PROGRAMMABLE RESISTANCE MEMORY DEVICES AND SYSTEMS USING THE SAME AND METHODS OF FORMING THE SAME

FIELD OF THE INVENTION

[0001] Embodiments of the invention relate to semiconductor devices and, in particular, to programmable resistance memory elements and methods of forming and using the same.

BACKGROUND OF THE INVENTION

[0002] Non-volatile memories are useful storage devices due to their ability to maintain data absent a power supply. Materials have been investigated for use in non-volatile memory cells. One class of programmable resistance materials are phase change materials, such as chalcogenide alloys, which are capable of stably transitioning between amorphous and crystalline phases. Each phase exhibits a particular resistance state and the resistance states distinguish the logic values of a memory element formed with such materials. Specifically, an amorphous state exhibits a relatively high resistance, and a crystalline state exhibits a relatively low resistance.

[0003] A conventional phase change memory element 1, illustrated in FIGS. 1A and 1B, often has a layer of phase change material 8 between first and second electrodes 2, 4. The first electrode is within a dielectric material 6. The phase change material 8 is set to a particular resistance state according to the amount of current applied between the first and second electrodes 2, 4. To obtain an amorphous state (FIG. 1B), a relatively high write current pulse (a reset pulse) is applied through the phase change memory element 1 to melt at least a portion 9 of the phase change material 8 covering the first electrode 2 for a first period of time. The current is removed and the phase change material 8 cools rapidly to a temperature below the crystallization temperature, which results in the portion 9 of the phase change material 8 covering the first electrode 2 having the amorphous state. To obtain a

crystalline state (FIG. 1A), a lower current write pulse (a set pulse) is applied to the phase change memory element 1 for a second period of time (typically longer in duration than the first period of time and crystallization time of amorphous phase change material) to heat the amorphous portion 9 of the phase change material 8 to a temperature below its melting point, but above its crystallization temperature. This causes the amorphous portion 9 of the phase change material 8 to re-crystallize to the crystalline state that is maintained once the current is removed and the phase change memory element 1 is cooled. The phase change memory element 1 is read by applying a read voltage, which does not change the phase state of the phase change material 8.

[0004] One drawback of conventional phase change memory is the large programming current needed to achieve the phase change. This requirement leads to large access transistor design to achieve adequate current drive. Another problem associated with the memory element 1, is poor reliability due to uncontrollable mixing of amorphous and polycrystalline states at the edges of the programmable volume (i.e., portion 9). Accordingly, it is desirable to have phase change memory devices with reduced programming current requirements and increased reliability.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] FIGS. 1A and 1B illustrate a conventional phase change memory element.

[0006] FIG. 2A illustrates partial cross-sectional view of a phase change memory device according to an embodiment of the invention.

[0007] FIG. 2B illustrates a top-down view of the phase change memory device of FIG. 2A.

[0008] FIGS. 2C-2E illustrates top-down views of phase change memory devices according to other embodiments of the invention.

[0009] FIGS. 3A-3F illustrate partial cross-sectional views depicting a method of fabricating the phase change memory device of FIGS. 2A-2B.

[0010] FIG. 4 is a schematic diagram of a phase change memory device circuit for the memory device of FIGS. 2A-2B.

[0011] FIG. 5 is a schematic diagram of a phase change memory device circuit for the memory device of FIG. 2C.

[0012] FIG. 6 is a block diagram of a processor system having a memory device incorporating a phase change memory element constructed in accordance with an embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0013] In the following detailed description, reference is made to various embodiments of the invention. These embodiments are described with sufficient detail to enable those skilled in the art to practice them. It is to be understood that other embodiments may be employed, and that various structural, logical and electrical changes may be made.

[0014] The term "substrate" used in the following description may include any supporting structure including, but not limited to, a semiconductor substrate that has an exposed substrate surface. A semiconductor substrate should be understood to include silicon, silicon-on-insulator (SOI), silicon-on-sapphire (SOS), doped and undoped semiconductors, epitaxial layers of silicon supported by a base semiconductor foundation, and other semiconductor structures, including those made of semiconductors other than silicon. When reference is made to a semiconductor substrate or wafer in the following description, previous process steps may have been utilized to form regions or junctions in or over the base semiconductor or foundation. The substrate also need not be semiconductor-based,

but may be any support structure suitable for supporting an integrated circuit, including, but not limited to, metals, alloys, glasses, polymers, ceramics, and any other supportive materials as is known in the art.

