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Memory Arrays Comprising Strings of Memory Cells and Methods Used in Forming a Memory Array Comprising Strings of Memory Cells

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 a conductor tier. Strings of memory cells comprise channel-material strings that extend through the insulative tiers and the conductive tiers. The channel-material strings directly electrically couple to conductor material of the conductor tier. Below the stack, an insulating tier is directly above the conductor tier and a metal-material tier is directly above the insulating tier. Conductive rings extend through the metal-material tier and the insulating tier to conductor material of the conductor tier. The conductive rings individually are around individual horizontal locations directly above which are individual of the channel-material strings. The channel-material strings directly electrically couple to the conductor material of the conductor tier through the insulating tier by the conductive rings. Other embodiments, including method, are disclosed.

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Background/Summary

RELATED PATENT DATA [0001] This patent resulted from a continuation application of U.S. patent application Ser. No. 17/727,515 filed Apr. 22, 2022, which is hereby incorporated herein by reference.

TECHNICAL FIELD

[0002] 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

[0003] 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.

[0004] 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.

[0005] 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.

[0006] 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.

[0007] Memory arrays may be arranged in memory pages, memory blocks and partial blocks (e.g., sub-blocks), and 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.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. 1 is a diagrammatic top plan view of a die or die area that may be part of a larger substrate (e.g., a semiconductor wafer, and not shown).

[0009] FIGS. 2 and 3 are diagrammatic cross-sectional views of portions of a construction (e.g., as part of FIG. 1) that will comprise an array of elevationally extending strings of memory cells in accordance with an embodiment of the invention.

[0010] FIGS. 4-42 are diagrammatic sequential sectional and/or enlarged views of the construction of FIGS. 2 and 3, or portions thereof or alternate and/or additional embodiments, in process in accordance with some embodiments of the invention.

DETAILED DESCRIPTION OF EXAMPLE EMBODIMENTS

[0011] Embodiments of the invention encompass methods used in forming a memory array, for example an array of NAND or other memory cells having 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 a memory array (e.g., NAND architecture) independent of method of manufacture. Example method embodiments are described with reference to FIGS. 1-42 which may be considered as “gate-last” or “replacement-gate” processing. Further, and regardless, the following sequence of processing steps is but one example and other sequences of the example processing steps (with or without other processing steps) may be used regardless of whether using “gate-last/replacement-gate” processing.

[0012] FIG. 1 shows an example diagrammatic embodiment comprising a die or die area **100** that may be part of a larger substrate (e.g., a semiconductor wafer, and not shown) and in which a memory array will be fabricated. Example die area **100** comprises at least one memory-plane region **105** (four being shown), memory-block regions **58** in individual memory-plane regions **105**, a stair-step region **60** (two being shown at longitudinal ends of the memory planes), and a peripheral circuitry region PC (two being shown). In this document, “block” is generic to include “sub-block”. Alternate orientations may be used, for example having a stair-step region between immediately-adjacent memory planes (not shown). Regions **105**, **58**, **60**, and/or PC may not be discernable at this point of processing. FIGS. 2 and 3 are diagrammatic larger scale views of portions of die area **100**.

[0013] Referring to FIGS. 2 and 3, a construction **10** is shown in a method of forming an array or array region **12** of elevationally-extending strings of transistors and/or memory cells (not yet

fabricated) and in forming a through-array-via (TAV) region **19**. A “TAV region” is a region in which operative TAVs are present or will be formed. An “operative TAV” is a circuit-operative conductive interconnect extending through a stack and between electronic components at different elevations in a finished construction of integrated circuitry that has been or is being fabricated (e.g., through a stack **18*** described below; an * being used as a suffix to be inclusive of all such same-numerically-designated components that may or may not have other suffixes). A TAV region may also contain one or more dummy TAVs (i.e., a circuit-inoperative structure extending through a stack **18*** in a finished construction of integrated circuitry that has been or is being fabricated). Example TAV region **19** may be in individual memory planes **105** (i.e., in-plane; e.g., FIG. **1**) or be out-of-plane (i.e., outside of a memory-plane region [not shown]; e.g., edge-of-plane or in a stair-step region **60**). By way of example only, example in-plane TAV regions **19** are so-designated in FIG. **1**. The discussion proceeds with respect to a single TAV region **19**, although likely multiple TAV regions to which the invention is applicable will exist and whether those multiple TAV regions are in-plane, out-of-plane, and/or a combination of in-plane and out-of-plane. A TAV region may be in a memory-block region (not shown).

