 of the first deck 103 to the channel material 120 of a corresponding pillar 125 of the second deck 105. In other words, the channel material 120 of the first deck 103 may be in electrical communication with the channel material 120 of the second deck 105 through the conductive contact 132. The conductive contacts 132 may comprise an electrically conductive material. In some embodiments, the conductive contacts 132 comprise polysilicon. In some embodiments, the conductive contacts 132 comprise the same material composition as the conductive materials 112.

[0044] The conductive contacts 132 may include protruding portions 134 which extend farther (up and down in the view shown in FIG. 1A) from an underlying insulative material 110 than other portions (e.g., central portions) of the respective conductive contact 132. In some embodiments, a distance D_2 between opposite sides of the conductive contacts 132 at a location proximate the underlying insulative material is less than a distance D_3 between opposing protruding portions 134 of the respective conductive contact 132.

[0045] An oxide material 136 may be located between the first deck 103 and the second deck 105. The oxide material 136 may comprise an electrically insulative material. In some embodiments, the oxide material 136 comprises a material that does not exhibit charge trapping (e.g., electron trapping) and de-trapping properties. For example, the oxide material 136 is free of (e.g., substantially free of) silicon nitride. In other words, the microelectronic device 100 may not include silicon nitride at locations between the first deck 103 and the second deck 105.

[0046] The oxide material 136 may comprise one or more of silicon dioxide, phosphosilicate glass, borosilicate glass,

borophosphosilicate glass (BPSG), fluorosilicate glass, an oxynitride (e.g., silicon oxynitride), aluminum oxide, hafnium oxide, zirconium oxide, titanium oxide, tantalum oxide, molybdenum oxide, or a spin-on dielectric (SOD) (e.g., hydrogen silsesquioxane (HSQ), methylsilsesquioxane (MSQ), a polyimide, polytetrafluoroethylene (PTFE), a spin-on polymer). The oxide material 136 may exclude silicon nitride. In some embodiments, the oxide material 136 comprises silicon dioxide. In some embodiments, at least a portion of the volume between the first deck 103 and the second deck 105 may include one or more voids. The one or more voids may be filled with one or more of oxygen, nitrogen, air, helium, or another gas. In some embodiments, the one or more voids is filled with oxygen and nitrogen.

[0047] The oxide material 136 may directly contact the first deck 103 and the second deck 105. In some embodiments, the oxide material 136 directly contacts an insulative material 110 of the first deck 103 and an insulative material 110 of the second deck 105 (such as where the second deck 105 does not include the etch stop material 106). For example, the oxide material 136 may be located directly between an uppermost insulative material 110 of the first deck 103 and a lowermost insulative material 110 of the second deck 105. In some embodiments, the oxide material 136 may directly contact the uppermost insulative material 110 of the first deck 103 and the lowermost insulative material 110 of the second deck 105. In other embodiments, the oxide material 136 directly contacts an insulative material 110 of the first deck 103 and directly contacts the etch stop material 106 in contact with an insulative material 110 of the second deck 105. In some embodiments, at least a portion of the oxide material 136 is located laterally directly between the conductive contacts 132 of adjacent pillars 125. Although FIG. 1A has been described and illustrated as including the oxide material 136 directly contacting the uppermost insulative material 110 of the first deck 103 and the etch stop material 106 of the second deck 105, the disclosure is not so limited. In other embodiments, the oxide material 136 may directly contact an uppermost conductive material of the first deck 103 and a lowermost conductive material 112 of the second deck 105 (or the etch stop material 106 of the second deck 105). In some such embodiments, the oxide material 136 is the only material intervening between portions of the uppermost conductive material 112 of the first deck 103 and the lowermost conductive material 112 of the second deck 105. In some embodiments, the oxide material 136 directly contacts the channel material proximate the bulge 140.

[0048] The oxide material 136 may have a thickness T_1 within a range from about 50 nm to about 200 nm, such as from about 50 nm to about 75 nm, from about 75 nm to about 100 nm, from about 100 nm to about 150 nm, or from about 150 nm to about 200 nm. In some embodiments, the thickness T_1 is about 100 nm.

