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Howder et al.

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(54) **MEMORY ARRAYS COMPRISING STRINGS OF MEMORY CELLS AND METHODS USED IN FORMING A MEMORY ARRAY COMPRISING STRINGS OF MEMORY CELLS**

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CPC H10B 43/27; H10B 43/35
See application file for complete search history.

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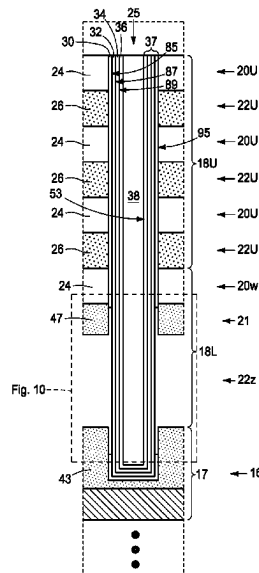
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(57) **ABSTRACT**

A memory array comprising strings of memory cells comprises laterally-spaced memory-blocks individually comprising a vertical stack comprising alternating insulative tiers and conductive tiers directly above conductor material of a conductor tier. Channel-material-string constructions extend through the insulative and conductive tiers to a lowest of the conductive tiers. The channel-material-string constructions individually comprise a charge-blocking-material string, a storage-material string laterally-inward of the charge-blocking-material string, a charge-passage-material string laterally-inward of the storage-material string, and a channel-material string laterally-inward of the charge-passage-material string. A lowest surface of the charge-blocking-material string that is above a lowest surface of a lowest of the insulative tiers is below a lowest surface of a lowest of the conductive tiers that is immediately-above the lowest conductive tier. Conductive material in the lowest conductive tier directly electrically couples together the channel material of individual of the channel-material strings and the conductor material of the conductor tier. Structure independent of method is disclosed.

13 Claims, 16 Drawing Sheets



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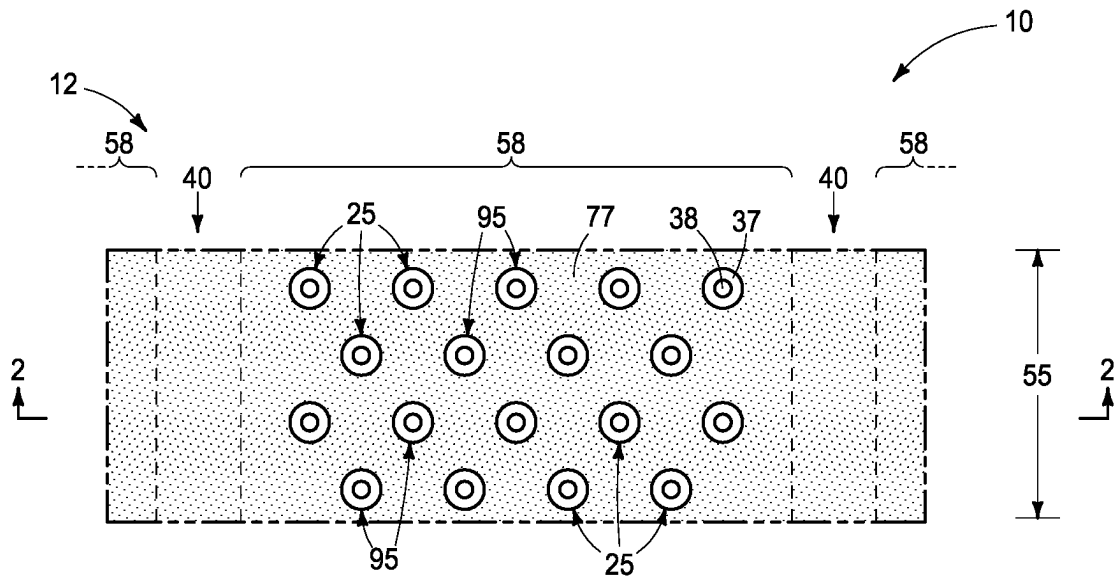