[0014] Example construction **10** comprises a base substrate **11** comprising conductive/conductor/conducting, semiconductive/semiconductor/semiconducting, and/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. **2** and **3**-depicted materials. For example, other partially or wholly fabricated components of integrated circuitry may be provided somewhere above, about, or in base substrate **11**. Control and/or other peripheral circuitry for operating components in an array (e.g., array **12** or memory-array region **12**) of elevationally-extending strings of memory cells may also be fabricated and may or may not be wholly or partially in 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.

[0015] A conductor tier **16** comprising conductor material **17** has been formed above substrate **11**. Conductor material **17** as shown comprises conductor material **44** (e.g., conductive metal material such as a metal silicide). 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 in array **12**.

[0016] An insulating tier **33** has been formed directly above conductor tier **16** (e.g., comprising silicon dioxide and/or silicon nitride). A metal-material tier **35** (e.g., containing metal material **39**) has been formed directly above insulating tier **33**. Metal material **39** may be insulative, conductive, and/or semiconductive. As examples, the metal material may comprise a metal oxide (e.g., an aluminum oxide, a tungsten oxide, a hafnium oxide, a hafnium aluminum oxide, a tantalum oxide, a titanium oxide, or other metal oxide). The metal material may comprise a metal nitride (e.g., a tungsten nitride, an aluminum nitride, a titanium nitride, a cobalt nitride, or other metal nitride). The metal material may comprise a metal silicide (e.g., a tungsten silicide, an aluminum silicide, a titanium silicide, a cobalt silicide, or other metal silicide). The metal material may comprise elemental-form metal (e.g., W, Co, Ti, or other metal element). In one embodiment, the metal material comprises an aluminum oxide and elemental-form tungsten.

[0017] Conductive rings **46** (e.g., comprising conductively-doped polysilicon and/or conductive metal material) have been formed to extend through insulating tier **33** and metal-material tier **35** to conductor material **17** of conductor tier **16**. Conductive rings **46** are individually around individual horizontal locations **27** directly above which individual channel-material strings will be formed. Ideally, conductive rings **46** are of different composition from that of metal material **39** of metal-material tier **35**. In one embodiment, conductive rings **46** have respective tops **70** that are elevationally-coincident with an uppermost surface **87** of metal-material tier **35**. In one embodiment, conductive rings **46** have respective bottoms **83** that are elevationally-coincident with

a lowest surface **79** of insulating tier **33**.

[0018] Referring to FIGS. **4** and **5**, and in one embodiment, a lower portion **18L** of a stack **18*** has been formed directly above metal-material tier **35** and conductive rings **46**. Stack **18*** will comprise vertically-alternating conductive tiers **22*** and insulative tiers **20***. Lower portion **18L**, conductor tier **16**, and tiers **33** and **35** there-between collectively comprise laterally-spaced memory-block regions **58** that will comprise laterally-spaced memory blocks **58** in a finished circuitry construction and comprise TAV region **19**. Memory-block regions **58** and resultant memory blocks **58** (not yet shown) may be considered as being longitudinally elongated and oriented, for example horizontally-parallel relative one another, along a direction **55**.

[0019] 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., in array region **12**; 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., in array region **12**; e.g., comprising material **63**, for example silicon dioxide and/or silicon nitride). 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**. Example 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**. Additional tiers may be present. For example, one or more additional tiers may be above tier **21** (tier **21** thereby not being the uppermost tier in portion **18L**, and not shown), between tier **21** and **20x** (not shown), and/or below tier **22z** (other than **20z** not being shown).

[0020] In one embodiment, lower portion **18L** of stack **18*** comprises horizontally-elongated lines **90** that are individually between immediately-adjacent of laterally-spaced memory-block regions **58**. In one embodiment, insulative material **15** (e.g., silicon dioxide, silicon nitride, and/or aluminum oxide) has been formed vertically through lower portion **18L** of stack **18*** in TAV region **19** circumferentially around horizontal locations **85** where individual TAVs will be formed. In one embodiment and as shown, insulative material **15** is formed through metal-material tier **35**, insulating tier **33**, and/or conductor tier **16**.