[0015] Embodiments of the invention are now explained with reference to the figures, in which like reference numbers indicate like features. FIGS. 2A-2B illustrate a portion of a phase change memory device 200A constructed in accordance with a first embodiment of the invention. FIG. 2B is a top-down view of a portion of the phase change memory device 200A. FIG. 2A is a cross-sectional view of the device 200A along the line 2A-2A' shown in FIG. 2B.

[0016] The memory device 200A includes memory elements 201, each for storing at least one bit, i.e., logic 1 or 0. The memory elements 201 are supported by a substrate 10. A first dielectric layer 12 is formed on the substrate 10, and conductive plugs 44 are formed within the first dielectric layer 12. First electrodes 14 are formed within a second dielectric layer 20. Each first electrode 14 is formed over and in contact with a conductive plug 44.

[0017] A third dielectric layer 21 is provided over the first electrodes 14 and second dielectric layer 20. Second electrodes 22 are provided over the third dielectric layers 21. The third dielectric layers 21 and second electrodes 22 are formed as lines in the Y direction (FIG. 2B).

[0018] Programmable resistance material layers, depicted as phase change material layers 16 are on sidewalls of second electrode 22 lines and third dielectric layer 21 lines and in contact with respective first electrodes 14. The phase change material layers 16 may be any suitable material. Examples of suitable phase change materials are provided below in connection with the description of FIG. 3D. From a top-down perspective, the third dielectric layers 21 and second electrodes 22 are laterally offset from the first electrodes 14 to provide a location for the phase change

material layers 16 to contact the first electrodes 14. The memory elements 201 correspond to where a first electrode 14 and second electrode 22 and a portion of a phase change material layer 16 intersect electrically. In FIGS. 2A-2B, the phase change material layers 16 are shown only on portions of the second electrode 22 line and third dielectric layer 21 line sidewalls that are directly over a first electrode 14. In such a case, the entirety of each phase change layer 16 in a memory element 201 serves as the programmable volume of that memory element 201 and can be thoroughly phase changed during operation of the device 200A. Alternatively, the phase change material layers 16 can fully cover sidewalls of the second electrode 22 lines and third dielectric layer 21 lines.

[0019] As shown in FIG. 2B, from a top-down perspective, the first electrodes 14 are arranged in columns along the Y direction. The second electrode 22 lines are formed over adjacent first electrodes 14 such that a lateral edge 223 of the second electrodes 22 are directly over a portion of the first electrodes 14. Each second electrode 22 line is associated with a single column of first electrodes 14. Accordingly, as shown in FIG. 2B, the phase change material layers 16 are along portions of only one lateral edge 223 of the second electrodes 22.

[0020] Since the phase change material layer 16 for each memory element 201 is formed only on a sidewall of a second electrode 22, the contact area of the phase change material layer 16 to the electrodes 14, 22 for each memory element 201 is minimized. The programming volume of the memory elements 201 and the voltage needed to achieve the phase change for the memory elements 201 is also minimized as compared to that required for a conventional phase change memory element 1 (FIG. 1A). Further, the programming volume can be limited to a fixed volume that is thoroughly phase changed during each programming operation to promote reliability.

[0021] Additional dielectric layers, contact and metal lines can also be included in the device 200A. For example, contacts to first and second electrodes 14, 22 and metal lines can be included.

[0022] FIG. 2C illustrates a top down perspective of a memory device 200C according to another embodiment. The memory device 200C of FIG. 2C is similar to that shown in FIGS. 2A-2B, except that each second electrode 22 line is associated with two columns of first electrodes 14. That is, each second electrode 22 overlies portions of first electrodes 14 in two columns. Accordingly, as shown in FIG. 2C, the phase change material layers 16 are along portions of both lateral edge 223 of the second electrodes 22.

[0023] FIG. 2D illustrates a top down perspective of a memory device 200D according to another embodiment. The memory device 200D of FIG. 2D is similar to that shown in FIGS. 2A-2B, except that instead of second electrode 22 lines, the second electrodes 22', third dielectric layers 21 and phase change material layer 16 are configured as individual mesa structures 23. Therefore, each second electrode 22' is associated with one first electrode 14.