FIG. 1

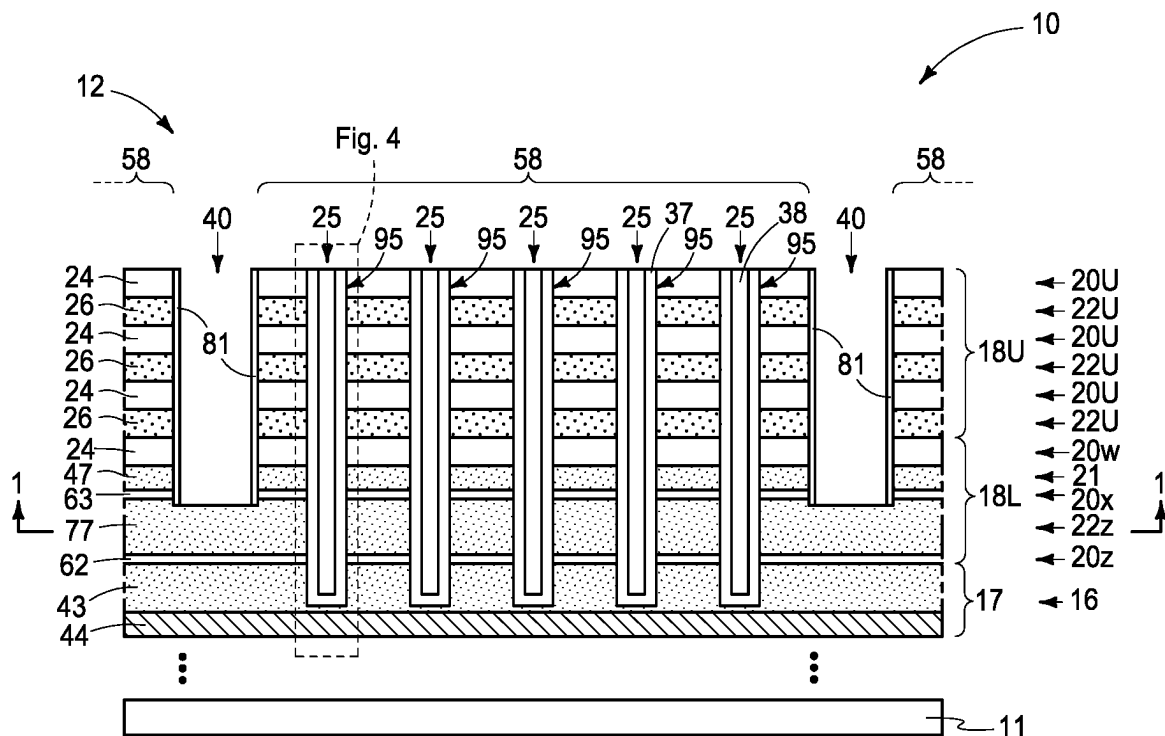


FIG. 2

FIG. 4

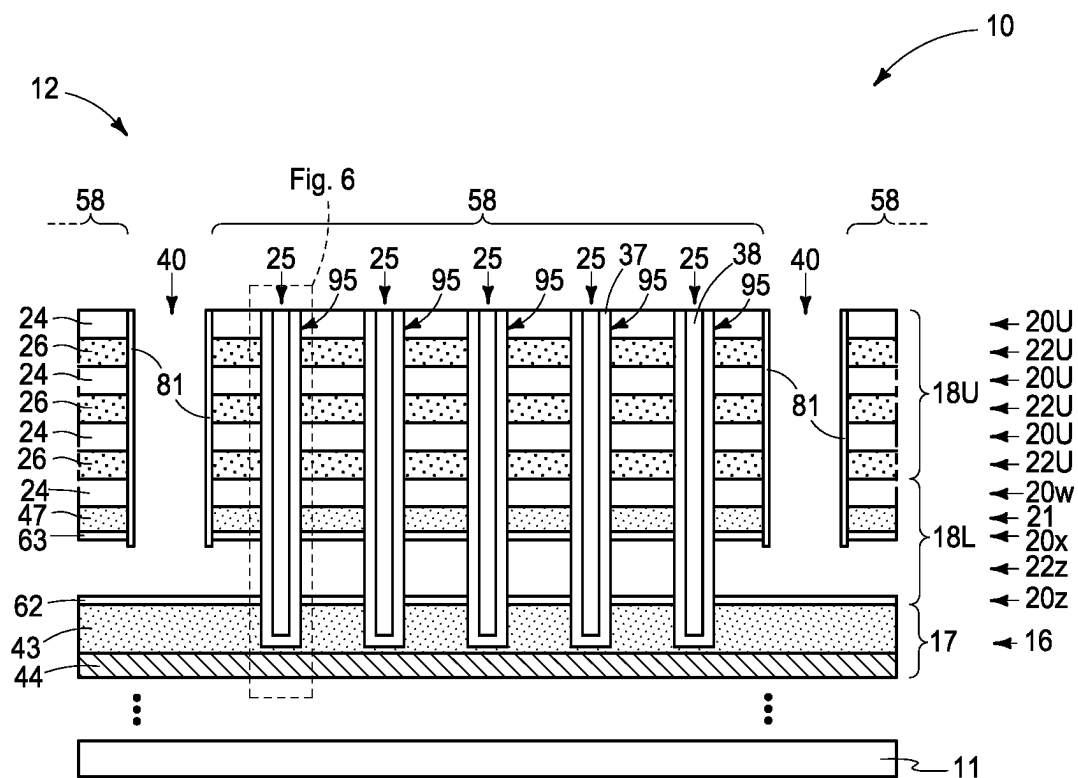


FIG. 5

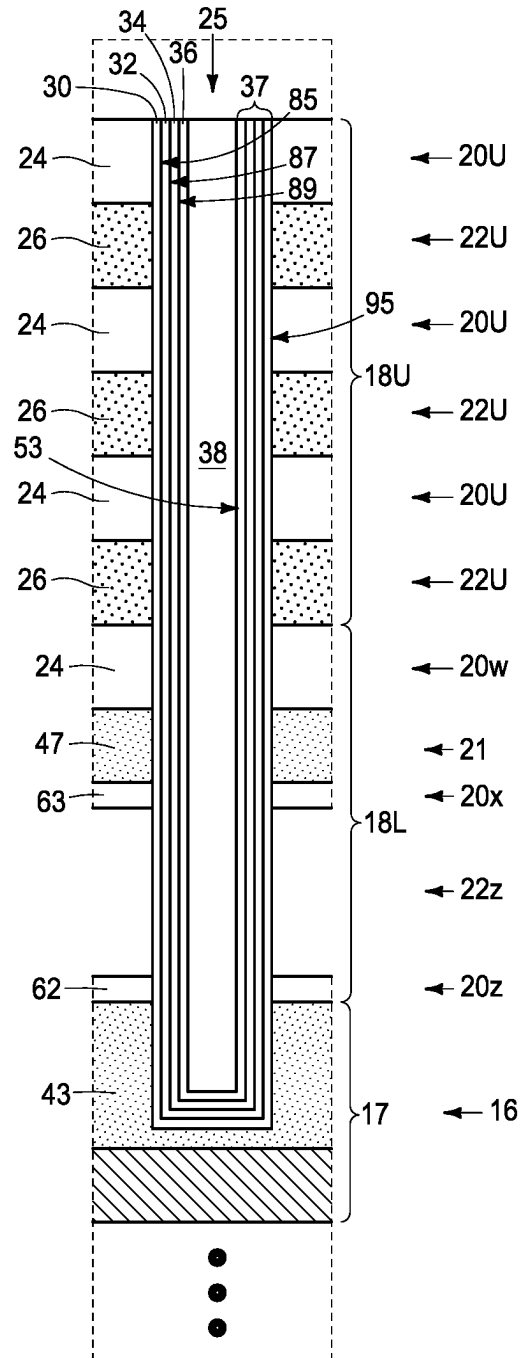


FIG. 6

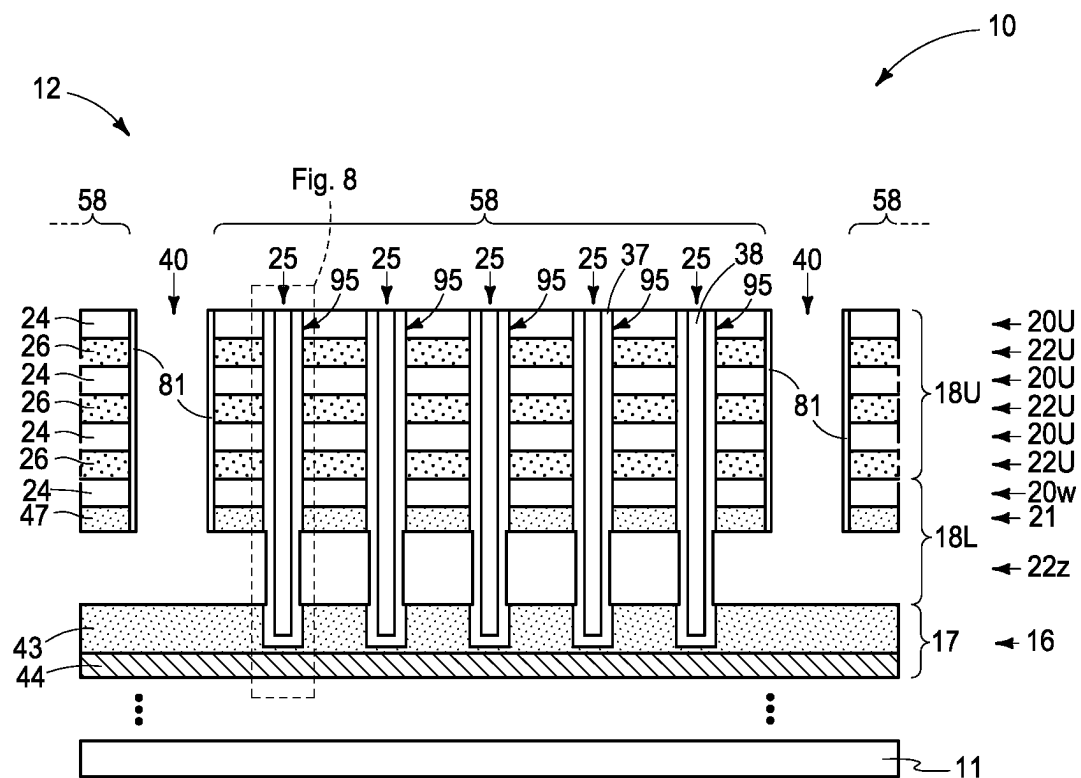


FIG. 7

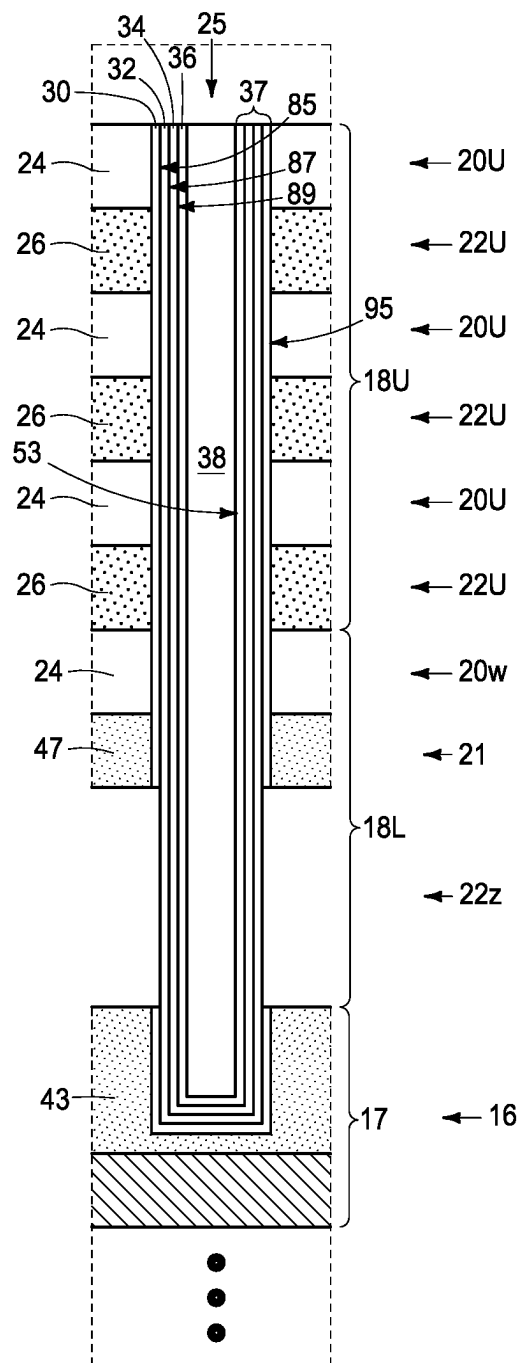
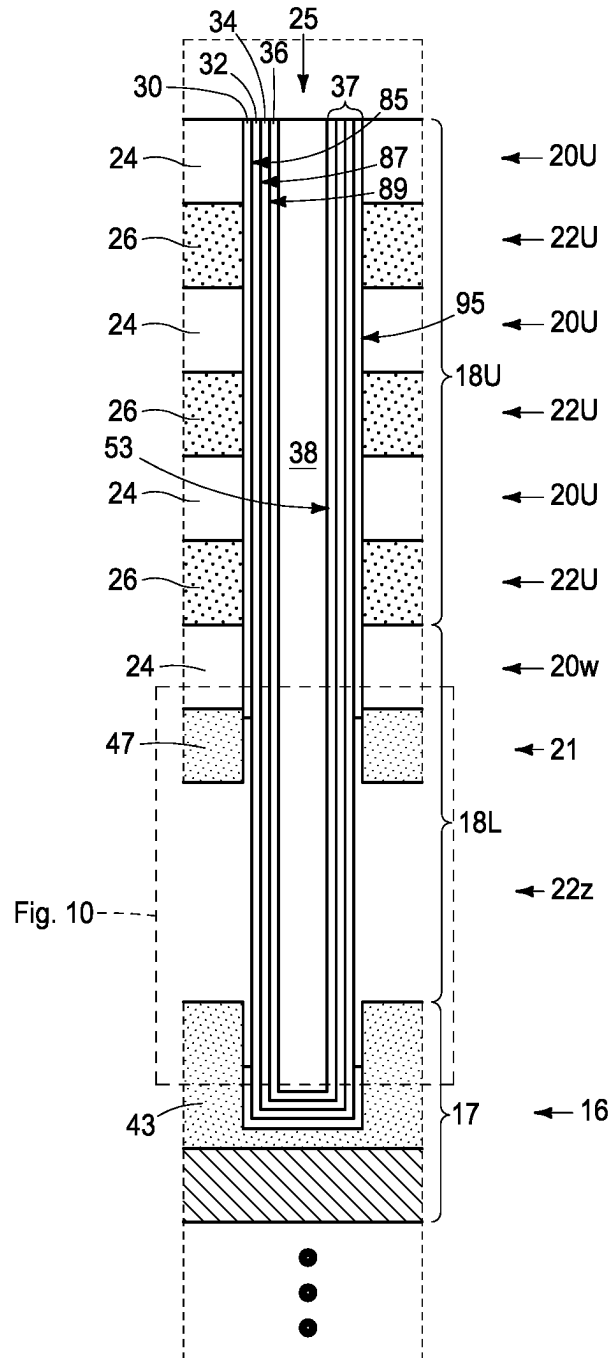