[0021] Referring to FIGS. **6** and **7**, an upper portion **18U** of stack **18*** has been formed directly above lower portion **18L** of stack **18***, insulative material **15** (when present), and horizontally-elongated lines **90** (when present). Example upper portion **18U** comprises vertically-alternating different composition first tiers **22** and second tiers **20**. First tiers **22** may be conductive and second tiers **20** may be insulative, 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 first tiers **22** and second tiers **20** comprise different composition materials **26** and **24** (e.g., silicon nitride and silicon dioxide), respectively. Example upper portion **18U** is shown starting above lower portion **18L** with a second tier **20** although such could alternately start with a first tier **22** (not shown) or tier **21** may be considered as being in upper portion **18U** (not so designated). 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 **20** and **22** 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 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.

[0022] In one embodiment, channel openings **25** have been etched through upper portion **18U** and lower portion **18L** of stack **18*** in laterally-spaced memory-block regions **58** and that extend to metal material **39** of metal-material tier **35** that is radially inside individual of conductive rings **46** using such metal material **39** as an etch-stop during such etching. Channel openings **25** may taper radially-inward or radially-outward (not shown) moving deeper into stack **18***. Example channel openings **25** for convenience are shown as being of the same size and shape as the internal shape of conductive rings **46** and perfectly aligned therewith, although none of such is required.

[0023] Referring to FIGS. **8** and **9**, in one embodiment after using metal material **39** as an etch-stop for the FIGS. **6** and **7** etching, metal material **39** that is/was radially inside rings **46** has been removed (e.g., by etching selectively relative to other exposed materials, with such metal material **39** that was radially inside rings **46** thereby not being shown) to extend channel openings **25** deeper (e.g., to insulating tier **33**).

[0024] 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 conductor 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.

[0025] Referring to FIGS. **10-13**, and in one embodiment as shown, charge-blocking material **30**, storage material **32**, and charge-passage material **34** have been formed in individual channel openings **25** elevationally along insulative tiers **20** and conductive tiers **22**. Transistor materials **30**, **32**, and **34** (e.g., memory-cell materials) may be formed by, for example, deposition of respective thin layers thereof over stack **18*** and in individual openings **25** followed by planarizing such back at least to a top surface of stack **18***.

[0026] Channel material **36** as a channel-material string **53** has also been formed in channel openings **25** elevationally along insulative tiers **20** and conductive tiers **22** in memory-block regions **58** (e.g., after removing sacrifice plugs **91** if such are used). Materials **30**, **32**, **34**, and **36** are collectively shown as and only designated as material **37** in some figures due to scale. 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** or may occur with respect to only some. 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). 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 in channel openings **25** may include void space(s) (not shown) and/or be devoid of solid material (not shown).

[0027] Referring to FIGS. **14** and **15**, and in one embodiment as shown, TAV openings **84** have been etched through upper portion **18U** of stack **18*** to metal material **39** of metal-material tier **35** and that are individually in individual of horizontal locations **85** where the individual TAVs will be formed. Metal material **39** of metal-material tier **35** is used as an etch-stop during such etching. TAV openings **84** may taper radially-inward or radially-outward moving deeper into stack **18*** (neither being shown).

[0028] Referring to FIGS. **16** and **17**, in one embodiment after using metal material **39** as an etch-stop for the FIGS. **14** and **15** etching, such metal material **39** has been removed (e.g., by etching and such thereby not being shown) to extend TAV openings **84** deeper (e.g., using some different chemistry and/or conditions to etch to insulating tier **33**).

[0029] Referring to FIGS. **18** and **19**, and in one embodiment as shown, an insulative lining **81** (e.g., hafnium oxide, aluminum oxide, multiple layers of silicon dioxide and silicon nitride, etc.) has been formed inside individual TAV openings **84**. Thereafter, punch etching has been conducted through insulative lining **81**, followed by etching TAV openings **84** through insulating tier **33** (e.g., at least to conductor material **44**).

[0030] Referring to FIGS. **20** and **21**, conductive material **73** (e.g., a Ti/TiN lining having W radially-inward thereof) has been formed to form individual TAVs **74** in individual TAV openings **84**.

