CLAIMS

1. A phase change material switch comprising:

a metal liner disposed on a portion of a dielectric layer;

a phase change layer disposed on ~~a~~the metal liner;

a gate dielectric layer disposed on the dielectric layer and the phase change layer; and

a metal gate liner disposed on the gate dielectric layer.

2. The phase change material switch of claim 1, wherein the phase change layer comprises a phase change material.

3. The phase change material switch of claim 2, wherein the phase change material comprises one of selenium and tellurium.

4. The phase change material switch of claim 2, wherein the phase change material is $Ge_2Sb_2Te_5$ (GST).

5. The phase change material switch of any of the preceding claims, further comprising:

a hardmask disposed on the metal gate liner;

one or more trenches disposed in the hardmask; and ~~configured to expose the metal gate liner; and~~

a conductive material disposed in the one or more trenches and on the metal gate liner.

6. The phase change material switch of claim 5, further comprising a sidewall spacer disposed on the hardmask, the metal gate liner and the gate dielectric layer.

7. The phase change material switch of any of the preceding claims, wherein the metal gate liner and the gate dielectric layer are configured to be orthogonal to the phase change layer.

8. The phase change material switch of claim 7, in the form of a four-terminal phase change material switch.

9. A phase change material bridge device comprising:

~~a phase change material switch of any of claims 1 to 8;~~

an electrode comprising an intra-metal dielectric layer and at least two metal contact vias in the intra-metal dielectric layer; and

a metal liner disposed on a portion of the intra-metal dielectric layer and the at least two metal contact vias;

wherein a phase change layer disposed on the metal liner;

a gate dielectric layer is further disposed on the metal liner and the phase change layer and a remaining portion of the intra-metal dielectric layer and the at least two metal contact vias, wherein the metal liner and the phase change layer comprise a horizontal bridge between the at least two metal contact vias.; and

a metal gate liner disposed on the gate dielectric layer.

10. The phase change material bridge device of claim 9, wherein the phase change layer comprises a phase change material.

11. The phase change material bridge device of claim 10, wherein the phase change material comprises one of selenium and tellurium.

12. The phase change material bridge device of claim 10, wherein the phase change material is $Ge_2Sb_2Te_5$ (GST).

13. The phase change material bridge device of claim 9, further comprising:

a hardmask disposed on the metal gate liner;

one or more trenches disposed in the hardmask; and

a conductive material disposed in the one or more trenches and on the metal gate liner.

14. The phase change material bridge device of claim 9, wherein the metal gate liner and the gate dielectric layer are configured to be orthogonal to the phase change layer.

15. A semiconductor structure comprising:

a phase change material switch of any of claims 1 to 8;

a semiconductor substrate;

an electrode disposed on the semiconductor substrate, wherein the electrode comprises an intra-metal dielectric layer and at least two metal contact vias in the intra-metal dielectric layer; and

a metal liner disposed on a portion of the intra-metal dielectric layer and the least two metal contact vias, wherein the metal liner and the phase change layer comprise a horizontal bridge between the at least two metal contact vias.

11. A method, comprising:

forming a metal liner on an electrode comprising an intra-metal dielectric layer and at least two metal contact vias in the intra-metal dielectric layer;

forming a phase change layer on the a metal liner;

forming a first hardmask on the phase change layer;

selectively removing disposed on a portion of the metal liner, the phase change layer and the first hardmask to expose a portion of each of the intra-metal dielectric layer and the at least two metal contact vias;

a phase change layer disposed on the metal liner; wherein a remaining portion of the metal liner, and the phase change layer and the first hardmask formscomprise a horizontal bridge between the at least two metal contact vias;

forming a gate dielectric layer disposed on exterior surfaces of the metal liner, the phase change layer; and the first hardmask, and the exposed portions of the intra-metal dielectric layer and each of the at least two metal contact vias; and

forming a metal gate liner disposed on the gate dielectric layer.

16. 12. The methodsemiconductor structure of claim 11, further comprising:

forming a second hardmask on15, wherein the metal gate liner;

etching the second hardmask to expose a portionphase change layer comprises one of the metal gate liner;selenium and tellurium.

removing the exposed portion of the metal gate liner to expose the gate dielectric layer.