FIG. 8



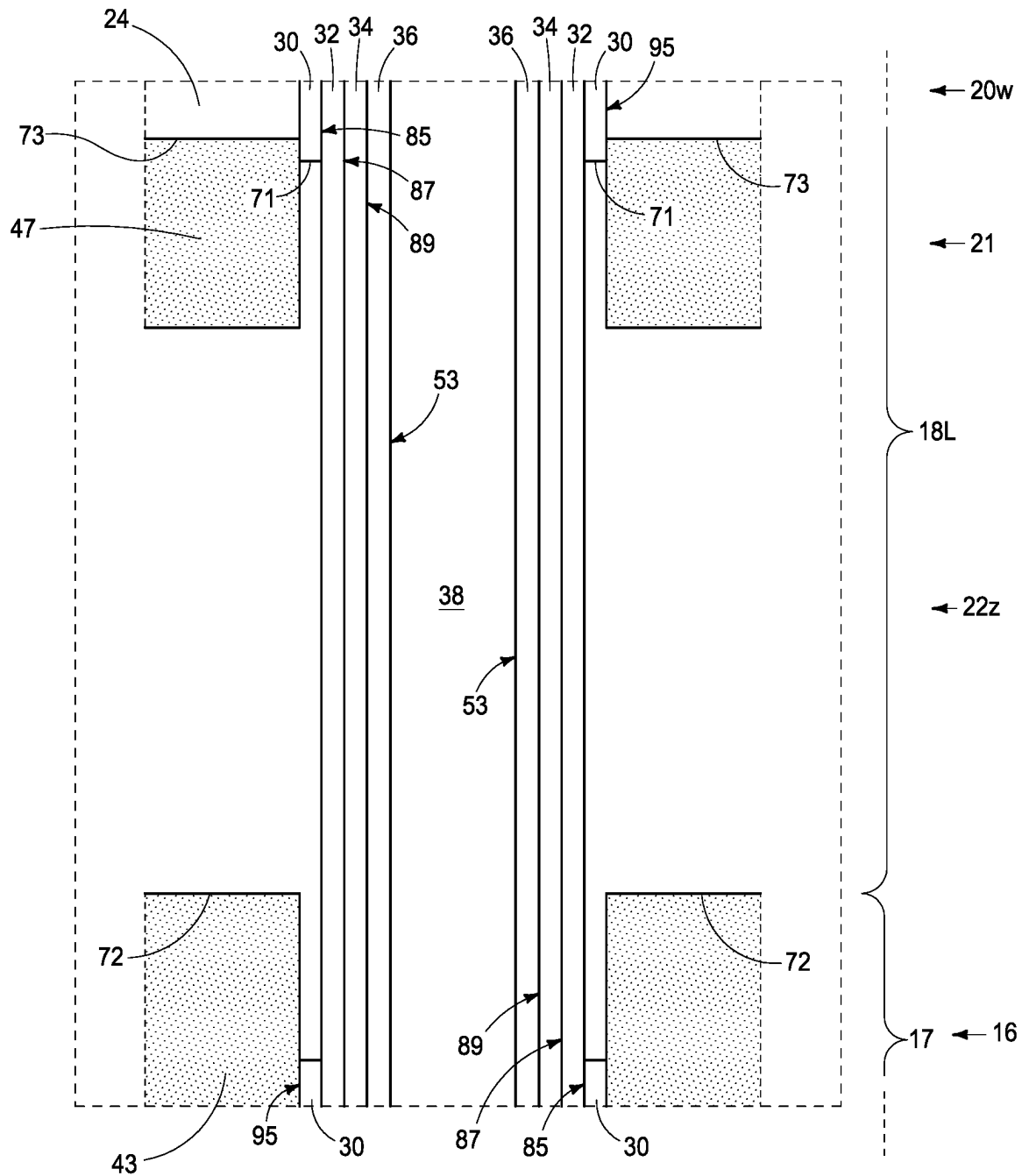


FIG. 10

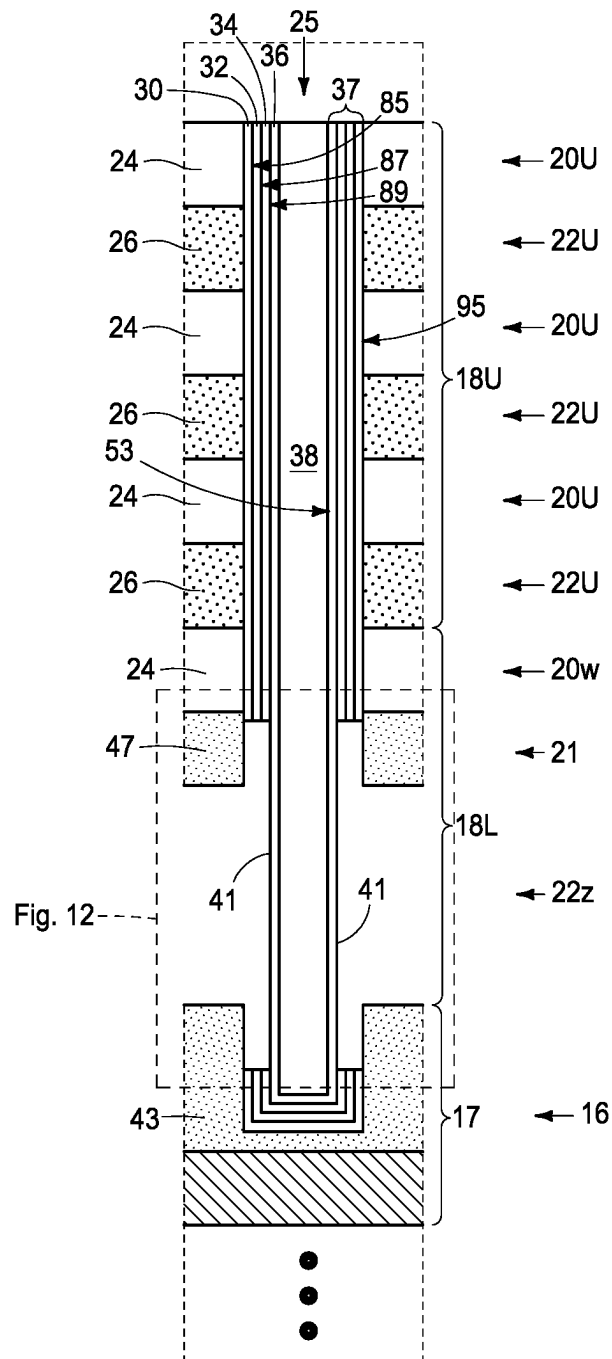


FIG. 11

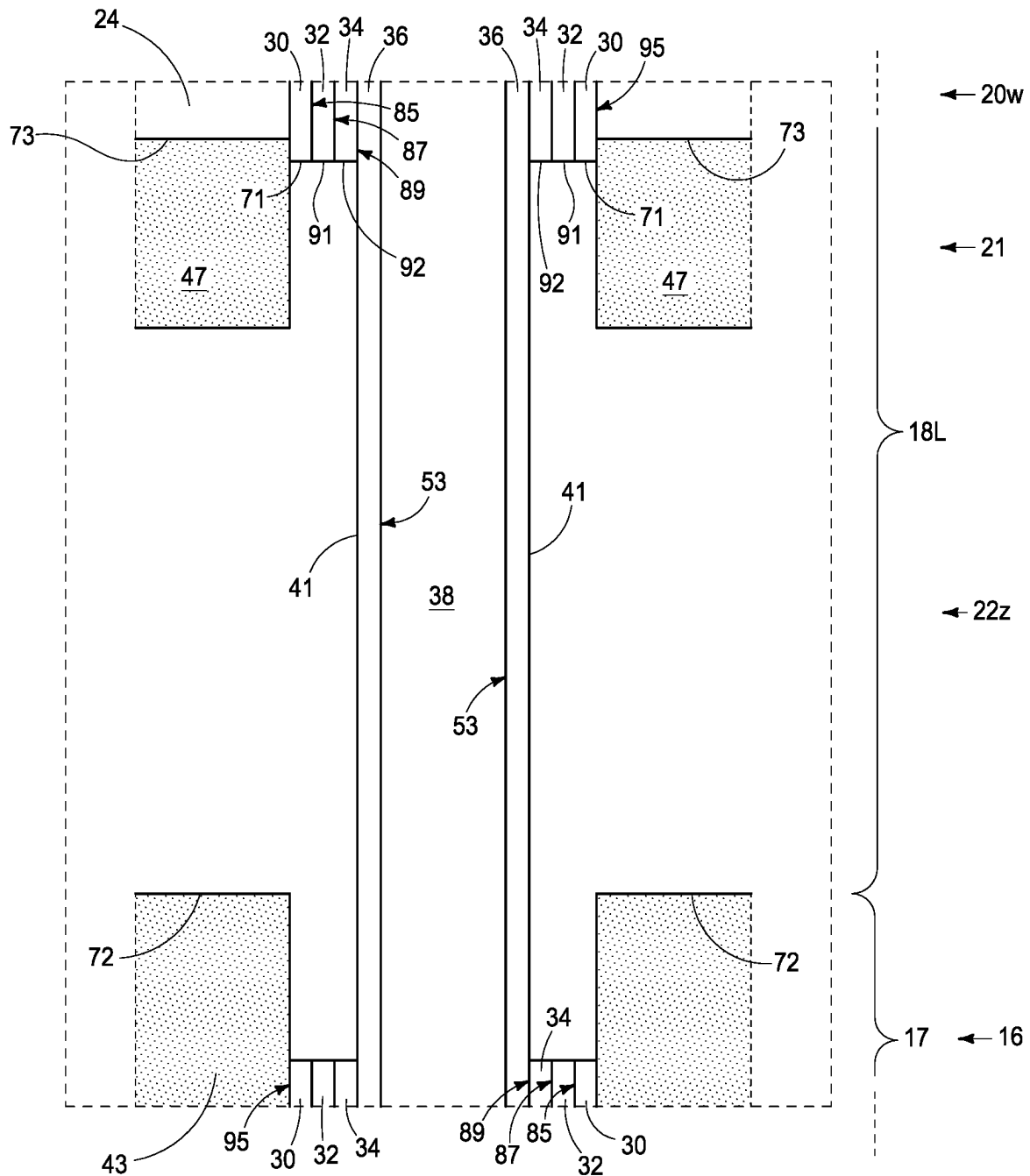
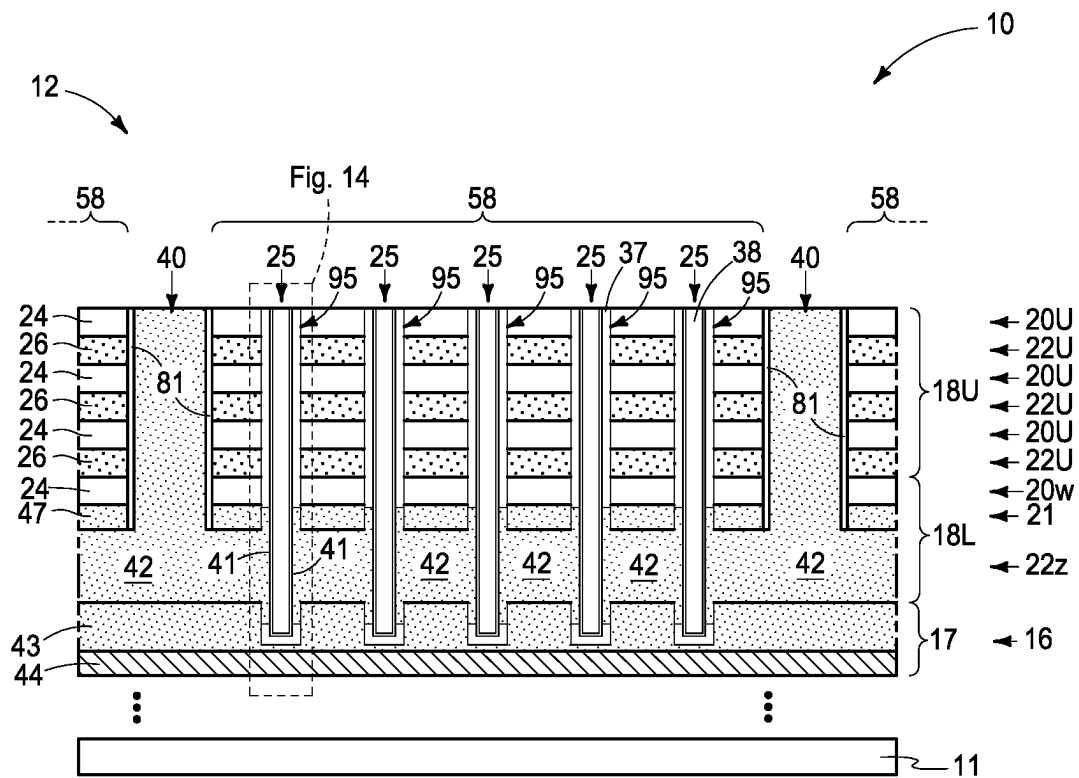