[0031] Referring to FIGS. **22** and **23**, in one embodiment and after forming TAVs **74** and channel-material strings **53**, (a) and (b) have been conducted simultaneously, where: [0032] (a): etching horizontally-elongated trenches **40** through upper portion **18U** between laterally-spaced memory-block regions **58** using horizontally-elongated lines **90** that are individually between immediately-adjacent of laterally-spaced memory-block regions **58** as an etch-stop; and [0033] (b): etching a horizontally-elongated trench **45** through upper and lower portions **18U** and **18L**, respectively, of stack **18*** in TAV region **19** using metal material **39** of metal-material tier **35** as an etch-stop.

[0034] Referring to FIGS. **24** and **25**, horizontally-elongated lines **90** have been removed through trenches **40** (not shown; e.g., by etching). Such removal may move trench **45** downwardly into metal-material **39**.

[0035] Referring to FIGS. **26** and **27**, an insulative lining **81** has been formed in trenches **40** and/or **45** and then punched there-through to expose metal material **39** there-below.

[0036] Referring to FIGS. **28** and **29**, and in one embodiment, an etching fluid (not shown) has been flowed into horizontally-elongated trenches **40** and **45** to isotropically etch material **77** from lowest conductive tier **22z** at least in array region **12** (material **77** thereby not being shown). Such etching is ideally conducted selectively relative to other exposed materials, for example using liquid or vapor H.sub.3PO.sub.4 as a primary etchant where material **77** is silicon nitride or using tetramethyl ammonium hydroxide [TMAH] where material **77** is polysilicon. The artisan is capable of selecting other chemistries for other materials **77**. Insulative lining **81** is ideally resistant to the etching fluid used during the flowing. FIGS. **28** and **29** show an embodiment where lining **81** has blocked removal of material **77** in TAV region **19** outside of insulating material **15**. Whole, partial, or no removal of material **77** in TAV region ("some" being shown even radially outside of insulating material **15**) may be dependent upon presence, size, number, and positioning of etch openings in TAV region **19** (e.g., trench opening[s] **45**), and whether and where an etch resistant lining **81** is therein).

[0037] Referring to FIGS. **30-32**, and in one embodiment, material **30** (e.g., silicon dioxide), material **32** (e.g., silicon nitride), and material **34** (e.g., silicon dioxide or a combination of silicon dioxide and silicon nitride) have been etched in tier **22z** to expose a sidewall **41** of channel material **36** of channel-material strings **53** in lowest first tier **22z**. Any of materials **30**, **32**, and **34** in tier **22z** may be considered as being sacrificial material therein. As an example, consider an embodiment

where liner **81** is one or more insulative oxides (other than silicon dioxide) and memory-cell materials **30**, **32**, and **34** individually are one or more of silicon dioxide and silicon nitride layers. In such example, the depicted construction can result by using modified or different chemistries for sequentially etching silicon dioxide and silicon nitride selectively relative to the other. As examples, a solution of 100:1 (by volume) water to HF will etch silicon dioxide selectively relative to silicon nitride, whereas a solution of 1000:1 (by volume) water to HF will etch silicon nitride selectively relative to silicon dioxide. Accordingly, and in such example, such etching chemistries can be used in an alternating manner where it is desired to achieve the example depicted construction. In one embodiment and as shown, such etching has been conducted selectively relative to liner **81** (when present). In one embodiment, materials **62** and **63** (not shown in memory-block regions **58**) are also removed. When so removed, such may be removed when removing materials **30**, **32**, and **34** are removed, for example if materials **62** and **63** comprise one or both of silicon dioxide and silicon nitride. Alternately, when so removed, such may be removed separately (e.g., by isotropic etching). The artisan is capable of selecting other chemistries for etching other different materials where a construction as shown is desired. All, some, or none of materials **62** and **63** may also be removed in TAV region **19**.

[0038] After exposing sidewall **41**, conductive material **42** (e.g., conductively-doped polysilicon) has been formed in lowest first tier **22z** and in one embodiment directly against 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**.

[0039] Referring to FIGS. **33** and **34**, conductive material **42** has been removed from trenches **40** as has liner **81** (not there-shown). Liner **81** (when present and removed) may be removed before or after forming conductive material **42**. Conductive material **42** and liner **81** have also been removed from trench **45** (when present, and in one such embodiment). Some of material **42** may remain in the bottom of trenches **40** and/or **45** (not shown). 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 region **12**.