[0024] FIG. 2E illustrates a top down perspective of a memory device 200E according to another embodiment. The memory device 200E of FIG. 2E is similar to that shown in FIGS. 2C, except that instead of second electrode 22 lines, the second electrodes 22', third dielectric layers 21 and phase change material layer 16 are configured as individual mesa structures 23. Therefore, each second electrode 22' is associated with two adjacent first electrodes 14.

[0025] FIGS. 3A-3F illustrate one embodiment of a method of fabricating the phase change memory device 200A illustrated in FIGS. 2A-2B. No particular order is required for any of the actions described herein, except for those logically requiring

the results of prior actions. Accordingly, while the actions below are described as being performed in a specific order, the order can be altered if desired.

[0026] As shown in FIG. 3A, a first dielectric layer 12 is formed over a substrate 10. The first dielectric layer 12 is etched to create vias 24 within which conductive plugs 44 are formed. The conductive plugs 44 are formed of any suitable conductive material, such as titanium-nitride (TiN), titanium-aluminum-nitride (TiAlN), titanium-tungsten (TiW), platinum (Pt) or tungsten (W), among others.

[0027] As depicted in FIG. 3B, a second insulating layer 20 is formed over the conductive plugs 44 and the first insulating layer 12. Openings 15 are formed over and aligned with each conductive plug 44 by any suitable technique. In the illustrated embodiment, the openings 15 are formed having a substantially square top down shape, however the openings 15 may have any shape e.g., circular, rectangular, etc. The first electrodes 14 are formed in openings 15 and are formed of any suitable conductive material, such as titanium-nitride (TiN), titanium-aluminum-nitride (TiAlN), titanium-tungsten (TiW), platinum (Pt) or tungsten (W), among others.

[0028] FIG. 3C illustrates the deposition of a third dielectric layer 21 and a conductive material layer for forming second electrodes 22. The second electrodes 22 are formed of any suitable conductive material and can be a same material as the conductive plugs 44 and/or the first electrodes 14. Using photolithography and trench etching, the third dielectric layer 21 and conductive material layer are patterned into lines to form third dielectric layers 21 and second electrodes 22. The etching depth is sufficient to expose an upper surface of electrodes 14. The lateral edges 223 (not shown) of the third dielectric layers 21 are formed in contact with first electrodes 14. This allows lateral edges 223 (FIG. 2B) of the second electrodes 22 to be directly over a portion of the first electrodes 14. The third dielectric layers 21 and

second electrodes 22 are formed such that one lateral edge 223 of each second electrode 22 is over a portion of first electrodes 14 in a single column of first electrodes 14. The etching forms substantially straight sidewalls for the third dielectric layer 21 and the second electrode 22 lines.

[0029] FIG. 3D is a cross-sectional view of a portion of the memory device 200 along the line 3D-3D' of FIG. 3C. As depicted in FIG. 3D, optionally, the sidewalls of the third dielectric layer 21 and second electrode 22 lines can be sloped instead of straight. The sloped sidewalls serve to promote coverage of the sidewalls with the phase change material layers 16.

[0030] As depicted in FIG. 3E, a layer of a conformal or partially conformal phase change material 16 is formed on the sidewalls of the third dielectric layer 21 and the second electrodes 22. Preferably the phase change material layer 16 is thin and has a thickness of, for example, about 100 Å. Any suitable technique may be used to form the phase change material layer 16. For example, a conformal or partially conformal phase change material layer 16 is deposited over the second electrode 22 lines and in contact with the sidewalls of each third dielectric layer 21 and the surface of each first electrode 14. Portions of the phase change material 16 are removed to leave phase change material 16 on the sidewalls of each second electrode 22 line and each third dielectric layer 21.

[0031] In the illustrated embodiment, the deposited phase change material 16 is a chalcogenide material, such as, for example, germanium-antimony-telluride. The phase change materials can also be or include other phase change materials, for example, In-Se, Sb2Te3, GaSb, InSb, As-Te, Al-Te, GeTe, Te-Ge-As, In-Sb-Te, Te-Sn-Se, Ge-Se-Ga, Bi-Se-Sb, Ga-Se-Te, Sn-Sb-Te, In-Sb-Ge, Te-Ge-Sb-S, Te-Ge-Sn-O, Te-Ge-Sn-Au, Pd-Te-Ge-Sn, In-Se-Ti-Co, Ge-Sb-Te-Pd, Ge-Sb-Te-Co, Sb-Te-Bi-Se, Ag-In-Sb-Te, Ge-Sb-Se-Te, Ge-Sn-Sb-Te, Ge-Te-Sn-Ni, Ge-Te-Sn-Pd, and Ge-Te-Sn-Pt.