[0049] In some embodiments, the thickness T_1 of the oxide material 136 may be greater than a thickness of the levels of the insulative material 110. In some embodiments, the thickness T_1 of the oxide material 136 is greater than the thickness of the levels of the conductive material 112. For example, each level of insulative material 110 may have a thickness T_2 within a range from about 20 nm to about 10 nm to about 50 nm, such as from about 10 nm to about 20 nm, from about 20 nm to about 30 nm, from about 30 nm to about 40 nm, or from about 40 nm to about 50 nm. Each

level of conductive material **112** may have a thickness T_3 within a range from about 10 nm to about 50 nm, such as from about 10 nm to about 20 nm, from about 20 nm to about 30 nm, from about 30 nm to about 40 nm, or from about 40 nm to about 50 nm. In some embodiments, the thickness T_1 of the oxide material **136** may be greater than a thickness of each of the tiers **107** (i.e., the sum of the thickness T_2 and the thickness T_3).

[0050] In some embodiments, the oxide material **136** may reduce or prevent (e.g., substantially prevent) coupling of the channel materials **120** of adjacent pillars **125** at locations between the first deck **103** and the second deck **105** or at locations proximate the oxide material **136**. In addition, the oxide material **136** may comprise a material composition formulated and configured to exhibit a reduced degree of charge trapping than conventional materials that are used between adjacent deck structures. For example, conventional microelectronic devices may include a silicon nitride material between adjacent decks. Due to the large space between the adjacent decks and, in particular, the large space between conductive materials **112** of the adjacent decks (e.g., an uppermost conductive material **112** of the first deck **103** and a lowermost conductive material **112** of the second deck **105**, which may be spaced from each other at least by an uppermost insulative material **110** of the first deck **103**, a lowermost insulative material **110** of the second deck **105**, and the oxide material **136** between the first deck **103** and the second deck **105**), the silicon nitride material may trap charges (e.g., electrons) that may cause one pillar **125** including the channel material **120** to couple to adjacent pillars **125**. In some instances, when a first pillar **125** is selected for programming (writing) and a second pillar **125** is inhibited, such as by applying a potential of about 0 V to the channel material **120** of the first pillar **125** and applying a potential (e.g., about 10 V) to the channel material **120** of the second pillar **125**, electrons may become trapped in such a silicon nitride material located between adjacent decks between the first pillar **125** and the second pillar **125**. The trapped charges (e.g., electrons) in the silicon nitride material may affect a threshold voltage of the memory cells **130** and may reduce the operating (e.g., read) window of the memory cells **130**.

[0051] In addition, charges may not become trapped in the oxide material **136**. By way of comparison, conventional microelectronic devices may include silicon nitride or other materials between the first deck **103** and the second deck **105**, which materials may trap charges and couple to the bulges **140**, which may be present in the channel material **120** due to various processing conditions (e.g., deposition of various materials, etching acts, cleaning acts) used to form the pillars **125**. In other words, the bulges **140** may couple to a charge trapping material between the adjacent decks in conventional devices. Further, the protruding portions **134** of the conductive contact **132** may exhibit a relatively higher electric field (such as by an increase in current density) than other portions of the conductive contact **132**. In conventional microelectronic devices, the high field at the protruding portions **134** may facilitate injection of electrons or other charges into a silicon nitride material proximate the conductive contact **132** during use and operation of the microelectronic device **100**. Injection of electrons or other charges may result in a reduced operating window for the memory cells **130**.

[0052] Forming the oxide material **136** to include a material composition that does not trap charges (e.g., electrons) may reduce or prevent charge trapping within the channel material **120**, such as proximate the bulges **140** and at locations proximate the protruding portions **134**. Accordingly, the microelectronic device **100** may include pillars **125** including strings of memory cells **130** exhibiting a larger operating window than in conventional microelectronic devices because the adjacent pillars **125** do not couple to one another.

[0053] Although FIG. 1A has been described and illustrated as including a particular type of memory cell **130** (e.g., floating gate memory cells), the disclosure is not so limited. FIG. 1C is a simplified cross-sectional view of a memory cell **150** that may be present in the microelectronic device **100** of FIG. 1A in place of the memory cells **130** (FIG. 1A). The memory cells **150** may comprise a so-called charge trapping material. In some such embodiments, the associated microelectronic device **100** may comprise a charge trapping NAND. The memory cells **150** may be referred to herein as a “charge trapping” memory cell.