[0040] Referring to FIGS. **35-42**, material **26** of conductive tiers **22** in array region **12** 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.sub.3PO.sub.4 as a primary etchant where material **26** is silicon nitride and other materials comprise one or more oxides or polysilicon). Material **26** in conductive tiers **22** in array region **12** 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., wordlines) and elevationally-extending strings **49** of individual transistors and/or memory cells **56**.

[0041] Some, all, or none of material **26** may be removed from TAV region **19** (removal of all being shown) and replaced with conducting material **48**, for example depending on proximity of trenches **40** that are closest thereto and/or presence or lack thereof of etch-blocking material(s)/structure(s) in tiers **22** in upper portion **18U** (not shown) and presence of other openings (e.g., trench **45**).

[0042] A thin insulative liner (e.g., Al.sub.2O.sub.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.

[0043] 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.

[0044] 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). In one embodiment and as shown, intervening material 57 has also been formed in trench 45 when present.

[0045] Any other attribute(s) or aspect(s) as shown and/or described herein with respect to other embodiments may be used.

[0046] It can be challenging when etching channel openings 25 and/or TAV openings 84 to stop such etching at desired elevations in the construction being fabricated. Isolated etch-stop structures (e.g., plugs/pillars) have been used for this purpose. Use of metal material as described herein may eliminate other separate fabrication of such etch-stop structures and may thereby reduce cost and/or improve or ease critical dimension and alignment of channel openings and/or TAV openings.

[0047] 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.

[0048] 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 a conductor tier (e.g., **16**). Strings (e.g., **49**) of memory cells (e.g., **56**) comprising channel-material strings (e.g., **53**) extend through the insulative tiers and the conductive tiers. The channel-material strings directly electrically couple with conductor material (e.g., **17**) of the conductor tier. An insulating tier (e.g., **33**) is directly above the conductor tier and a metal-material tier (e.g., **35**) is directly above the insulating tier, with both such tiers being below the stack. Conductive rings (e.g., **46**) extend through the metal-material tier and the insulating tier to conductor material of the conductor tier. The conductive rings individually are around individual horizontal locations (e.g., **27**) directly above which are individual of the channel-material strings. The channel-material strings directly electrically couple to the conductor material of the conductor tier through the insulating tier by the conductive rings (e.g., conductive material **42** being directly against sidewalls **41** of channel-material strings **53** and directly against tops **70** of conductive rings **46**, with conductive rings **46** extending through insulating tier **33** to be directly against material **44/17** of conductor tier **16**).

[0049] Any other attribute(s) or aspect(s) as shown and/or described herein with respect to other embodiments may be used.

[0050] 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 a conductor tier (e.g., **16**). Strings (e.g., **49**) of memory cells (e.g., **56**) comprising channel-material strings (e.g., **53**) extend through the insulative tiers and the conductive tiers. The channel-material strings directly electrically couple with conductor material (e.g., **17**) of the conductor tier. An insulating tier (e.g., **33**) is directly above the conductor tier and a metal-material tier (e.g., **35**) is directly above the insulating tier, with both such tiers being below the stack. A through-array-via (TAV) region (e.g., **19**) comprises TAVs (e.g., **74**) that individually extend through the stack, the insulating tier, and the metal-material tier to the conductor tier. Individual of the TAVs in a vertical cross-section (e.g., that of FIG. **41**) comprise at least one external upper jog surface in the metal-material tier (e.g., two external upper jog surfaces **115** and **117** being shown). The individual TAVs comprise at least one external lower jog surface in the metal-material tier and that is below the upper jog surface (e.g., two external lower jog surfaces **118** and **119** being shown). In this document, a “jog surface” is characterized or defined by an abrupt change in direction [at least 15°] in comparison to surfaces that are immediately-above and immediately-below the jog surface.

[0051] In one embodiment, the upper and lower jog surfaces individually include a part that is horizontal and in one such embodiment the part being exactly horizontal (e.g., the part(s) being all of the upper and lower jog surfaces and being exactly horizontal in the example embodiment). In one embodiment, conductive material of the TAVs (e.g., **74**) is wider in the vertical cross-section immediately-below the upper jog surface than immediately-above the upper jog surface. In one embodiment, conductive material of the TAVs is wider in the vertical cross-section immediately-above the lower jog surface than immediately-below the lower jog surface.