FIG. 12



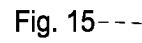


FIG. 14

FIG. 15

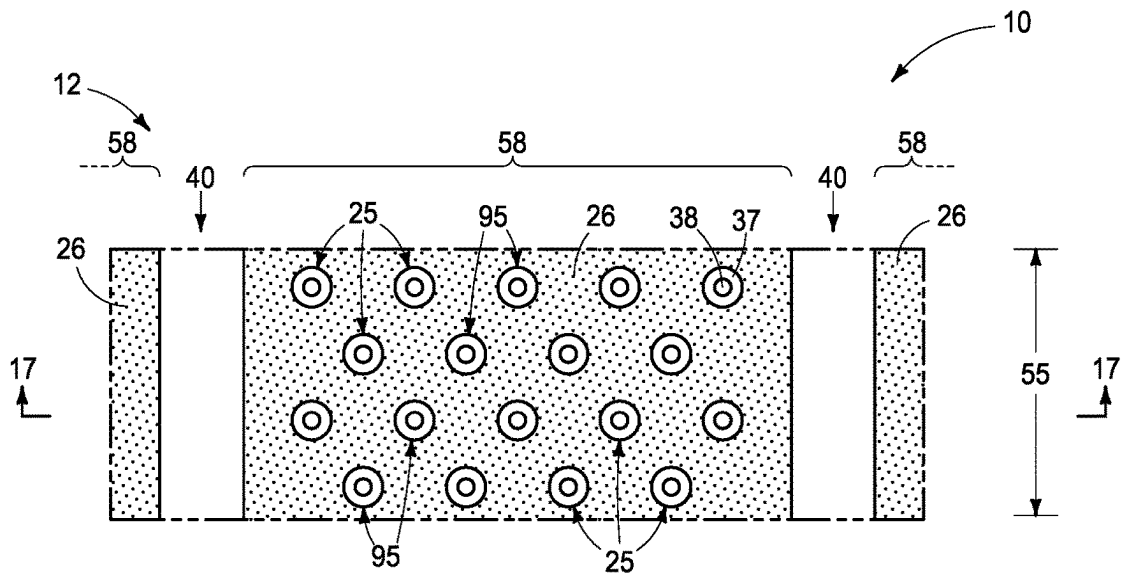


FIG. 16

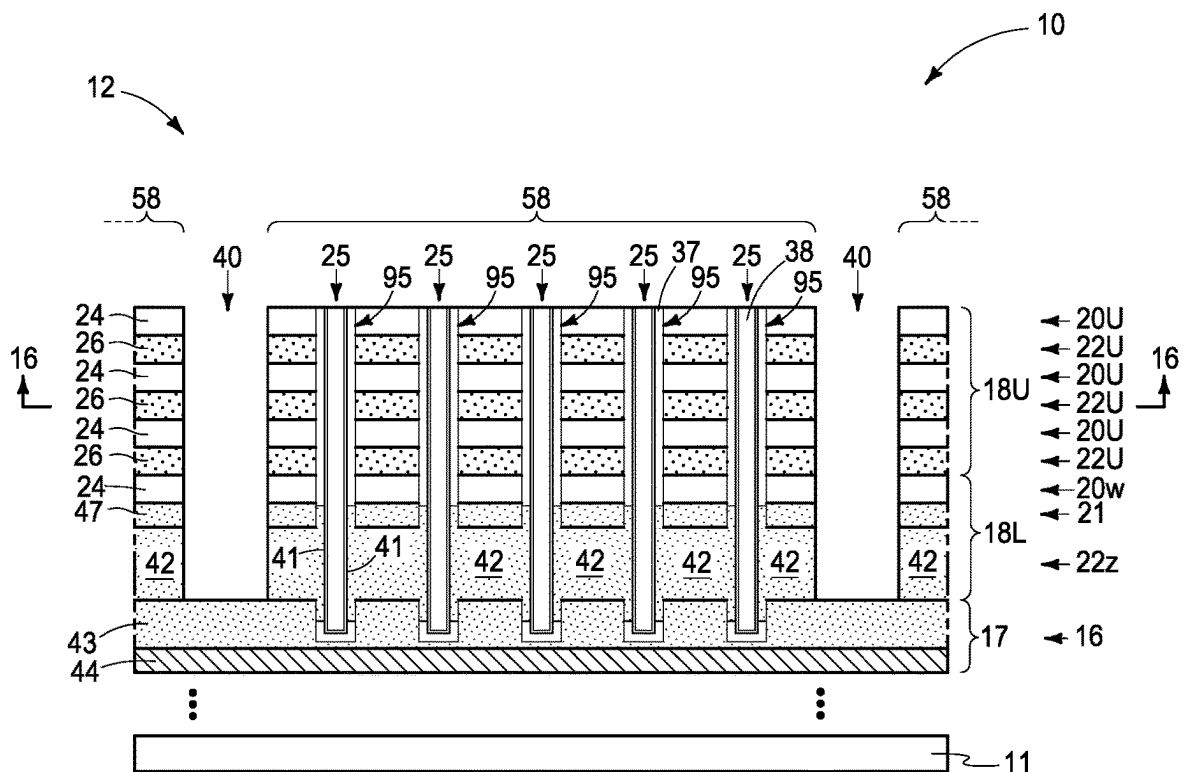


FIG. 17

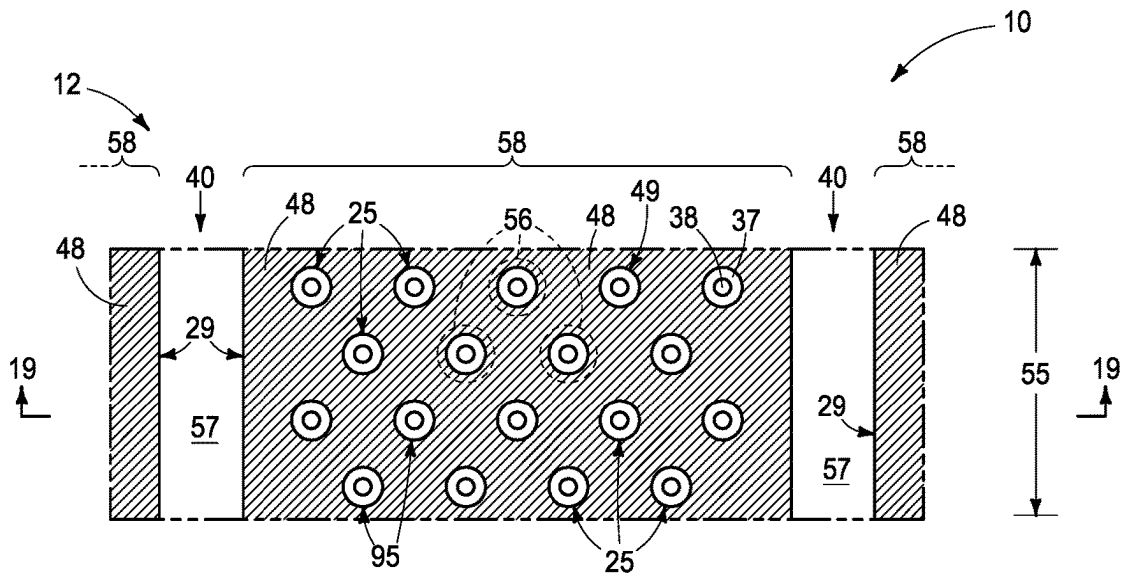


FIG. 18

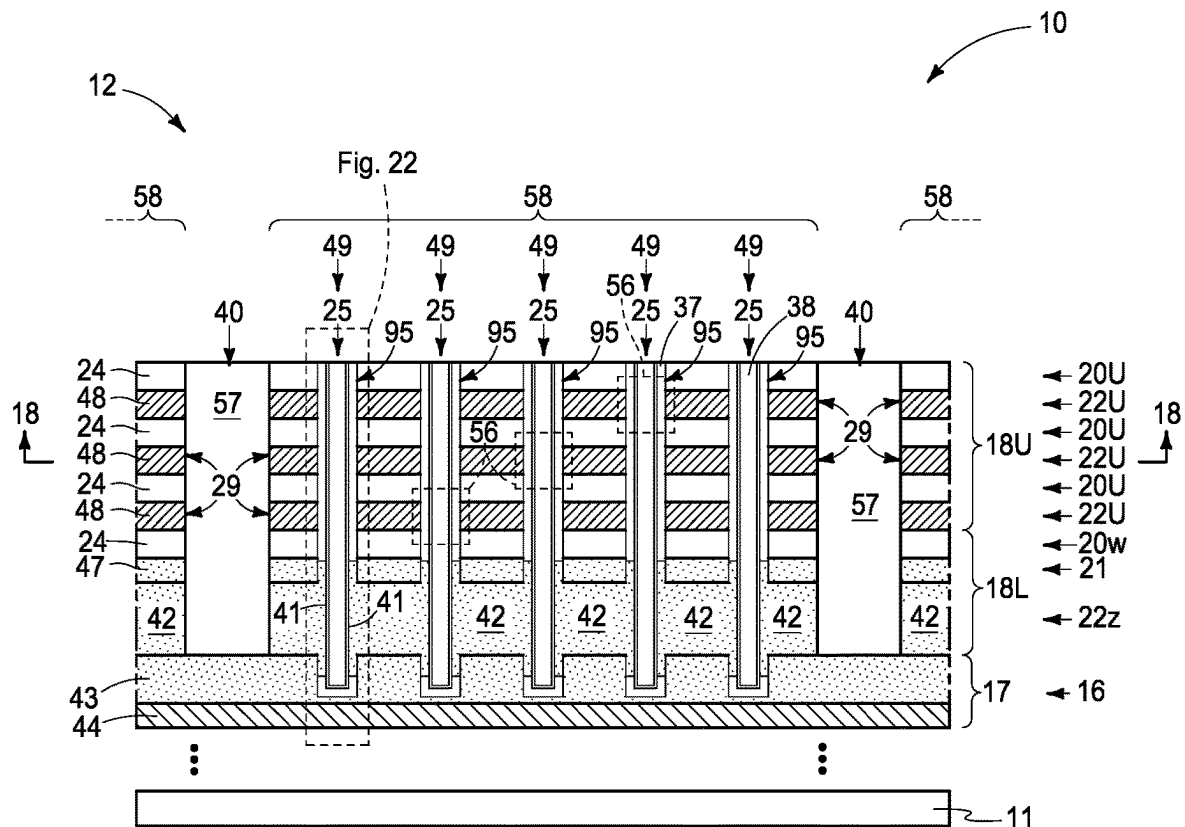


FIG. 19

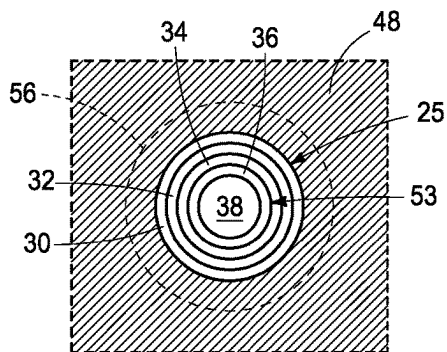


FIG. 20

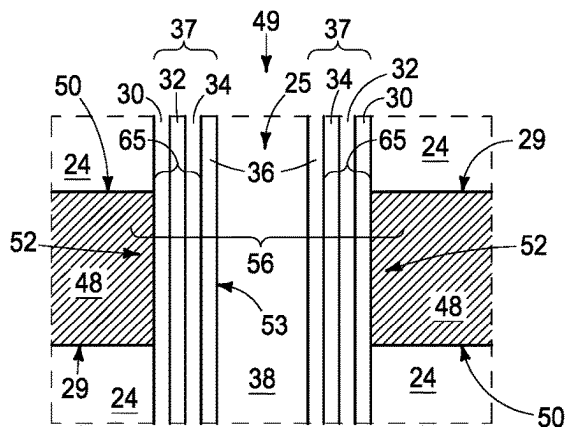


FIG. 21

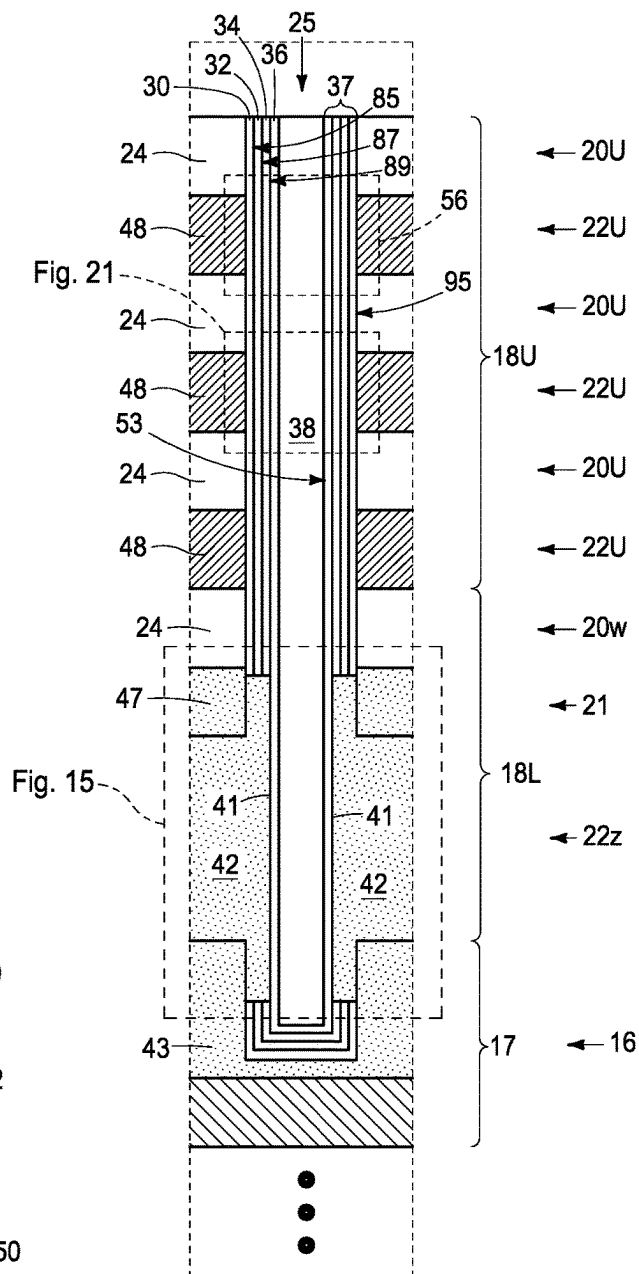


FIG. 22

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MEMORY ARRAYS COMPRISING STRINGS OF MEMORY CELLS AND METHODS USED IN FORMING A MEMORY ARRAY COMPRISING STRINGS OF MEMORY CELLS

TECHNICAL FIELD

Embodiments disclosed herein pertain to memory arrays comprising strings of memory cells and to methods used in forming a memory array comprising strings of memory cells.

BACKGROUND

Memory is one type of integrated circuitry and is used in computer systems for storing data. Memory may be fabricated in one or more arrays of individual memory cells. Memory cells may be written to, or read from, using digitlines (which may also be referred to as bitlines, data lines, or sense lines) and access lines (which may also be referred to as wordlines). The sense lines may conductively interconnect memory cells along columns of the array, and the access lines may conductively interconnect memory cells along rows of the array. Each memory cell may be uniquely addressed through the combination of a sense line and an access line.

Memory cells may be volatile, semi-volatile, or non-volatile. Non-volatile memory cells can store data for extended periods of time in the absence of power. Non-volatile memory is conventionally specified to be memory having a retention time of at least about 10 years. Volatile memory dissipates and is therefore refreshed/rewritten to maintain data storage. Volatile memory may have a retention time of milliseconds or less. Regardless, memory cells are configured to retain or store memory in at least two different selectable states. In a binary system, the states are considered as either a “0” or a “1”. In other systems, at least some individual memory cells may be configured to store more than two levels or states of information.

A field effect transistor is one type of electronic component that may be used in a memory cell. These transistors comprise a pair of conductive source/drain regions having a semiconductive channel region therebetween. A conductive gate is adjacent the channel region and separated therefrom by a thin gate insulator. Application of a suitable voltage to the gate allows current to flow from one of the source/drain regions to the other through the channel region. When the voltage is removed from the gate, current is largely prevented from flowing through the channel region. Field effect transistors may also include additional structure, for example a reversibly programmable charge-storage region as part of the gate construction between the gate insulator and the conductive gate.

Flash memory is one type of memory and has numerous uses in modern computers and devices. For instance, modern personal computers may have BIOS stored on a flash memory chip. As another example, it is becoming increasingly common for computers and other devices to utilize flash memory in solid state drives to replace conventional hard drives. As yet another example, flash memory is popular in wireless electronic devices because it enables manufacturers to support new communication protocols as they become standardized, and to provide the ability to remotely upgrade the devices for enhanced features.

Memory arrays may be arranged in memory pages, memory blocks and partial blocks (e.g., sub-blocks), and

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memory planes, for example as shown and described in any of U.S. Patent Application Publication Nos. 2015/0228651, 2016/0267984, and 2017/0140833. The memory blocks may at least in part define longitudinal outlines of individual wordlines in individual wordline tiers of vertically-stacked memory cells. Connections to these wordlines may occur in a so-called “stair-step structure” at an end or edge of an array of the vertically-stacked memory cells. The stair-step structure includes individual “stairs” (alternately termed “steps” or “stair-steps”) that define contact regions of the individual wordlines upon which elevationally-extending conductive vias contact to provide electrical access to the wordlines.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1-4 are diagrammatic cross-sectional views of portions of a construction that will comprise an array of elevationally-extending strings of memory cells in accordance with an embodiment of the invention.

FIGS. 5-22 are diagrammatic sequential sectional and/or enlarged views of the construction of FIGS. 1-4, or portions thereof or alternate and/or additional embodiments, in process in accordance with some embodiments of the invention.

DETAILED DESCRIPTION OF EXAMPLE EMBODIMENTS