[0054] FIG. 1C is a simplified cross-sectional view of a memory cell **150** that may be used interchangeably with the memory cells **130** of FIG. 1A, in accordance with embodiments of the disclosure. The memory cell **150** may include a dielectric material **152** (e.g., a tunnel dielectric material), a charge trapping material **154**, and a charge blocking material **156** between the channel material **120** and the conductive material **112**. The charge trapping material **154** may be located directly between the dielectric material **152** and the charge blocking material **156**. In some embodiments, the dielectric material **152** directly contacts the channel material **120** and the charge trapping material **154**. The charge blocking material **156** may directly contact and may be located directly adjacent to the charge trapping material **154** and the conductive material **112**.

[0055] Although FIG. 1A has been described and illustrated as including the oxide material **136** between the first deck **103** and the second deck **105**, the disclosure is not so limited. In other embodiments, one or more other materials may be located between the first deck **103** and the second deck **105**. FIG. 2 is a simplified cross-sectional view of a microelectronic device **200** in accordance with embodiments of the disclosure. The microelectronic device **200** may be substantially the same as the microelectronic device **100** of FIG. 1A, except that the microelectronic device **200** may include one or more additional materials between the first deck **103** and the second deck **105**.

[0056] The microelectronic device **200** includes an oxide material **160** between the first deck **103** and the second deck **105** to electrically isolate adjacent conductive contacts **132** from each other. In some embodiments, the oxide material **160** may not substantially fill an entire volume between the first deck **103** and the second deck **105**, such as a volume between the etch stop material **106** proximate the second deck **105** and an upper insulative material **110** of the first deck **103**. In some embodiments, a remaining portion of the volume between the first deck **103** and the second deck **105** may be filled with one or more gases, such as one or more of oxygen, nitrogen, air, helium, or another gas. In some embodiments, the one or more voids is filled with oxygen and nitrogen. In other embodiments, a conductive material **162** may also be located between adjacent pillars **125** and

electrically isolated from the adjacent pillars 125 and the associated conductive contact 132 at least by the oxide material 160.

[0057] In some embodiments, the oxide material 160 may comprise an oxide liner around sidewalls of the conductive contacts 132 and sidewalls of the channel material 120 located between the first deck 103 and the second deck 105. In some embodiments, the oxide material 160 may be adjacent to (e.g., conformally overlie) the conductive contact 132, the sidewalls of the channel material 120 located between the first deck 103 and the second deck 105, and an uppermost insulative material 110 of the first deck 103. The oxide material 160 may be adjacent to the bulge 140 of the channel material 120 and the protruding portions 134 of the conductive contacts 132.

[0058] The oxide material 160 may be adjacent to surfaces of an insulative material 110 of the first deck 103 and may be adjacent to surfaces of the conductive contacts 132 and the channel material 120 to a surface of the etch stop material 106. In other embodiments, the oxide material 160 extends adjacent to the surfaces of the conductive contacts 132 and the channel material 120 to a surface of an insulative material 110 of the second deck 105. As discussed above with reference to FIG. 1A and the oxide material 136, the oxide material 160 may be located directly between an uppermost insulative material 110 of the first deck 103 and a lowermost insulative material 110 of the second deck 105. In some embodiments, the oxide material 136 may directly contact the uppermost insulative material 110 of the first deck 103 and the lowermost insulative material 110 of the second deck 105. In other embodiments, the oxide material 160 directly contacts an insulative material 110 of the first deck 103 and directly contacts the etch stop material 106 in contact with an insulative material 110 of the second deck 105. In some embodiments, at least a portion of the oxide material 160 is located laterally directly between the conductive contacts 132 of adjacent pillars 125. In some such embodiments, spaces between the oxide material 160 on the conductive contacts 132 of adjacent pillars 125 may be separated by a void. The void may be filled with one or more gases or may be filled with the conductive material 162. Although FIG. 1A has been described and illustrated as including the oxide material 160 directly contacting the uppermost insulative material 110 of the first deck 103 and the etch stop material 106 of the second deck 105, the disclosure is not so limited. In other embodiments, the oxide material 160 may directly contact an uppermost conductive material of the first deck 103 and a lowermost conductive material 112 of the second deck 105 (or the etch stop material 106 of the second deck 105).

[0059] The oxide material 160 may comprise the same materials described above with reference to the oxide material 136 (FIG. 1A). In some embodiments, the oxide material 160 comprises silicon dioxide.

[0060] The conductive material 162 may be adjacent to the oxide material 160 and may fill a remaining volume between the first deck 103 and the second deck 105. The conductive material 162 may be adjacent to surfaces of the oxide material 160 adjacent to the first deck 103 and be adjacent to the oxide material 160 extending adjacent to the conductive contacts 132 and the channel material 120. The conductive material 162 may extend from the oxide material 160 adjacent to the first deck 103 to the etch stop material 106 adjacent to the second deck 105. In other embodiments,

the conductive material 162 extends from the oxide material 160 to an insulative material 110 of the second deck 105.