[0052] Any other attribute(s) or aspect(s) as shown and/or described herein with respect to other embodiments may be used.

[0053] 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 separately and sequentially (e.g., one atop another), or two or more stacks/decks may be fabricated at essentially the same time.

[0054] 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.

[0055] 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.

[0056] 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).

[0057] 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 overlie. 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.

[0058] 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.

[0059] 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.

[0060] 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).

[0061] 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).

[0062] 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.

[0063] Unless otherwise indicated, use of “or” herein encompasses either and both.

Conclusion

[0064] In some embodiments, a method used in forming a memory array comprising strings of memory cells comprises forming a conductor tier comprising conductor material on a substrate. An insulating tier is formed directly above the conductor tier and a metal-material tier is formed directly above the insulating tier. Conductive rings extend through the insulating tier and the metal-material tier to the conductor material of the conductor tier. The conductive rings individually are around individual horizontal locations directly above which individual channel-material strings will be formed. A stack comprising vertically-alternating first tiers and second tiers is formed directly

above the metal-material tier and the conductive rings. The stack comprises laterally-spaced memory-block regions and a through-array-via (TAV) region. Through the stack, individual channel openings are etched in the laterally-spaced memory-block regions and that extend to the metal material of the metal-material tier that is radially inside individual of the conductive rings and TAV openings are formed in the TAV region to the metal material of the metal-material tier. The metal material of the metal-material tier is used as an etch-stop during the etching. Individual of the TAVs are formed in individual of the TAV openings and a channel-material string is formed in individual of the channel openings that directly electrically couples to conductor material in the conductor tier.

[0065] In some embodiments, a method used in forming a memory array comprising strings of memory cells comprises forming a conductor tier comprising conductor material on a substrate. An insulating tier is formed directly above the conductor tier and a metal-material tier is formed directly above the insulating tier. Conductive rings extend through the insulating tier and the metal-material tier to the conductor material of the conductor tier. The conductive rings individually are around individual horizontal locations directly above which individual channel-material strings will be formed. The conductive rings are of different composition from that of the metal material of the metal-material tier. A lower portion of a stack is formed that will comprise vertically-alternating first tiers and second tiers directly above the metal-material tier and the conductive rings. The stack comprises laterally-spaced memory-block regions and a through-array-via (TAV) region. The lower portion of the stack comprises horizontally-elongated lines that are individually between immediately-adjacent of the laterally-spaced memory-block regions. The vertically-alternating first tiers and second tiers of an upper portion of the stack are formed directly above the lower portion of the stack. Through the upper and lower portions of the stack, individual channel openings are etched in the laterally-spaced memory-block regions and that extend to the metal material of the metal-material tier that is radially inside individual of the conductive rings and TAV openings are formed in the TAV region to the metal material of the metal-material tier. The metal material of the metal-material tier is used as an etch-stop during the etching of the channel openings and the TAV openings. Individual of the TAVs are formed in individual of the TAV openings and a channel-material string is formed in individual of the channel openings. After forming the TAVs and the channel-material string, occurring simultaneously are (a) and (b), where (a): etching horizontally-elongated trenches through the upper portion between the laterally-spaced memory-block regions using the horizontally-elongated lines that are individually between immediately-adjacent of the laterally-spaced memory-block regions as an etch-stop; and (b): etching a horizontally-elongated trench through the upper and lower portions of the stack in the TAV region using the metal material of the metal-material tier as an etch-stop.

[0066] 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 a conductor tier. Strings of memory cells comprise channel-material strings that extend through the insulative tiers and the conductive tiers. The channel-material strings directly electrically couple to conductor material of the conductor tier. Below the stack, an insulating tier is directly above the conductor tier and a metal-material tier is directly above the insulating tier. Conductive rings extend through the metal-material tier and the insulating tier to conductor material of the conductor tier. The conductive rings individually are around individual horizontal locations directly above which are individual of the channel-material strings. The channel-material strings directly electrically couple to the conductor material of the conductor tier through the insulating tier by the conductive rings.

[0067] 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 a conductor tier. Strings of memory cells comprise channel-material strings that extend through the insulative tiers and the conductive tiers.