Embodiments of the invention encompass methods used in forming a memory array, for example an array of NAND or other memory cells that may have at least some peripheral control circuitry under the array (e.g., CMOS-under-array). Embodiments of the invention encompass so-called “gate-last” or “replacement-gate” processing, so-called “gate-first” processing, and other processing whether existing or future-developed independent of when transistor gates are formed. Embodiments of the invention also encompass integrated circuitry comprising a memory array comprising strings of memory cells (e.g., NAND architecture) independent of method of manufacture. Example method embodiments are described with reference to FIGS. 1-22.

FIGS. 1-4 show a construction 10 having an array or array area 12 in which elevationally-extending strings of transistors and/or memory cells will be formed. Such includes a base substrate 11 having any one or more of conductive/conductor/conducting, semiconductive/semiconductor/semiconducting, or insulative/insulator/insulating (i.e., electrically herein) materials. Various materials have been formed elevationally over base substrate 11. Materials may be aside, elevationally inward, or elevationally outward of the FIGS. 1-4-depicted materials. For example, other partially or wholly fabricated components of integrated circuitry may be provided somewhere above, about, or within base substrate 11. Control and/or other peripheral circuitry for operating components within an array (e.g., array 12) of elevationally-extending strings of memory cells may also be fabricated and may or may not be wholly or partially within an array or sub-array. Further, multiple sub-arrays may also be fabricated and operated independently, in tandem, or otherwise relative one another. In this document, a “sub-array” may also be considered as an array.

A conductor tier 16 comprising conductor material 17 has been formed above substrate 11. Conductor material 17 as shown comprises upper conductor material 43 directly above and directly electrically coupled to (e.g., directly against) lower conductor material 44 of different composition from upper conductor material 43. In one embodiment, upper conductor material 43 comprises conductively-doped

semiconductive material (e.g., n-type-doped or p-type-doped polysilicon). In one embodiment, lower conductor material **44** comprises metal material (e.g., a metal silicide such as WSi_x). Conductor tier **16** may comprise part of control circuitry (e.g., peripheral-under-array circuitry and/or a common source line or plate) used to control read and write access to the transistors and/or memory cells that will be formed within array **12**.

A lower portion **18L** of a stack **18*** has been formed above substrate **11** and conductor tier **16** (an * being used as a suffix to be inclusive of all such same-numerically-designated components that may or may not have other suffixes). Stack **18*** comprises vertically-alternating conductive tiers **22*** and insulative tiers **20***, with material of tiers **22*** being of different composition from material of tiers **20***. Stack **18*** comprises laterally-spaced memory-block regions **58** that will comprise laterally-spaced memory blocks **58** in a finished circuitry construction. In this document, unless otherwise indicated, “block” is generic to include “sub-block”. Memory-block regions **58** and resultant memory blocks **58** (not yet shown) may be considered as being longitudinally elongated and oriented, for example along a direction **55**.

Conductive tiers **22*** (alternately referred to as first tiers) may not comprise conducting material and insulative tiers **20*** (alternately referred to as second tiers) may not comprise insulative material or be insulative at this point in processing in conjunction with the hereby initially-described example method embodiment which is “gate-last” or “replacement-gate”. In one embodiment, lower portion **18L** comprises a lowest tier **20z** of second tiers **20*** directly above (e.g., directly against) conductor material **17**. Example lowest second tier **20z** is insulative and may be sacrificial (e.g., comprising material **62**, for example silicon dioxide and/or silicon nitride). A next-lowest second tier **20x** of second tiers **20*** is directly above lowest second tier **20z** and may be sacrificial (e.g., comprising material **63**, for example silicon dioxide and/or silicon nitride). In some embodiments, a lowest tier **22z** of first tiers **22*** comprising sacrificial material **77** (e.g., polysilicon or silicon nitride) is vertically between lowest second tier **20z** and next-lowest second tier **20x**. In one embodiment, lower portion **18L** comprises a conducting-material tier **21** comprising conducting material **47** (e.g., conductively-doped polysilicon) that is directly above next-lowest second tier **20x**. Example lower portion **18L** comprises an upper second tier **20w** (e.g., a next-next lowest second tier) comprising insulative material **24** (e.g., silicon dioxide). Additional tiers may be present. For example, one or more additional tiers may be above tier **20w** (tier **20w** thereby not being the uppermost tier in portion **18L**, and not shown), between tier **20w** and tier **21** (not shown), and/or below tier **22z** (other than **20z** not being shown). Example lower portion **18L** comprises multiple first/conductive tiers (e.g., **22z** and **21**) tiers and multiple second/insulative tiers (e.g., **20z**, **20x**, **20w**), at least as initially formed.