[0061] The conductive material 162 may include an electrically conductive material. In some embodiments, the conductive material 162 comprises polysilicon. The conductive material 162 may be doped with one or more of boron, phosphorus, arsenic, antimony, or another material. In other embodiments, the conductive material 162 comprises tungsten. The conductive material 162 may, in some embodiments, comprise the same material composition as the conductive contacts 132.

[0062] The microelectronic device 200 may exhibit reduced charge trapping within the channel material 120 such as proximate the bulges 140 and at locations proximate the protruding portions 134. In addition, the conductive material 162 may facilitate shielding between adjacent pillars 125 and the channel materials 120 of adjacent pillars 125. In other words, the conductive material 162 between adjacent pillars 125 may reduce or prevent interactions between the channel material 120 of adjacent pillars 125.

[0063] In some embodiments, the conductive material 162 may improve string current of the string of memory cells 130 and may also improve gate induced drain leakage (GIDL). The conductive material 162 may be in electrical communication with a conductive contact located in a so-called stair-step structure of the microelectronic device. In use and operation, a voltage may be applied to the conductive material 162 proximate, for example, the channel material 120 of a selected memory string or an unselected memory string.

[0064] Accordingly, in at least some embodiments, a microelectronic device comprises decks comprising alternating levels of a conductive material and an insulative material, the decks comprising pillars including a channel material extending through the alternating levels of the conductive material and the insulative material, a conductive contact between adjacent decks and in electrical communication with the channel material of the adjacent decks, and an oxide material between the adjacent decks, the oxide material extending between an uppermost level of a first deck and a lowermost level of a second deck adjacent to the first deck.

[0065] FIG. 3A through FIG. 3D are simplified cross-sectional views illustrating a method of forming the microelectronic device 100 of FIG. 1A, in accordance with embodiments of the disclosure. Referring to FIG. 3A, the first deck 103 (FIG. 1A) may be formed adjacent to the base material 102, the source 104, the etch stop material 106, and the conductive material 108 to form a semiconductor structure 300. The alternating levels of the insulative material 110 and the conductive material 112 of the first deck 103 may be formed adjacent to the conductive material 108.

[0066] After forming the levels of the insulative material 110 and the conductive material 112, openings may be formed through the levels of the insulative material 110 and the conductive material 112 and the conductive material 108 to expose portions of the etch stop material 106. The exposed portions of the etch stop material 106 may be removed through the openings to expose portions of the source 104. For example, in some embodiments, portions of the insulative material 110, the conductive material 112, and the conductive material 108 may be removed to form the

openings by one removal act while a second removal act may be used to remove the portions of the etch stop material 106.

[0067] In some embodiments, such as in so-called “gate first” processes, the memory cells 130 may be formed by removing portions of the conductive material 112 to form recesses. The other dielectric material 128 may be formed in the recesses and adjacent to the remaining portions of the conductive material 112. The electrode material 126 may be formed adjacent to the other dielectric material 128 and the dielectric material 124 may be formed adjacent to the electrode material 126. After forming the dielectric material 124, the channel material 120 may be formed adjacent sides of the openings to form the memory cells 130. In some embodiments, after forming the channel material 120, the electrically insulative material 122 may be formed adjacent the channel material 120.

[0068] After forming the channel material 120 and the electrically insulative material 122, portions of the channel material 120 and the electrically insulative material 122 may be removed from surfaces of the uppermost insulative material 110.

[0069] A silicon nitride material 170 may be formed adjacent to the exposed (e.g., the uppermost) insulative material 110. Referring to FIG. 3B, openings may be formed through the silicon nitride material 170 to expose the channel material 120. A conductive material may be formed in the openings and in electrical communication with the channel material 120 to form the conductive contacts 132. The conductive contacts 132 are illustrated in FIG. 3A through FIG. 3D without the protruding portions 134 (FIG. 1A). However, the conductive contacts 132 may include the protruding portions 134. An etch stop material 172 having an etch selectivity relative to the silicon nitride material 170 may be formed adjacent to the conductive contacts 132.