The channel-material strings directly electrically couple to conductor material of the conductor tier. Below the stack, an insulating tier is directly above the conductor tier and a metal-material tier is directly above the insulating tier. A through-array-via (TAV) region comprises TAVs that individually extend through the stack, the insulating tier, and the metal-material tier to the conductor tier. Individual of the TAVs in a vertical cross-section comprise at least one external upper jog surface in the metal-material tier. The individual TAVs comprise at least one external lower jog surface in the metal-material tier and that is below the upper jog surface.

[0068] 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.

Claims

1. A memory array comprising strings of memory cells, comprising: laterally-spaced memory blocks individually comprising a vertical stack comprising alternating insulative tiers and conductive tiers directly above a conductor tier, strings of memory cells comprising channel-material strings that extend through the insulative tiers and the conductive tiers; below the stack, an insulating tier directly above the conductor tier and a metal-comprising material tier directly above the insulating tier; and conductive rings extending through the metal-comprising material tier and the insulating tier to an uppermost surface of the conductor material of the conductor tier, the conductive rings having a bottom surface in direct physical contact with the uppermost surface of the conductor material, the channel-material strings directly electrically coupling to the conductor material of the conductor tier through the insulating tier by the conductive rings.
2. The memory array of clam 1 wherein the metal-comprising material is insulative.
3. The memory array of clam 1 wherein the metal-comprising material is conductive.
4. The memory array of clam 1 wherein the metal-comprising material is semiconductive.
5. The memory array of clam 1 wherein the metal-comprising material comprises a metal oxide.
6. The memory array of clam 1 wherein the metal-comprising material comprises a metal nitride.
7. The memory array of clam 1 wherein the metal-comprising material comprises elemental form metal.
8. The memory array of clam 1 wherein the metal-comprising material comprises a metal silicide.
9. The memory array of clam 1 wherein the metal-comprising material of the metal comprising material tier comprises an aluminum oxide.
10. The memory array of clam 1 wherein the metal-comprising material of the metal comprising material tier comprises elemental-form tungsten.
11. The memory array of clam 1 wherein the metal material of the metal material tier comprises an aluminum oxide and elemental-form tungsten.
12. The memory array of clam 1 wherein the conductive rings comprise conductive metal material.
13. The memory array of clam 1 wherein the conductive rings comprise conductively-doped polysilicon.
14. The memory array of clam 1 wherein the conductive rings have respective tops that are elevationally-coincident with an uppermost surface of the metal material tier.
15. The memory array of clam 1 wherein, the conductive rings have respective tops that are elevationally-coincident with an uppermost surface of the metal material tier; and the conductive rings have respective bottoms that are elevationally-coincident with a lowest surface of the insulating tier.
16. A memory array comprising strings of memory cells, comprising: laterally-spaced memory

blocks individually comprising a vertical stack comprising alternating insulative tiers and conductive tiers directly above a conductor tier, strings of memory cells comprising channel-material strings that extend through the insulative tiers and the conductive tiers, the channel-material strings directly electrically coupling to conductor material of the conductor tier; below the stack, an insulating tier directly above the conductor tier and a metal-comprising-material tier directly above the insulating tier; and a through-array-via (TAV) region comprising TAVs that individually extend through the stack, the insulating tier, and the metal-comprising material tier to the conductor tier, individual of the TAVs in a vertical cross-section comprising at least one external upper jog surface in the metal-comprising material tier, the individual TAVs comprising at least one external lower jog surface in the metal-comprising material tier and that is below the upper jog surface.

17. The memory array of clam **16** wherein the upper and lower jog surfaces individually include a part that is horizontal.

18. The memory array of clam **16** wherein conductive material of the TAVs is wider in the vertical cross-section immediately-below the upper jog surface than immediately-above the upper jog surface.

19. The memory array of clam **16** wherein conductive material of the TAVs is wider in the vertical cross-section immediately-above the lower jog surface than immediately-below the lower jog surface.

20. The memory array of clam **16** wherein, conductive material of the TAVs is wider in the vertical cross-section immediately-below the upper jog surface than immediately-above the upper jog surface; and the conductive material of the TAVs is wider in the vertical cross-section immediately-above the lower jog surface than immediately-below the lower jog surface.