Vertically-alternating first tiers **22U** and second tiers **20U** of an upper portion **18U** of stack **18*** have been formed above lower portion **18L**. Material **26** of first tiers **22U** is sacrificial (e.g., silicon nitride; in some embodiments referred to as sacrificial material) and of different composition from material **24** of second tiers **20U** (e.g., silicon dioxide). First tiers **22U** may be conductive and second tiers **20U** may be insulative (e.g., comprising silicon dioxide **24**), yet need not be so at this point of processing in conjunction with the hereby initially-described example method embodiment which is “gate-last” or “replacement-gate”. Example upper portion **18U** is shown starting above lower portion

18L with a first tier **22U** although such could alternately start with a second tier **20U** (not shown). Further, and by way of example, lower portion **18L** may be formed to have one or more first and/or second tiers as a top thereof. Regardless, only a small number of tiers **20U** and **22U** is shown, with more likely upper portion **18U** (and thereby stack **18***) comprising dozens, a hundred or more, etc. of tiers **20*** and **22***. Further, other circuitry that may or may not be part of peripheral and/or control circuitry may be between conductor tier **16** and stack **18***. By way of example only, multiple vertically-alternating tiers of conductive material and insulative material of such circuitry may be below a lowest of conductive tiers **22*** and/or above an uppermost of conductive tiers **22***. For example, one or more select gate tiers (not shown) may be between conductor tier **16** and the lowest conductive tier **22*** and one or more select gate tiers may be above an uppermost of conductive tiers **22***. Alternately or additionally, at least one of the depicted uppermost and lowest conductive tiers **22*** may be a select gate tier.

Channel openings **25** have been formed (e.g., by etching) through second tiers **20*** and first tiers **22*** in upper portion **18U** to lower portion **18L** (e.g., at least to lowest first tier **22z** in lower portion **18L**). Channel openings **25** may taper radially-inward or radially-outward (not shown) moving deeper into stack **18**. In some embodiments, channel openings **25** may go into conductor material **17** of conductor tier **16** as shown or may stop there-atop (not shown). Alternately, as an example, channel openings **25** may stop atop or within the lowest second tier **20z**. A reason for extending channel openings **25** at least to conductor material **17** of conductor tier **16** is to provide an anchoring effect to material that is within channel openings **25**. Etch-stop material (not shown) may be within or atop conductor material **17** of conductor tier **16** to facilitate stopping of the etching of channel openings **25** relative to conductor tier **16** when such is desired. Such etch-stop material may be sacrificial or non-sacrificial.

Transistor channel material may be formed in the individual channel openings elevationally along the insulative tiers and the conductive tiers, thus comprising individual channel-material strings, which is directly electrically coupled with conductive material in the conductor tier. Individual memory cells of the example memory array being formed may comprise a gate region (e.g., a control-gate region) and a memory structure laterally-between the gate region and the channel material. In one such embodiment, the memory structure is formed to comprise a charge-blocking region, storage material (e.g., charge-storage material), and an insulative charge-passage material. The storage material (e.g., floating gate material such as doped or undoped silicon or charge-trapping material such as silicon nitride, metal dots, etc.) of the individual memory cells is elevationally along individual of the charge-blocking regions. The insulative charge-passage material (e.g., a band gap-engineered structure having nitrogen-containing material [e.g., silicon nitride] sandwiched between two insulator oxides [e.g., silicon dioxide]) is laterally-between the channel material and the storage material.

Channel-material-string constructions **95** have been formed that extend through first tiers **22*** and second tiers **20*** to lowest first tier **22z**. Channel-material-string constructions **95** individually comprise a charge-blocking-material string **85** (e.g., comprising charge-blocking material **30**), a storage-material string **87** (e.g., comprising storage material **32**) laterally-inward of charge-blocking-material string **85**, a charge-passage-material string **89** (e.g., comprising charge-passage material **34**) laterally-inward of stor-

age-material string **87**, and a channel-material string **53** (e.g., comprising channel material **36**) laterally-inward of charge-passage-material string **89**. Materials **30**, **32**, and **34** (e.g., transistor materials and/or memory-cell materials) may be formed by, for example, deposition of respective thin layers thereof over stack **18*** and within individual openings **25** followed by planarizing such back at least to a top surface of stack **18***. Materials **30**, **32**, **34**, and **36** are collectively shown as and only designated as material **37** in some figures due to scale. In one embodiment and as shown, channel-material-string constructions **95** extend into conductor tier **16**.

Example channel materials **36** include appropriately-doped crystalline semiconductor material, such as one or more silicon, germanium, and so-called III/V semiconductor materials (e.g., GaAs, InP, GaP, and GaN). Example thickness for each of materials **30**, **32**, **34**, and **36** is **25** to **100** Angstroms. Punch etching may be conducted to remove materials **30**, **32**, and **34** from the bases of channel openings **25** (not shown) to expose conductor tier **16** such that channel material **36** is directly against conductor material **17** of conductor tier **16**. Such punch etching may occur separately with respect to each of materials **30**, **32**, and **34** (as shown) or may occur with respect to only some (not shown). Alternately, and by way of example only, no punch etching may be conducted and channel material **36** may be directly electrically coupled to conductor material **17** of conductor tier **16** only by a separate conductive interconnect (not yet shown). Regardless, sacrificial etch-stop plugs (not shown) may be formed in lower portion **18L** in horizontal locations where channel openings **25** will be prior to forming upper portion **18U**. Channel openings **25** may then be formed by etching materials **24** and **26** to stop on or within the material of the sacrificial plugs, followed by exhuming remaining material of such plugs prior to forming material in channel openings **25**. A radially-central solid dielectric material **38** (e.g., spin-on-dielectric, silicon dioxide, and/or silicon nitride) is shown in channel openings **25**. Alternately, and by way of example only, the radially-central portion within channel openings **25** may include void space(s) (not shown) and/or be devoid of solid material (not shown).

Horizontally-elongated trenches **40** have been formed (e.g., by anisotropic etching) into stack **18*** and that are individually between immediately-laterally-adjacent memory-block regions **58**. Trenches **40** individually extend through upper portion **18U** to lowest first tier **22z** and expose sacrificial material **77** therein. A sacrificial etch-stop line (not shown) having the same general horizontal outline as trenches **40** may individually be formed in a lower portion of stack **18*** prior to forming trenches **40**. Trenches **40** may then be formed by etching materials **24** and **26** to stop on or within the material of the individual sacrificial lines, followed by exhuming remaining material of such sacrificial lines. An optional thin sacrificial liner **81** (e.g., hafnium oxide, aluminum oxide, multiple layers of the same or other materials, [e.g., silicon dioxide and silicon nitride] etc.) has then be formed in trenches **40**, followed by punch-etching there-through to expose material **77**. Trenches **40** may taper laterally-inward or laterally-outward moving deeper into stack **18*** (not shown). By way of example and for brevity only, channel openings **25** are shown as being arranged in groups or columns of staggered rows of four and five channel openings **25** per row. Trenches **40** will typically be wider than channel openings **25** (e.g., 2 to 5 timeswider). Any alternate existing or future-developed arrangement and

construction may be used. Trenches **40** and channel openings **25** may be formed in any order relative the other or at the same time.

Referring to FIGS. **5** and **6**, sacrificial material **77** (not shown) has been removed (e.g., by isotropic etching) from lowest first tier **22z** through trenches **40**. Such may occur, for example, by isotropic etching that is ideally conducted selectively relative to materials **62** and **63**, for example using liquid or vapor H_3PO_4 as a primary etchant where material **77** is silicon nitride or using tetramethyl ammonium hydroxide [TMAH] where material **77** is polysilicon.

FIGS. **7** and **8** show example subsequent processing wherein, in one embodiment, material **30** (e.g., silicon dioxide) has been etched in lowest first tier **22z** to removed it therefrom and in one embodiment to expose storage-material string **87**. As examples, a solution of 100:1 (by volume) water to HF will etch silicon dioxide selectively relative to silicon nitride. In one embodiment, such etching may be conducted selectively relative to liner **81** (when present and as shown). In one embodiment and as shown, materials **62** and **63** (when present and not shown) have been removed. When so removed, such may be removed when removing materials **30**, for example if materials **62** and **63** comprise the same composition as that of material **30**. Alternately, when so removed, such may be removed separately (e.g., by isotropic etching).

Referring to FIGS. **9** and **10**, charge-blocking-material string **85** has been etched upwardly from and through lowest first tier **22z** selectively relative to storage-material string **87** (e.g., using the above 100:1 water to HF solution where storage material **32** is silicon nitride). In one embodiment, such etching also etches charge-blocking-material string **85** downwardly from lowest first tier **22z** selectively relative to storage-material string **87**. In one embodiment, such etching leaves a lowest surface of charge-blocking-material string **85** that is above a lowest surface **72** of lowest first tier **22z** (e.g., lowest surface **71**) to be below a lowest surface **73** of a lowest of second tiers **20*** that is immediately-above lowest first tier **22z** (i.e., there being no other lowest second tier **20*** between lowest first tier **22z** and said lowest second tier that is immediately there-above; e.g., **20w**). The example FIGS. **9** and **10** etching may be a continuing of the etching shown by FIGS. **7** and **8** (e.g., there being no temporal space between the etching shown by FIGS. **7**, **8** and that shown by FIGS. **8**, **9** where the etching is stopped.)

Referring to FIGS. **11** and **12**, storage-material string **87** and charge-passage-material string **89** have been etched in lowest first tier **22z** to expose channel material **36** of channel-material string **53** in lowest first tier **22z** (e.g., a laterally-outer sidewall **41** of channel-material string **53**). In one embodiment and as shown, such etching is upwardly from and through lowest first tier **22z** selectively relative to channel-material string **53** and in one such embodiment is also downwardly from and through lowest first tier **22z** selectively relative to channel-material string **53**. In one embodiment, such etching leaves respective lowest surfaces of storage-material string **87** and charge-passage-material string **89** that are above the lowest surface **72** of lowest first tier **22z** (e.g., surfaces **91**, **92**) to be below lowest surface **73** of lowest second tier **20w** that is immediately-above lowest first tier **22z**. In one embodiment, lowest surfaces **71**, **91**, and **92** are planar and coplanar.

Referring to FIGS. **13-15**, conductive material **42** (e.g., conductively-doped polysilicon) has been formed in lowest first tier **22z** and in one embodiment directly against laterally-outer sidewall **41** of channel material **36**. In one embodiment and as shown, such has been formed directly

against a bottom of conducting material **47** of conducting-material tier **21** and directly against a top of conductor material **43** of conductor tier **16**, thereby directly electrically coupling together channel material **36** of individual channel-material strings **53** with conductor material **43** of conductor tier **16** and conducting material **47** of conducting-material tier **21**.