[0070] Referring to FIG. 3C, substantially all of the silicon nitride material 170 may be removed to expose portions of the insulative material 110. The insulative material 110 may exhibit an etch selectivity relative to the silicon nitride material 170. After removing the silicon nitride material 170, the conductive contacts 132 and the etch stop material 172 may remain adjacent to (e.g., over) the channel material 120.

[0071] With reference to FIG. 3D, the oxide material 136 may be formed adjacent to the semiconductor structure 300, such as adjacent to (e.g., over) the insulative material 110 and adjacent to (e.g., on sides of) the conductive contacts 132 and the etch stop material 172. In some embodiments, after forming the oxide material 136, the semiconductor structure 300 may be exposed to a chemical mechanical planarization (CMP) process to expose portions of the etch stop material 172 through the oxide material 136. Although FIG. 3D illustrates that the oxide material 136 is formed directly on the uppermost insulative material 110, the disclosure is not so limited. In other embodiments, the oxide material 136 is formed directly on the uppermost conductive material 112.

[0072] After forming and planarizing the oxide material 136, the second deck 105 (FIG. 1A) may be formed adjacent to the semiconductor structure 300. For example, the etch stop material 106 (FIG. 1A) may be formed adjacent to the oxide material 136, and a stack of alternating levels of the insulative material 110 and conductive material 112 may be formed adjacent to the semiconductor structure 300. The

second deck 105 may be formed in the same manner as formation of the first deck 103 (FIG. 1A). For example, openings may be formed in the stack of alternating levels of insulative material 110 and conductive material 112, portions of the conductive material 112 may be removed to form recesses, the other dielectric material 128 may be formed in the recesses, the electrode material 126 may be formed adjacent to the other dielectric material 128, the dielectric material 124 may be formed adjacent to the electrode material 126, and the channel material 120 may be formed adjacent to the dielectric material 124.

[0073] After forming the pillars 125 (FIG. 1A), the conductive contacts 116 may be formed through the insulative material 114 and adjacent to (e.g., over) the pillars 125 and in electrical communication with the channel material 120 of the second deck 105 (FIG. 1A). The conductive line 118 may be formed in electrical communication with the conductive contacts 116.

[0074] Although FIG. 3A through FIG. 3D illustrates forming the semiconductor structure 300 to include the oxide material 136 to fill the volume between the first deck 103 (FIG. 1A) and the second deck 105 (FIG. 1A), the disclosure is not so limited. Referring to FIG. 3C and FIG. 4, after removing the silicon nitride material 170 (FIG. 3B), the oxide material 160 may be conformally formed adjacent to (e.g., over, on sides of) the conductive contacts 132 and the etch stop material 172, if present. For example, the oxide material 160 may form a liner over the uppermost insulative material 110, the conductive contacts 132, and the etch stop material 172. The oxide material 160 may be formed by, for example, one or more of CVD, ALD, plasma-enhanced ALD, PVD, PECVD, or LPCVD.

[0075] After forming the oxide material 160, the conductive material 162 may be formed adjacent to surfaces of the oxide material 160 and the semiconductor structure 400 may be exposed to a CMP process. The second deck 105 (FIG. 2) may be formed adjacent to the conductive material 162 as described above with reference to FIG. 3D to form the microelectronic device 200 described with reference to FIG. 2.

[0076] Although FIG. 3A through FIG. 3D and FIG. 4 have been described as a gate first process, the disclosure is not so limited. In other embodiments, the microelectronic devices 100, 200 may be formed by a so-called “replacement gate” process. In some such embodiments, rather than forming the stack to include alternating levels of the insulative material 110 and the conductive material 112 as described above with reference to FIG. 3A, a stack comprising alternating levels of the insulative material 110 and an other insulative material may be formed adjacent to the conductive material 108 (e.g., the conductive materials 112 of FIG. 3A may be replaced with the other insulative material). The other insulative material may comprise an electrically insulative material exhibiting an etch selectivity relative to the insulative material 110, such as silicon nitride. Openings may be formed through the stack of alternating levels of the insulative material 110 and the other insulative material and through the conductive material 108 and the etch stop material 106. A channel material may be formed in the openings, such as in an entirety of the opening or at least on sidewalls of the opening. In some embodiments, a dielectric material (e.g., silicon dioxide) may fill a remainder of the opening. Additional openings through the alternating levels of the insulative material and the other insulative

material may be formed to expose the source **104**. The other insulative material may be selectively removed relative to the insulative material **110** to form recesses between adjacent levels of the insulative material **110**. After removing the other insulative material, memory cells **130** may be formed in the another openings, such as by forming a dielectric material (e.g., a charge storage material) in the recesses, forming an electrode material adjacent to the charge storage material, and forming an insulative material in the remaining portion of the another openings. In other embodiments, the other dielectric material **128** is formed in the recesses, the electrode material **126** is formed adjacent to the other dielectric material **128**, and the dielectric material **124** is formed adjacent to the electrode material **126**. The micro-electronic device may be completed as described above.