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13. The methodsemiconductor structure of claim 12, further comprising:

forming one or more metal gate contacts by forming one or more trenches in the second hardmask to expose the metal gate liner; and

depositing a conductive material in the one or more trenches15.

14. The method of any of claims 11 to 13, wherein the phase change layer comprises $Ge_2Sb_2Te_5$ (GST).

15. A method, comprising:

forming a metal liner on 18. The semiconductor structure of claim 15, wherein the metal gate liner and the gate dielectric layer are configured to be orthogonal to the phase change layer.

19. An integrated circuit comprising:

one or more semiconductor structures, wherein at least one of the one or more semiconductor structures comprises:

a semiconductor substrate;

an electrode comprisingdisposed on the semiconductor substrate, wherein the electrode comprises an intra-metal dielectric layer and at least two metal contact vias in the intra-metal dielectric layer;

forming a sacrificial layer on the metal liner;

forming a first hardmask on the sacrificial layer;

selectively removing a portion of the metal liner, the sacrificial layer and the first hardmask to expose disposed on a portion of the intra-metal dielectric layer and each of the at least two metal contact vias;;

a phase change layer disposed on the metal liner; wherein a remaining portion of the metal liner, the sacrificial layer and the first hardmask formsphase change layer comprise a horizontal bridge between the at least two metal contact vias;

removing the first hardmask;

forming a gate dielectric layer disposed on the metal liner and the exposed portions of the intra-metal dielectric layer and each of the at least two metal contact vias, phase change layer; and

forming a metal gate liner disposed on the gate dielectric layer;.

forming

20. The integrated circuit of claim 19, wherein the at least one of the one or more semiconductor structures further comprises:

a second hardmask disposed on the metal gate liner;

etchingone or more trenches disposed in the second hardmask to expose ; and

a portion ofconductive material disposed in the one or more trenches and on the metal gate liner;

.

removing the exposed portion of

21. The integrated circuit of claim 19, wherein the metal gate liner ~~to expose~~and the gate dielectric layer~~;~~ are configured to be orthogonal to the phase change layer.

~~removing the exposed portion of the~~

22. The integrated circuit of claim 19, wherein the phase change layer comprises one of selenium and tellurium.

23. A 4-terminal switching device comprising:

a gate dielectric layer ~~to expose the sacrificial layer and~~ disposed on a ~~portion of the intra-metal~~ dielectric layer and between a phase change layer and ~~each of the at least two~~ a metal ~~contact vias;~~

~~removing the sacrificial layer to expose the metal~~ gate liner ~~and form an airgap defined between a top surface of the metal liner and a bottom surface of the gate dielectric layer; and~~

~~depositing a phase change layer in the airgap and on the exposed portion of the metal liner, the intra-metal dielectric layer and each of the at least two metal contact vias.~~

; wherein~~16. The method of claim 15, further comprises forming sidewall spacers on sidewalls of the second hardmask, and~~ the metal gate liner and the gate dielectric layer ~~under the second hardmask prior to removing the sacrificial~~are configured to be orthogonal to the phase change layer.

~~17.~~ 24. The ~~method~~4-terminal switching device of claim ~~16~~23, further comprising~~:~~ the phase change layer disposed on a metal liner.

~~recessing~~

25. The 4-terminal switching device of claim 23, wherein the phase change layer ~~on the exposed portion of the metal liner, the intra-metal dielectric layer~~comprises one of selenium and ~~each of the at least two metal contact vias;~~

~~forming a dielectric cap layer on the recessed phase change layer;~~

~~recessing the dielectric cap layer;~~

~~forming an organic planarization layer on the recessed dielectric cap layer;~~

~~patterning the organic planarization layer to expose a portion of the intra-metal dielectric layer and each of the at least two metal contact vias;~~

~~forming the one or more metal gate contacts by forming one or more trenches in the second hardmask to expose the metal gate liner; and~~

~~depositing a conductive material in the one or more trenches~~tellurium.