Referring to FIGS. **16** and **17**, conductive material **42** has been removed from trenches **40** as has sacrificial liner **81** (not there-shown). Sacrificial liner **81** (when present and removed) may be removed before or after forming conductive material **42**. In one embodiment as shown, conducting material **47** of tier **21** and conductive material **42** of tier **22z** being directly against one another may collectively be considered as the lowest conductive tier at least in array **12**.

Referring to FIGS. **18-22**, material **26** (not shown) of conductive tiers **22U** has been removed, for example by being isotropically etched away through trenches **40** ideally selectively relative to the other exposed materials (e.g., using liquid or vapor H_3PO_4 as a primary etchant where material **26** is silicon nitride and other materials comprise one or more oxides or polysilicon). Material **26** (not shown) in conductive tiers **22U** in the example embodiment is sacrificial and has been replaced with conducting material **48**, and which has thereafter been removed from trenches **40**, thus forming individual conductive lines **29** (e.g., word-lines) and elevationally-extending strings **49** of individual transistors and/or memory cells **56**.

A thin insulative liner (e.g., Al_2O_3 and not shown) may be formed before forming conducting material **48**. Approximate locations of some transistors and/or some memory cells **56** are indicated with a bracket or with dashed outlines, with transistors and/or memory cells **56** being essentially ring-like or annular in the depicted example. Alternately, transistors and/or memory cells **56** may not be completely encircling relative to individual channel openings **25** such that each channel opening **25** may have two or more elevationally-extending strings **49** (e.g., multiple transistors and/or memory cells about individual channel openings in individual conductive tiers with perhaps multiple wordlines per channel opening in individual conductive tiers, and not shown). Conducting material **48** may be considered as having terminal ends **50** corresponding to control-gate regions **52** of individual transistors and/or memory cells **56**. Control-gate regions **52** in the depicted embodiment comprise individual portions of individual conductive lines **29**. Materials **30**, **32**, and **34** may be considered as a memory structure **65** that is laterally between control-gate region **52** and channel material **36**. In one embodiment and as shown with respect to the example "gate-last" processing, conducting material **48** of conductive tiers **22*** is formed after forming openings **25** and/or trenches **40**. Alternately, the conducting material of the conductive tiers may be formed before forming channel openings **25** and/or trenches **40** (not shown), for example with respect to "gate-first" processing.

A charge-blocking region (e.g., charge-blocking material **30**) is between storage material **32** and individual control-gate regions **52**. A charge block may have the following functions in a memory cell: In a program mode, the charge block may prevent charge carriers from passing out of the storage material (e.g., floating-gate material, charge-trapping material, etc.) toward the control gate, and in an erase mode the charge block may prevent charge carriers from flowing into the storage material from the control gate. Accordingly, a charge block may function to block charge migration between the control-gate region and the storage material of individual memory cells. An example charge-

blocking region as shown comprises insulator material **30**. By way of further examples, a charge-blocking region may comprise a laterally (e.g., radially) outer portion of the storage material (e.g., material **32**) where such storage material is insulative (e.g., in the absence of any different-composition material between an insulative storage material **32** and conducting material **48**). Regardless, as an additional example, an interface of a storage material and conductive material of a control gate may be sufficient to function as a charge-blocking region in the absence of any separate-composition-insulator material **30**. Further, an interface of conducting material **48** with material **30** (when present) in combination with insulator material **30** may together function as a charge-blocking region, and as alternately or additionally may a laterally-outer region of an insulative storage material (e.g., a silicon nitride material **32**). An example material **30** is one or more of silicon hafnium oxide and silicon dioxide.

Intervening material **57** has been formed in trenches **40** and thereby laterally-between and longitudinally-along immediately-laterally-adjacent memory blocks **58**. Intervening material **57** may provide lateral electrical isolation (insulation) between immediately-laterally-adjacent memory blocks. Such may include one or more of insulative, semiconductive, and conducting materials and, regardless, may facilitate conductive tiers **22** from shorting relative one another in a finished circuitry construction. Example insulative materials are one or more of SiO_2 , Si_3N_4 , and Al_2O_3 . Intervening material **57** may include through array vias (not shown).

Any other attribute(s) or aspect(s) as shown and/or described herein with respect to other embodiments may be used.

In one embodiment, a method used in forming a memory array (e.g., **12**) comprising strings (e.g., **49**) of memory cells (e.g., **56**) comprises forming laterally-spaced memory-block regions (e.g., **58**) individually comprising a vertical stack (e.g., **18***) comprising alternating first tiers (e.g., **22***) and second tiers (e.g., **20***) directly above conductor material (e.g., **17**) of a conductor tier (e.g., **16**). Channel-material-string constructions (e.g., **95**) are formed and that extend through the first and second tiers to a lowest of the first tiers (e.g., **22z**). The channel-material-string constructions individually comprise a charge-blocking-material string (e.g., **85**), a storage-material string (e.g., **87**) laterally-inward of the charge-blocking-material string, a charge-passage-material string (e.g., **89**) laterally-inward of the storage-material string, and a channel-material string (e.g., **53**) laterally-inward of the charge-passage-material string. The charge-blocking-material string, the storage-material string, and the charge-passage-material string are etched in the lowest first tier to expose the channel material (e.g., **36**) of the channel-material string in the lowest first tier. The etching leaves a lowest surface (e.g., **71**) of the charge-blocking-material string that is above a lowest surface (e.g., **72**) of the lowest first tier to be below a lowest surface (e.g., **73**) of a lowest of the second tiers (e.g., **20w**) that is immediately-above the lowest first tier. Conductive material (e.g., **42**) is formed in the lowest first tier and that directly electrically couples together the channel material (e.g., **36**) of individual of the channel-material strings and the conductor material of the conductor tier.

Any other attribute(s) or aspect(s) as shown and/or described herein with respect to other embodiments may be used.

Alternate embodiment constructions may result from method embodiments described above, or otherwise.

Regardless, embodiments of the invention encompass memory arrays independent of method of manufacture. Nevertheless, such memory arrays may have any of the attributes as described herein in method embodiments. Likewise, the above-described method embodiments may incorporate, form, and/or have any of the attributes described with respect to device embodiments.

In one embodiment, a memory array (e.g., 12) comprising strings (e.g., 49) of memory cells (e.g., 56) comprises laterally-spaced memory blocks (e.g., 58) individually comprising a vertical stack (e.g., 18*) comprising alternating insulative tiers (e.g., 20*) and conductive tiers (e.g., 22*) directly above conductor material (e.g., 17) of a conductor tier (e.g., 16). Channel-material-string constructions (e.g., 95) extend through the insulative and conductive tiers to a lowest of the conductive tiers (e.g., 22z). The channel-material-string constructions individually comprising a charge-blocking-material string (e.g., 85), a storage-material string (e.g., 87) laterally-inward of the charge-blocking-material string, a charge-passage-material string (e.g., 89) laterally-inward of the storage-material string, and a channel-material string (e.g., 53) laterally-inward of the charge-passage-material string. A lowest surface of the charge-blocking-material string (e.g., 71) that is above a lowest surface (e.g., 72) of the lowest conductive tier is below a lowest surface (e.g., 73) of the lowest of the insulative tiers (e.g., 20w) that is immediately-above the lowest conductive tier. Conductive material (e.g., 42) in the lowest conductive tier directly electrically couples together the channel material (e.g., 36) of individual of the channel-material strings and the conductor material of the conductor tier.

In one embodiment, respective lowest surfaces of the storage-material string and the charge-passage-material string that are above the lowest surface of the lowest first tier (e.g., 91, 92) are below the lowest surface of the lowest insulative tier that is immediately-above the lowest conductive tier. In one embodiment, the lowest surfaces above the lowest surface of the lowest conductive tier of the charge-blocking-material string, the storage-material string, and the charge-passage-material string are planar and coplanar.

Any other attribute(s) or aspect(s) as shown and/or described herein with respect to other embodiments may be used.

Aspects of the invention may increase contact area between materials 42 and 36, particularly for narrower trenches 40 and/or a thinner lowest conductive tier 22z, in comparison to some prior art constructions.

The above processing(s) or construction(s) may be considered as being relative to an array of components formed as or within a single stack or single deck of such components above or as part of an underlying base substrate (albeit, the single stack/deck may have multiple tiers). Control and/or other peripheral circuitry for operating or accessing such components within an array may also be formed anywhere as part of the finished construction, and in some embodiments may be under the array (e.g., CMOS under-array). Regardless, one or more additional such stack(s)/deck(s) may be provided or fabricated above and/or below that shown in the figures or described above. Further, the array(s) of components may be the same or different relative one another in different stacks/decks and different stacks/decks may be of the same thickness or of different thicknesses relative one another. Intervening structure may be provided between immediately-vertically-adjacent stacks/decks (e.g., additional circuitry and/or dielectric layers). Also, different stacks/decks may be electrically coupled relative one another. The multiple stacks/decks may be fabricated sepa-

ately and sequentially (e.g., one atop another), or two or more stacks/decks may be fabricated at essentially the same time.

The assemblies and structures discussed above may be used in integrated circuits/circuitry and may be incorporated into electronic systems. Such electronic systems may be used in, for example, memory modules, device drivers, power modules, communication modems, processor modules, and application-specific modules, and may include multilayer, multichip modules. The electronic systems may be any of a broad range of systems, such as, for example, cameras, wireless devices, displays, chip sets, set top boxes, games, lighting, vehicles, clocks, televisions, cell phones, personal computers, automobiles, industrial control systems, aircraft, etc.

In this document unless otherwise indicated, “elevational”, “higher”, “upper”, “lower”, “top”, “atop”, “bottom”, “above”, “below”, “under”, “beneath”, “up”, and “down” are generally with reference to the vertical direction. “Horizontal” refers to a general direction (i.e., within 10 degrees) along a primary substrate surface and may be relative to which the substrate is processed during fabrication, and vertical is a direction generally orthogonal thereto. Reference to “exactly horizontal” is the direction along the primary substrate surface (i.e., no degrees there-from) and may be relative to which the substrate is processed during fabrication. Further, “vertical” and “horizontal” as used herein are generally perpendicular directions relative one another and independent of orientation of the substrate in three-dimensional space. Additionally, “elevationally-extending” and “extend(ing) elevationally” refer to a direction that is angled away by at least 45° from exactly horizontal. Further, “extend(ing) elevationally”, “elevationally-extending”, “extend(ing) horizontally”, “horizontally-extending” and the like with respect to a field effect transistor are with reference to orientation of the transistor’s channel length along which current flows in operation between the source/drain regions. For bipolar junction transistors, “extend(ing) elevationally”, “elevationally-extending”, “extend(ing) horizontally”, “horizontally-extending” and the like, are with reference to orientation of the base length along which current flows in operation between the emitter and collector. In some embodiments, any component, feature, and/or region that extends elevationally extends vertically or within 10° of vertical.