[0077] Accordingly, in at least one embodiment, a method of forming a microelectronic device comprises forming a first deck comprising a channel material extending through a stack of alternating levels of a first material and a second material, forming a nitride material adjacent to the first deck, forming openings in the nitride material and conductive contacts in the openings, removing the nitride material, forming an oxide material adjacent to the conductive contacts, and forming a second deck adjacent to the oxide material, the second deck comprising alternating levels of a first material and a second material.

[0078] microelectronic devices (e.g., the microelectronic devices **100**, **200**) including the oxide material **136** or the oxide material **160** and the conductive material **162** between the first deck **103** and the second deck **105** in accordance with embodiments of the disclosure may be used in embodiments of electronic systems of the disclosure. For example, FIG. **5** is a block diagram of an illustrative electronic system **503** according to embodiments of disclosure. The electronic system **503** may comprise, for example, a computer or computer hardware component, a server or other networking hardware component, a cellular telephone, a digital camera, a personal digital assistant (PDA), portable media (e.g., music) player, a Wi-Fi or cellular-enabled tablet such as, for example, an iPad® or SURFACE® tablet, an electronic book, a navigation device, etc. The electronic system **503** includes at least one memory device **505**. The memory device **505** may include, for example, an embodiment of a microelectronic device previously described herein (e.g., microelectronic devices **100**, **200**) including an oxide material (e.g., the oxide material **136** or the oxide material **160**) between adjacent decks (e.g., the first deck **103**, the second **105**) comprising a material that does not trap charges.

[0079] The electronic system **503** may further include at least one electronic signal processor device **507** (often referred to as a “microprocessor”). The electronic signal processor device **507** may, optionally, include an embodiment of a microelectronic device previously described herein (e.g., the microelectronic devices **100**, **200**). The electronic system **503** may further include one or more input devices **509** for inputting information into the electronic system **503** by a user, such as, for example, a mouse or other pointing device, a keyboard, a touchpad, a button, or a control panel. The electronic system **503** may further include one or more output devices **511** for outputting information (e.g., visual or audio output) to a user such as, for example, a monitor, a display, a printer, an audio output jack, a speaker, etc. In some embodiments, the input device **509** and the output device **511** may comprise a single touchscreen

device that can be used both to input information to the electronic system **503** and to output visual information to a user. The input device **509** and the output device **511** may communicate electrically with one or more of the memory device **505** and the electronic signal processor device **507**.

[0080] With reference to FIG. **6**, depicted is a processor-based system **600**. The processor-based system **600** may include various electronic devices manufactured in accordance with embodiments of the present disclosure. The processor-based system **600** may be any of a variety of types such as a computer, pager, cellular phone, personal organizer, control circuit, or other electronic device. The processor-based system **600** may include one or more processors **602**, such as a microprocessor, to control the processing of system functions and requests in the processor-based system **600**. The processor **602** and other subcomponents of the processor-based system **600** may include microelectronic devices (e.g., microelectronic devices **100**, **200**) manufactured in accordance with embodiments of the present disclosure.

[0081] The processor-based system **600** may include a power supply **604** in operable communication with the processor **602**. For example, if the processor-based system **600** is a portable system, the power supply **604** may include one or more of a fuel cell, a power scavenging device, permanent batteries, replaceable batteries, and rechargeable batteries. The power supply **604** may also include an AC adapter; therefore, the processor-based system **600** may be plugged into a wall outlet, for example. The power supply **604** may also include a DC adapter such that the processor-based system **600** may be plugged into a vehicle cigarette lighter or a vehicle power port, for example.