[0032] FIG. 3F is a cross sectional view of the memory device 200 of FIG. 3E along the line 3F-3F' and shows the phase change material layer 16 on the sidewalls of the second electrodes 22 and third dielectric layer 21. The programmable volume of the memory elements 201 is adjusted by adjusting the thickness of the phase change material layers 16. If desired, the phase change material layers 16 can be left along the length of the sidewalls of each second electrode 22.

[0033] Alternatively, portions of the phase change material layers 16 can be removed to achieve the structure shown in FIGS. 2A-2B. For this, a photoresist (not shown) is formed to protect the portions of the phase change material layers 16 in contact with the first electrodes 14. A wet etch or isotropic phase change material dry etch is performed to remove the unprotected portions of the phase change material layers 16 to achieve the structure shown in FIGS. 2A-2B. A fourth dielectric layer (not shown) is formed over the phase change material layers 16 to isolate the individual phase change material layers 16 from one another. By isolating the phase change material layers 16 associated with each first electrode 14, cross talk between memory elements 201 is reduced. If desired, to form the memory device 200D (FIG. 2D), portions of the phase change material layers 16, third dielectric layer 21 and second electrodes 22 can be removed to form individual mesa structures 23 shown in FIG. 2D.

[0034] After the phase change material layer 16 is formed on the sidewalls of dielectric layer 21 and second electrodes 22, the remaining trench is filled with a dielectric material by subsequent processing steps. Additional processing steps are also conducted to form additional dielectric layers, contacts and metal lines. For example, contacts to first and second electrodes 14, 22 and metal lines are formed.

[0035] The memory device 200C is formed in a similar manner as described above in connection with FIGS. 3A-3F. To form the memory device 200C, however,

the third dielectric layer 21 and conductive material layer are patterned using photolithographic and etching techniques into lines to form third dielectric layers 21 and second electrodes 22 such that each lateral edge 223 of each second electrode 22 is over a portion of first electrodes in a single column of first electrodes 14. Therefore, each second electrode 22 is associated with first electrodes 14 in two adjacent columns, as shown in FIG. 2C. Other than this, processing proceeds as described in connection with FIGS. 3A-3F. The memory device 200E (FIG. 2E) is formed similarly to the memory device 200C, except that portions of the phase change material layers 16, third dielectric layer 21 and second electrodes 22 are removed to form individual mesa structures 23 shown in FIG. 2E.

[0036] FIG. 4 is a schematic diagram of a memory device circuit 400 for the memory device 200A of FIGS. 2A-2B. The memory elements 201 are arranged in columns and rows. Each memory element 201 is connected to a select line 450 for a respective column. Specifically, each select line 450 is connected to a second electrode 22 of a respective memory element 201 or is the second electrode line 22 for the memory elements 201 of a respective column. Each select line 450 is connected to column decoder circuitry 460.

[0037] Each memory element 201 is further switchably connected to a bit line 470. In the FIG. 4 embodiment, each memory element 201 is connected to a first source/drain region 433a of an associated access transistor 433. The second source/drain region of each access transistor 433 is connected to a respective bit line 470. Each bit line 470 is connected to a voltage source or a bit line decoder circuit 462. Each gate 433c of each access transistor 433 is connected to a word line 440 for a respective row. Each word line 440 is connected to row decoder circuitry 461.

[0038] To select a particular element 201, the corresponding select line 450 is selected by the column decoder 460 and the corresponding word line 440 is selected

by the row decoder 461. For example, by selecting the specific word line 444 and select line 455, the specific memory element 430 is selected.

[0039] FIG. 5 is a schematic diagram of a memory device circuit 500 for the memory device 200C of FIG. 2C. The memory device circuit 500 is similar to that shown in FIG. 4, except that one select line 450 is provided for every two columns of memory elements 201.