Further, “directly above”, “directly below”, and “directly under” require at least some lateral overlap (i.e., horizontally) of two stated regions/materials/components relative one another. Also, use of “above” not preceded by “directly” only requires that some portion of the stated region/material/component that is above the other be elevationally outward of the other (i.e., independent of whether there is any lateral overlap of the two stated regions/materials/components). Analogously, use of “below” and “under” not preceded by “directly” only requires that some portion of the stated region/material/component that is below/under the other be elevationally inward of the other (i.e., independent of whether there is any lateral overlap of the two stated regions/materials/components).

Any of the materials, regions, and structures described herein may be homogenous or non-homogenous, and regardless may be continuous or discontinuous over any material which such overlies. Where one or more example composition(s) is/are provided for any material, that material may comprise, consist essentially of, or consist of such one or more composition(s). Further, unless otherwise stated, each material may be formed using any suitable

existing or future-developed technique, with atomic layer deposition, chemical vapor deposition, physical vapor deposition, epitaxial growth, diffusion doping, and ion implanting being examples.

Additionally, "thickness" by itself (no preceding directional adjective) is defined as the mean straight-line distance through a given material or region perpendicularly from a closest surface of an immediately-adjacent material of different composition or of an immediately-adjacent region. Additionally, the various materials or regions described herein may be of substantially constant thickness or of variable thicknesses. If of variable thickness, thickness refers to average thickness unless otherwise indicated, and such material or region will have some minimum thickness and some maximum thickness due to the thickness being variable. As used herein, "different composition" only requires those portions of two stated materials or regions that may be directly against one another to be chemically and/or physically different, for example if such materials or regions are not homogenous. If the two stated materials or regions are not directly against one another, "different composition" only requires that those portions of the two stated materials or regions that are closest to one another be chemically and/or physically different if such materials or regions are not homogenous. In this document, a material, region, or structure is "directly against" another when there is at least some physical touching contact of the stated materials, regions, or structures relative one another. In contrast, "over", "on", "adjacent", "along", and "against" not preceded by "directly" encompass "directly against" as well as construction where intervening material(s), region(s), or structure(s) result(s) in no physical touching contact of the stated materials, regions, or structures relative one another.

Herein, regions-materials-components are "electrically coupled" relative one another if in normal operation electric current is capable of continuously flowing from one to the other and does so predominately by movement of subatomic positive and/or negative charges when such are sufficiently generated. Another electronic component may be between and electrically coupled to the regions-materials-components. In contrast, when regions-materials-components are referred to as being "directly electrically coupled", no intervening electronic component (e.g., no diode, transistor, resistor, transducer, switch, fuse, etc.) is between the directly electrically coupled regions-materials-components.

Any use of "row" and "column" in this document is for convenience in distinguishing one series or orientation of features from another series or orientation of features and along which components have been or may be formed. "Row" and "column" are used synonymously with respect to any series of regions, components, and/or features independent of function. Regardless, the rows may be straight and/or curved and/or parallel and/or not parallel relative one another, as may be the columns. Further, the rows and columns may intersect relative one another at 90° or at one or more other angles (i.e., other than the straight angle).

The composition of any of the conductive/conductor/conducting materials herein may be conductive metal material and/or conductively-doped semiconductive/semiconductor/semiconducting material. "Metal material" is any one or combination of an elemental metal, any mixture or alloy of two or more elemental metals, and any one or more metallic compound(s).

Herein, any use of "selective" as to etch, etching, removing, removal, depositing, forming, and/or formation is such an act of one stated material relative to another stated

material(s) so acted upon at a rate of at least 2:1 by volume. Further, any use of selectively depositing, selectively growing, or selectively forming is depositing, growing, or forming one material relative to another stated material or materials at a rate of at least 2:1 by volume for at least the first 75 Angstroms of depositing, growing, or forming.

Unless otherwise indicated, use of "or" herein encompasses either and both.

CONCLUSION

In some embodiments, a method used in forming a memory array comprising strings of memory cells comprises forming laterally-spaced memory-block regions individually comprising a vertical stack comprising alternating first tiers and second tiers directly above conductor material of a conductor tier. Channel-material-string constructions are formed that extend through the first and second tiers to a lowest of the first tiers. The channel-material-string constructions individually comprise a charge-blocking-material string, a storage-material string laterally-inward of the charge-blocking-material string, a charge-passage-material string laterally-inward of the storage-material string, and a channel-material string laterally-inward of the charge-passage-material string. The charge-blocking-material string is etched upwardly from and through the lowest first tier selectively relative to the storage-material string. After the etching of the charge-blocking-material string, the storage-material string and the charge-passage-material string in the lowest first tier are etched to expose the channel material of the channel-material string in the lowest first tier. Conductive material is formed in the lowest first tier that directly electrically couples together the channel material of individual of the channel-material strings and the conductor material of the conductor tier.

In some embodiments, a method used in forming a memory array comprising strings of memory cells comprises forming laterally-spaced memory-block regions individually comprising a vertical stack comprising alternating first tiers and second tiers directly above conductor material of a conductor tier. Channel-material-string constructions are formed that extend through the first and second tiers to a lowest of the first tiers. The channel-material-string constructions individually comprise a charge-blocking-material string, a storage-material string laterally-inward of the charge-blocking-material string, a charge-passage-material string laterally-inward of the storage-material string, and a channel-material string laterally-inward of the charge-passage-material string. The charge-blocking-material string, the storage-material string, and the charge-passage-material string in the lowest first tier are etched to expose the channel material of the channel-material string in the lowest first tier. The etching leaves a lowest surface of the charge-blocking-material string that is above a lowest surface of the lowest first tier to be below a lowest surface of a lowest of the second tiers that is immediately-above the lowest first tier. Conductive material is formed in the lowest first tier that directly electrically couples together the channel material of individual of the channel-material strings and the conductor material of the conductor tier.

In some embodiments, a memory array comprising strings of memory cells comprises laterally-spaced memory-blocks individually comprising a vertical stack comprising alternating insulative tiers and conductive tiers directly above conductor material of a conductor tier. Channel-material-string constructions extend through the insulative and conductive tiers to a lowest of the conductive tiers. The channel-

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material-string constructions individually comprise a charge-blocking-material string, a storage-material string laterally-inward of the charge-blocking-material string, a charge-passage-material string laterally-inward of the storage-material string, and a channel-material string laterally-inward of the charge-passage-material string. A lowest surface of the charge-blocking-material string that is above a lowest surface of the lowest conductive tier is below a lowest surface of a lowest of the insulative tiers that is immediately-above the lowest conductive tier. Conductive material in the lowest conductive tier directly electrically couples together the channel material of individual of the channel-material strings and the conductor material of the conductor tier.

In compliance with the statute, the subject matter disclosed herein has been described in language more or less specific as to structural and methodical features. It is to be understood, however, that the claims are not limited to the specific features shown and described, since the means herein disclosed comprise example embodiments. The claims are thus to be afforded full scope as literally worded, and to be appropriately interpreted in accordance with the doctrine of equivalents.

The invention claimed is:

1. A method used in forming a memory array comprising strings of memory cells, comprising:

forming laterally-spaced memory-block regions individually comprising a vertical stack comprising alternating first tiers and second tiers directly above conductor material of a conductor tier;

forming channel-material structures that extend through the first and second tiers to a lowest of the first tiers, the channel-material-structures individually comprising a charge-blocking-material, a storage-material radially-inward of the charge-blocking-material, a charge-passage-material radially-inward of the storage-material, and a channel material radially-inward of the charge-passage-material;

etching the charge-blocking-material upwardly from and through the lowest first tier selectively relative to the storage-material;

after the etching of the charge-blocking-material, etching the storage-material and the charge-passage-material in the lowest first tier to expose the channel material in the lowest first tier; and

forming conductive material in the lowest first tier that directly electrically couples together the channel material of individual of the channel-material structures and the conductor material of the conductor tier.

2. The method of claim 1 wherein the channel-material structures extend into the conductor tier.

3. The method of claim 1 wherein the etching of the charge-blocking-material through the lowest first tier etches the charge-blocking-material downwardly from the lowest first tier selectively relative to the storage-material.

4. The method of claim 1 wherein the etching of the storage-material and the charge-passage-material in the lowest first tier etches the storage-material and the charge-passage-material upwardly from and through the lowest first tier selectively relative to the channel material.

5. The method of claim 1 wherein the upwardly etching of the charge-blocking-material leaves a lowest surface of the charge-blocking-material that is above a lowest surface of the lowest first tier to be below a lowest surface of a lowest of the second tiers that is immediately-above the lowest first tier.

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6. The method of claim 5 wherein the etching of the storage-material and the charge-passage-material string in the lowest first tier etches the storage-material and the charge-passage-material upwardly from and through the lowest first tier selectively relative to the channel-material to leave respective lowest surfaces of the storage-material and the charge-passage-material that are above the lowest surface of the lowest first tier to be below the lowest surface of the lowest second tier that is immediately-above the lowest first tier.

7. The method of claim 6 wherein the lowest surfaces above the lowest surface of the lowest first tier of the charge-blocking-material, the storage-material, and the charge-passage-material are planar and coplanar.

8. The method of claim 1 wherein the conductive material in the lowest first tier is directly against a laterally-outer sidewall of the channel material.

9. A method used in forming a memory array comprising strings of memory cells, comprising:

forming laterally-spaced memory-block regions individually comprising a vertical stack comprising alternating first tiers and second tiers directly above conductor material of a conductor tier;

forming channel-material structures that extend through the first and second tiers to a lowest of the first tiers, the channel-material structures individually comprising a charge-blocking-material, a storage-material radially-inward of the charge-blocking-material, a charge-passage-material radially-inward of the storage-material, and a channel material radially-inward of the charge-passage-material;

etching the charge-blocking-material, the storage-material, and the charge-passage-material in the lowest first tier to expose the channel material in the lowest first tier; the etching leaving a lowest surface of the charge-blocking-material that is above a lowest surface of the lowest first tier to be below a lowest surface of a lowest of the second tiers that is immediately-above the lowest first tier; and

forming conductive material in the lowest first tier that directly electrically couples together the channel material of individual of the channel-material structures and the conductor material of the conductor tier.

10. The method of claim 9 wherein the etching of the storage-material and the charge-passage-material in the lowest first tier etches the storage-material and the charge-passage-material upwardly from and through the lowest first tier selectively relative to the channel material to leave respective lowest surfaces of the storage-material and the charge-passage-material that are above the lowest surface of the lowest first tier to be below the lowest surface of the lowest second tier that is immediately-above the lowest first tier.

11. The method of claim 9 wherein the conductive material in the lowest first tier is directly against a laterally-outer sidewall of the channel material.

12. The method of claim 10 wherein the lowest surfaces above the lowest surface of the lowest first tier of the charge-blocking-material, the storage-material, and the charge-passage-material are planar and coplanar.

13. The method of claim 9 wherein the conductive material in the lowest first tier is directly against a laterally-outer sidewall of the channel material.