[0082] Various other devices may be coupled to the processor **602** depending on the functions that the processor-based system **600** performs. For example, a user interface **606** may be coupled to the processor **602**. The user interface **606** may include input devices such as buttons, switches, a keyboard, a light pen, a mouse, a digitizer and stylus, a touch screen, a voice recognition system, a microphone, or a combination thereof. A display **608** may also be coupled to the processor **602**. The display **608** may include an LCD display, an SED display, a CRT display, a DLP display, a plasma display, an OLED display, an LED display, a three-dimensional projection, an audio display, or a combination thereof. Furthermore, an RF sub-system/baseband processor **610** may also be coupled to the processor **602**. The RF sub-system/baseband processor **610** may include an antenna that is coupled to an RF receiver and to an RF transmitter (not shown). A communication port **612**, or more than one communication port **612**, may also be coupled to the processor **602**. The communication port **612** may be adapted to be coupled to one or more peripheral devices **614**, such as a modem, a printer, a computer, a scanner, or a camera, or to a network, such as a local area network, remote area network, intranet, or the Internet, for example.

[0083] The processor **602** may control the processor-based system **600** by implementing software programs stored in the memory. The software programs may include an operating system, database software, drafting software, word processing software, media editing software, or media playing software, for example. The memory is operably coupled to the processor **602** to store and facilitate execution of various programs. For example, the processor **602** may be coupled to system memory **616**, which may include one or

more of spin torque transfer magnetic random-access memory (STT-MRAM), magnetic random-access memory (MRAM), dynamic random-access memory (DRAM), static random-access memory (SRAM), racetrack memory, and other known memory types. The system memory 616 may include volatile memory, non-volatile memory, or a combination thereof. The system memory 616 is typically large so that it can store dynamically loaded applications and data. In some embodiments, the system memory 616 may include microelectronic devices, such as the microelectronic devices (e.g., the microelectronic devices 100, 200) described above, or a combination thereof.

[0084] The processor 602 may also be coupled to non-volatile memory 618, which is not to suggest that system memory 616 is necessarily volatile. The non-volatile memory 618 may include one or more of STT-MRAM, MRAM, read-only memory (ROM) such as an EPROM, resistive read-only memory (RROM), and flash memory to be used in conjunction with the system memory 616. The size of the non-volatile memory 618 is typically selected to be just large enough to store any necessary operating system, application programs, and fixed data. Additionally, the non-volatile memory 618 may include a high-capacity memory such as disk drive memory, such as a hybrid-drive including resistive memory or other types of non-volatile solid-state memory, for example. The non-volatile memory 618 may include microelectronic devices, such as the microelectronic devices (e.g., the microelectronic devices 100, 200) described above, or a combination thereof.

[0085] Accordingly, in at least some embodiments, an electronic system comprises a first deck and a second deck. Each of the first deck and the second deck comprise a stack of alternating levels of conductive material and insulative material, and pillars comprising a channel material extending through the alternating levels of the conductive material and the insulative material. The electronic system further comprises conductive contacts between the channel material of the pillars of the first deck and the channel material of the pillars of the second deck, and an oxide material adjacent to the conductive contacts and between the first deck and the second deck.

[0086] While certain illustrative embodiments have been described in connection with the figures, those of ordinary skill in the art will recognize and appreciate that embodiments encompassed by the disclosure are not limited to those embodiments explicitly shown and described herein. Rather, many additions, deletions, and modifications to the embodiments described herein may be made without departing from the scope of embodiments encompassed by the disclosure, such as those hereinafter claimed, including legal equivalents. In addition, features from one disclosed embodiment may be combined with features of another disclosed embodiment while still being encompassed within the scope of the disclosure.

What is claimed is:

1. A memory device, comprising:

- a first deck including tiers vertically arranged relative to one another and respectively comprising a level of conductive material vertically neighboring a level of insulative material;
- a second deck vertically above the first deck and including additional tiers vertically arranged relative to one another, the additional tiers respectively comprising a

- level of additional conductive material vertically neighboring a level of additional insulative material;
- first pillars respectively comprising channel material vertically extending through the first deck;
- second pillars respectively comprising additional channel material vertically extending through the second deck;
- conductive contacts vertically positioned between the first deck and the second deck, the conductive contacts individually electrically coupling a respective one of the first pillars to a respective one of the second pillars; and

- an interdeck structure vertically positioned between the first deck and the second deck, the interdeck structure comprising oxide material physically contacting surfaces of the conductive contacts and lower portions of side surfaces of the second pillars.

2. The memory device of claim 1, wherein the oxide material of the interdeck structure physically contacts and continuously extends along each of:

- an upper surface of an uppermost tier of the first deck; and
- sidewalls of the conductive contacts.

3. The memory device of claim 1, wherein the interdeck structure further comprises further conductive material on the oxide material and positioned vertically below the second deck.