[0040] Further, each bit line 570a, 570b is switchably connected to a voltage source 462 or a bit line decoder circuit (not shown) by bit line select circuitry 585. In the FIG. 5 embodiment, the bit line select circuitry 585 includes several bit line select transistors 581a, 581b. The bit line select transistors 581a and 581b are shown as n-type and p-type transistors, respectively. For the two columns associated with a single select line 450, a first column 590 is associated with a bit line 570a connected to an n-type bit line select transistor 581a and the second column 591 is associated with a bit line 570b connected to a p-type bit line select transistor 581b. The bit line select circuitry 585 also includes a bit line select line 580 connected to the gate of each bit line select transistor 581a, 581b for selectively activating the bit line select transistors 581a, 581b.

[0041] As in the memory device circuit 400 (FIG. 4), to operate memory device circuit 500 to select a particular memory element 201, the corresponding select line 450 is selected by the column decoder circuitry 460 and the corresponding word line 440 is selected by the row decoder circuitry 461. Further, bit line select line 580 is driven high or low to selectively operate one type of the bit line select transistors 581a, 581b. For example, to select the specific memory element 530, the specific word line 544 and select line 555 are selected. Further, the bit line select line 580 is driven high to selectively operate the n-type bit line select transistors 581a to

selectively connect the specific bit line 570a, also designated 577, to the voltage source 462.

[0042] FIGS. 4 and 5 depict only examples of memory device circuits 400, 500 including the memory devices 200A, 200C and memory elements 201 described herein. Other circuit designs incorporating the memory devices 200A, 200C and memory elements 201 are possible. Also, embodiments have been described as employing phase change material 16 as a programmable resistance material. Embodiments may also employ one or more layers of other programmable resistance materials in place of phase change material layer 16. Examples of other programmable resistance materials include such as metal doped chalcogenide glass and those programmable resistance materials discussed in various patents and patent applications assigned to Micron Technology, Inc., including, but not limited to the following: U.S. Patent Application No. 10/765,393; U.S. Patent Application No. 09/853,233; U.S. Patent Application No. 10/022,722; U.S. Patent Application No. 10/663,741; U.S. Patent Application No. 09/988,984; U.S. Patent Application No. 10/121,790; U.S. Patent Application No. 09/941,544; U.S. Patent Application No. 10/193,529; U.S. Patent Application No. 10/100,450; U.S. Patent Application No. 10/231,779; U.S. Patent Application No. 10/893,299; U.S. Patent No. 10/077,872; U.S. Patent Application No. 10/865,903; U.S. Patent Application No. 10/230,327; U.S. Patent Application No. 09/943,190; U.S. Patent Application No. 10/622,482; U.S. Patent Application No. 10/081,594; U.S. Patent Application No. 10/819,315; U.S. Patent Application No. 11/062,436; U.S. Patent Application No. 10/899,010; and U.S. Patent Application No. 10/796,000, the disclosures of each of which are incorporated herein by reference.

[0043] FIG. 6 illustrates a simplified processor system 600, which includes a memory unit 626 including memory circuit 400 having a phase change memory device 200A and memory elements 201 constructed in accordance with embodiments

of the invention. The system 600 could instead include memory circuit 500 having a phase change memory device 200C.

[0044] The FIG. 6 processor system 600, which can be any system including one or more processors, for example, a computer or other control system, generally comprises a central processing unit (CPU) 622, such as a microprocessor, a digital signal processor, or other programmable digital logic devices, which communicates with one or more input/output (I/O) devices 625 over a bus 621. The memory unit 626 communicates with the CPU 622 over bus 621 typically through a memory controller.

[0045] In the case of a computer system, the processor system 600 may include peripheral devices such as a compact disc (CD) ROM drive 623 and hard drive 624, which also communicate with CPU 622 over the bus 621. If desired, the memory circuit 626 may be combined with the processor, for example CPU 622, in a single integrated circuit.

[0046] The above description and drawings are only to be considered illustrative of specific embodiments, which achieve the features and advantages described herein. Modification and substitutions to specific process conditions and structures can be made. Accordingly, the embodiments of the invention are not to be considered as being limited by the foregoing description and drawings, but is only limited by the scope of the appended claims.