4. The memory device of claim 3, wherein the oxide material of the interdeck structure has a vertical span substantially equal to a vertical height of the interdeck structure.

5. The memory device of claim 1, wherein the conductive contacts respectively include:

- a concave upper surface; and
- a substantially planar lower surface having a smaller horizontal area than that of the concave upper surface.

6. The memory device of claim 5, wherein the conductive contacts further respectively include a side surface extending from the concave upper surface to the substantially planar lower surface, the side surface having an arcuate vertical cross-sectional profile.

7. The memory device of claim 1, wherein the second pillars are individually substantially vertically aligned with respective ones of the first pillars and the conductive contacts.

8. The memory device of claim 1, wherein a lower portion of a respective one of the second pillars, within a vertical span of the interdeck structure, has a lateral width greater than that of an upper portion of the respective one of the second pillars within a vertical extent of the second deck.

9. The memory device of claim 1, further comprising an etch stop material vertically between a lowermost one of the additional tiers of the second deck and the oxide material of the interdeck structure, the etch stop material having a different material composition than each of the level of additional insulative material of the lowermost one of the additional tiers and the oxide material of the interdeck structure.

10. A non-volatile memory device, comprising:

- a lower deck comprising conductive material vertically alternating with insulative material;
- strings of non-volatile memory cells extending vertically through the lower deck;
- an interdeck region above the lower deck, the interdeck region comprising:
 - conductive contact structures electrically coupled to the strings of non-volatile memory cells; and

dielectric oxide material surrounding the conductive contact structures;

- a dielectric etch stop material above the interdeck region and having a material composition different than that of each of the insulative material of the lower deck and the dielectric oxide material of the interdeck region;
- an upper deck above the dielectric etch stop material and comprising additional conductive material vertically alternating with additional insulative material; and
- additional strings of non-volatile memory cells extending vertically through the upper deck and electrically coupled to the conductive contact structures of the interdeck region.

11. The non-volatile memory device of claim **10**, wherein the interdeck region further comprises further conductive material laterally positioned between horizontally neighboring ones of the conductive contact structures, the further conductive material electrically isolated from the conductive contact structures by the dielectric oxide material.

12. The non-volatile memory device of claim **11**, wherein a vertical span of the dielectric oxide material of the interdeck region is greater than that of the further conductive material of the interdeck region.

13. The non-volatile memory device of claim **12**, wherein the dielectric etch stop material physically contacts upper surfaces of the dielectric oxide material and the further conductive material of the interdeck region.

14. The non-volatile memory device of claim **10**, further comprising:

- a source structure below the lower deck and electrically coupled to the strings of non-volatile memory cells and the additional strings of non-volatile memory cells; and
- digit line structures above the upper deck and electrically coupled to the strings of non-volatile memory cells and the additional strings of non-volatile memory cells.

15. The non-volatile memory device of claim **14**, further comprising additional dielectric etch stop material vertically between the lower deck and the source structure, the additional dielectric etch stop material an additional material

composition different than that of each of the insulative material of the lower deck and the dielectric oxide material of the interdeck region.

16. A 3D NAND Flash memory device, comprising:

- two decks vertically neighboring one another and respectively comprising tiers vertically stacked relative to one another, each of the tiers including conductive material vertically neighboring insulative material;

vertically extending strings of memory cells located within vertical extents of the two decks; and

an interdeck structure vertically interposed between the two decks and comprising:

- conductive contact structures electrically coupled to the vertically extending strings of memory cells and respectively including an upper surface having an at least partially arcuate vertical cross-sectional profile; and

dielectric oxide material in physical contact with the upper surface and outer side surfaces of respective ones of the conductive contact structures.

17. The 3D NAND Flash memory device of claim **16**, wherein the outer side surfaces of the conductive contact structures respectively have a convex vertical cross-sectional profile.

18. The 3D NAND Flash memory device of claim **16**, wherein the interdeck structure further comprises additional conductive material adjacent to the dielectric oxide material, the additional conductive material electrically isolated from the vertically extending strings of memory cells and from the conductive material of the respective ones of the tiers of the two decks.

19. The 3D NAND Flash memory device of claim **18**, wherein the additional conductive material of the interdeck structure comprises one or more of conductively doped polycrystalline silicon and tungsten.

20. The 3D NAND Flash memory device of claim **16**, wherein the conductive contact structures respectively have horizontal widths that increase relative to one another in a direction vertically extending away from a vertically lower one of the two decks.

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