CLAIMS

1. A memory element comprising:

a first electrode having a top surface;

a dielectric material over the first electrode, the dielectric material having a top surface, a bottom surface and at least one sidewall;

a second electrode over the dielectric material, the second electrode having a top surface, a bottom surface and at least one sidewall; and

a programmable resistance material in contact with a top surface of the first electrode and at least a portion of the at least one sidewall of the dielectric material and the at least one sidewall of the second electrode, wherein the programmable resistance material is not in contact with a top surface of the dielectric material or a top surface of the second electrode.

2. The memory element of claim 1, wherein the bottom surface of the second electrode is in contact with the top surface of the dielectric material.

3. The memory element of claim 1, wherein the at least one sidewall of the dielectric material and the at least one sidewall of the second electrode are sloped.

4. The memory element of claim 1, wherein the dielectric material and the second electrode are laterally offset from the first electrode.

5. The memory element of claim 1, wherein the programmable resistance material is a phase change material.

6. A memory device comprising:

a plurality of first electrodes arranged in columns;

a second electrode over at least one of the plurality of first electrodes and spaced therefrom by a dielectric material; and

a programmable resistance material in contact with the at least one of the plurality of first electrodes a sidewall of the dielectric material, and the second electrode to define a plurality of memory elements, wherein a first lateral edge of each second electrode is directly over a portion of at least one first electrode in a first column and a second lateral edge of the second electrode is directly over a portion of at least one first electrode in a second column.

7. The memory device of claim 6, wherein the second electrode is configured as a line over the plurality of first electrodes, and further comprising a plurality of portions of the programmable resistance material, each programmable resistance material portion in contact with a respective first electrode and defining a memory element.

8. The memory device of claim 6, further comprising a plurality of conductive plugs, each conductive plug underlying and in contact with a respective first electrode.

9. The memory device of claim 6, further comprising a plurality of second electrodes, wherein each second electrode is directly over a portion of at least one first electrode in a respective column.

10. The memory device of claim 9, further comprising a plurality of select lines, each select line electrically connected to a respective second electrode.

11. The memory device of claim 9, wherein the plurality of second electrodes are configured to be select lines, each second electrode is disposed directly over a portion of each first electrode in a respective column.

12. The memory device of claim 6, further comprising a select line electrically connected to the second electrode.

13. The memory device of claim 12, further comprising a first bit line switchably connected to each first electrode in the first column and a second bit line switchably connected to each first electrode in the second column.

14. The memory device of claim 13, further comprising bit line select circuitry for selectively connecting one of the first and second bit lines to a voltage source.

15. The memory device of claim 14, wherein the bit line select circuitry comprises a transistor of a first conductivity type connected to the first bit line, a transistor of a second conductivity type connected to the second bit line and a bit line select line connected to a gate of each of the first and second conductivity type transistors.

16. A processor system comprising:

a processor; and

a memory circuit coupled to the processor, the memory circuit comprising:

a plurality of first electrodes arranged in a plurality of columns,

a second electrode line over the plurality of first electrodes and spaced therefrom by a dielectric material, and

one or more layers of programmable resistance material in contact with each of the first electrodes, the second electrode line and dielectric material to define a plurality of memory elements, wherein a first lateral edge of each second electrode line is directly over a portion of at least one first electrode in a first column and a second lateral edge of the second electrode line is directly over a portion of at least one first electrode in a second column; and

a plurality of bit lines, each bit line selectively connected to each first electrode in a respective column.

17. The system of claim 16, further comprising a plurality of select lines and a plurality of second electrode lines, each select line electrically connected to a respective second electrode line.

18. The system of claim 16, further comprising bit line select circuitry for selectively connecting the plurality of bit lines to a voltage source.

19. The system of claim 18, wherein the bit line select circuitry comprises a transistor of a first conductivity type connected to a first bit line, a transistor of a second conductivity type connected to the second bit line and a bit line select line connected to a gate of each of the first

and second conductivity type transistors, wherein the first bit line is switchably connected to each first electrode in the first column, and wherein the second bit line is switchably connected to each first electrode in the second column.

20. A method of forming a memory element, the method comprising:

forming a first electrode having a top surface;

forming a stack on the top surface of the first electrode, the stack having sidewalls and a top surface and comprising:

a first dielectric material, the first dielectric material having a top surface, and a second electrode in contact with the top surface of the first dielectric material, the sidewalls of the stack comprising a lateral edge of the second electrode over and in contact with a lateral edge of the first dielectric material;

forming a programmable resistance material in contact with the top surface of the first electrode and the sidewalls and the top surface of the stack; and

removing a portion of the programmable resistance material in contact with the top surface of the stack, such that the programmable resistance material is not in contact with a top surface of the stack.

21. The method of claim 20, wherein the second electrode is formed as a line.

22. The method of claim 21, wherein forming the second electrode comprises forming a conductive material over the first dielectric material and etching the first dielectric material and conductive material to form the line.

23. The method of claim 22, wherein etching comprises etching the first dielectric material and conductive material such that sidewalls of the stack are sloped.

24. The method of claim 23, wherein the programmable resistance material is formed in contact with all portions of the sidewalls of the stack.

25. The method of claim 20, wherein the second electrode is formed laterally offset from the first electrode.

26. The method of claim 20, further comprising forming a second dielectric material, wherein the first electrode is formed within the second dielectric material.

27. The method of claim 26, further comprising forming a third dielectric material underlying the first electrode and second dielectric material and forming a conductive plug within the third dielectric material and in contact with the first electrode.

28. The method of claim 20, wherein the programmable resistance material is formed as a phase change material.

29. A method of forming a memory device, the method comprising:

forming a plurality of first electrodes arranged in a plurality of columns;

forming a dielectric material over the plurality of first electrodes, the dielectric material having sidewalls and a top surface;

forming a plurality of second electrodes in contact with the top surface of the first dielectric layer; and

forming a programmable resistance material in contact with one of the plurality of first electrodes, a sidewall of the dielectric layer and a portion of a second electrode to form a memory element, wherein a first lateral edge of the second electrode is formed directly over a portion of a first electrode in a first column and a second lateral edge of the second electrode is formed directly over a portion of a first electrode in a second column.

30. The method of claim 29, wherein the programmable resistance material is formed in contact with more than one of the plurality of first electrodes to form a plurality of memory elements.

31. The method of claim 29, further comprising forming a plurality of portions of programmable resistance material, each programmable resistance material portion formed in contact with a respective first electrode to form a memory element.

32. The method of claim 29, further comprising forming dielectric material portions, each second electrode and dielectric material portion formed as a line and directly over a portion of each first electrode in respective columns.

33. A method of forming a memory device, the method comprising:

forming a plurality of first electrodes arranged in columns and rows;

forming a dielectric material over the plurality of first electrodes;

forming a conductive material in contact with a top surface of the dielectric material and directly over each of the plurality of first electrodes;

etching the dielectric material and conductive material in a same pattern to form a plurality of second electrode lines stacked on a top surface of a plurality of dielectric lines and to expose a top surface of each first electrode, each second electrode line directly over at least a portion of each first electrode within a respective column;

forming programmable resistance material in contact with the top surface of the plurality of second electrode lines and in contact with the sidewalls of the plurality of dielectric lines and the top surface of each first electrode; and

removing portions of the programmable resistance material in contact with the top surface of the plurality of second electrode lines to leave programmable resistance material only on the sidewalls of each second electrode line, the sidewalls of each dielectric lines and the top surface of each first electrode.

34. A method of forming a memory device, the method comprising:

forming a plurality of first electrodes arranged in columns and rows;

forming a dielectric material over the plurality of first electrodes;

forming a conductive material in contact with a top surface of the dielectric material;

etching the dielectric material and conductive material to form a plurality of second electrode lines and a plurality of dielectric lines and to expose a surface of each first electrode, each second electrode line located on a top surface of a respective dielectric line;

forming programmable resistance material over the second electrode lines and in contact with the sidewalls of the dielectric lines and the surface of each first electrode; and

removing portions of the programmable resistance material to leave programmable resistance material on a sidewall of each second electrode line and a sidewall of each dielectric lines, wherein the dielectric material and conductive material are etched such that a first lateral edge of each second electrode line and each dielectric line are formed directly over a portion of each first electrode in a first column and a second lateral edge of the second electrode line is formed directly over a portion of each first electrode in a second column.

35. The method of claim 33, further comprising, further etching the plurality of second electrode lines, the plurality of dielectric lines and programmable resistance material to form a plurality of mesa structures, a portion of each mesa structure overlying at least one first electrode.

36. The method of claim 29, wherein the programmable resistance material is formed in contact with a sidewall of the second electrode.