CLAIMS

The invention claimed is:

1. A method of forming a switch, comprising:

forming a bottom electrode over a base;

forming a first electrically conductive structure directly over the bottom electrode;

forming dielectric material along a sidewall of the first electrically conductive structure, the first electrically conductive structure and the dielectric material together covering a first portion of the bottom electrode and leaving a second portion of the bottom electrode exposed;

forming a graphene structure electrically coupled with the exposed portion of the bottom electrode, along the dielectric material and laterally spaced from the first electrically conductive structure by the dielectric material;

forming a second electrically conductive structure on an opposing side of the graphene structure from the first electrically conductive structure, the second electrically conductive structure being directly over the bottom electrode;

forming a top electrode over the graphene structure; the bottom electrode being electrically coupled with one of the first and second electrically conductive structures, the top electrode being electrically coupled with the other of the first and second electrically conductive structures; and

wherein the first and second electrically conductive structures are configured to provide an electric field across the graphene structure.

2. The method of claim 1 wherein the switch is formed in an opening over the bottom electrode, and wherein the switch is the only switch formed in the opening over the bottom electrode.

3. The method of claim 1 wherein the switch is one of a pair of switches that are formed in a common opening over a pair of bottom electrodes.

4. The method of claim 1 wherein the switch is one of a plurality of switches that are formed in a common opening over a plurality of bottom electrodes.

5. The method of claim 1 wherein the forming of the graphene structure comprises:

forming seed material along the dielectric material; and

epitaxially growing graphene along the seed material.

6. A method of forming a switch, comprising:

forming first and second electrically conductive structures over a bottom electrode and laterally spaced from one another; the first electrically conductive structure directly contacting the bottom electrode, and the second electrically conductive structure not directly contacting the bottom electrode;

forming a dielectric liner along a sidewall of one of the first and second electrically conductive structures, a portion of the bottom electrode being exposed after formation of the dielectric liner;

forming a graphene structure along the dielectric liner, the graphene structure being electrically coupled with the bottom electrode;

forming a top electrode over the graphene structure and the first and second electrically conductive structures; the top electrode being electrically coupled with the graphene structure, directly contacting the second electrically conductive structure, and not directly contacting the first electrically conductive structure; and

wherein the first and second electrically conductive structures are configured to provide an electric field across the graphene structure.

7. The method of claim 6 wherein the first and second electrically conductive structures are formed simultaneously.

8. The method of claim 6 wherein the first and second electrically conductive structures are formed sequentially relative to one another.

9. The method of claim 6 wherein an opening remains over the bottom electrode after forming the graphene structure; the opening being on an opposing side of the graphene structure from the dielectric liner, the method further comprising filling the opening with dielectric material prior to forming the top electrode.

10. The method of claim 6 wherein the dielectric liner comprises a second dielectric material, and further comprising:

forming a first dielectric material over the bottom electrode;

forming an opening extending through the first dielectric material to the bottom electrode, the opening having a pair of sidewalls along a cross-section;

forming a dielectric spacer along a bottom region of one of the sidewalls; and

forming electrically conductive liners along the sidewalls of the opening, one of the liners being the first electrically conductive structure and the other of the liners being the second electrically conductive structure; the second electrically conductive structure being spaced from the bottom electrode by the dielectric spacer.

11. The method of claim 10 wherein the forming of the electrically conductive liners comprises:

deposition of electrically conductive material along the sidewalls of the opening and across a bottom of the opening; and

anistropically etching the electrically conductive material.

12. The method of claim 10 wherein the dielectric spacer is a first dielectric spacer, and further comprising replacing a top portion of said one of the electrically conductive liners with a second dielectric spacer prior to forming the top electrode.

13. A method of forming switches, comprising:

forming a pair of spaced apart bottom electrodes over a base;

forming a first dielectric material over the bottom electrodes;

forming an opening extending through the first dielectric material to the bottom electrodes;

forming a pair of upwardly-extending electrically conductive structures along sidewalls of the opening, one of the upwardly-extending electrically conductive structures being directly against one of the bottom electrodes and the other of the upwardly-extending electrically conductive structures being directly against the other of the bottom electrodes;

forming second dielectric material along sidewalls of the upwardly-extending electrically conductive structures, portions of the bottom electrodes being exposed after formation of the second dielectric material;

forming a pair of graphene structures extending upwardly from the exposed portions of the bottom electrodes; a first of the graphene structures being electrically coupled with, and directly over, one of the bottom electrodes; a second of the graphene structures being electrically coupled with, and directly over, the other of the bottom electrodes;

forming third dielectric material along sidewalls of the graphene structures;

forming a pair of downwardly-extending electrically conductive structures along the third dielectric material;

forming fourth dielectric material between the downwardly-extending electrically conductive structures; and

forming a pair of top electrodes over the graphene structures and the downwardly-extending electrically conductive structures; one of the top electrodes being electrically coupled with the first graphene structure and with one of the downwardly-extending electrically conductive structures, and the other of the top electrodes being electrically coupled with the second graphene structure and with the other of the downwardly-extending electrically conductive structures.

14. The method of claim 13 wherein the forming of the upwardly-extending electrically conductive structures comprises:

deposition of electrically conductive material along the sidewalls of the opening and across a bottom of the opening;

anistropically etching the electrically conductive material; and

recessing the electrically conductive material relative to a top of the opening so that upper surfaces of the upwardly-extending electrically conductive structures are below the top of the opening.

15. The method of claim 14 wherein the forming of the second dielectric material comprises:

deposition of the second dielectric material along and over the upwardly-extending electrically conductive structures, and across a bottom of the opening; and

anistropically etching the second dielectric material to form dielectric liners along sidewalls of the upwardly-extending electrically conductive structures, and to form dielectric spacers over the upwardly-extending electrically conductive structures.

16. The method of claim 15 wherein the top electrodes are formed directly on the dielectric spacers.

17. The method of claim 15 wherein the forming of the graphene structures comprises:

deposition of seed material along sidewalls of the dielectric liners and dielectric spacers; and

epitaxial growth of graphene along the seed material.

18. The method of claim 17 further comprising anisotropically etching the seed material to remove the seed material from over tops of the dielectric spacers prior to growing the graphene.

19. The method of claim 17 wherein the graphene grows over tops of the dielectric spacers, and further comprising anisotropically etching the graphene to remove the graphene from over the tops of the dielectric spacers.

20. The method of claim 13 wherein regions of the bottom electrodes are exposed after forming the graphene structures, wherein the third dielectric material covers such exposed regions, and wherein bottoms of the downwardly-extending electrically conductive structures are spaced from the bottom electrodes by the third dielectric material.

CLAIMS

Claim 1: A method of forming a switch, comprising:

forming a bottom electrode over a base;

forming a first electrically conductive structure directly overthe bottom electrode;

forming dielectric material along a sidewall of the first electrically conductive structure, the first electrically conductive structure and the dielectric material together covering a first portion of the bottom electrode and leaving a second portion of the bottom electrode exposed;

forming a graphene structure electrically coupled with the exposed portion of the bottom electrode, along the dielectric material and laterally spaced from the first electrically conductive structure by the dielectric material;

forming a second electrically conductive structure on an opposing side of the graphene structure from the first electrically conductive structure, the second electrically conductive structure being directly over the bottom electrode;

forming a top electrode over the graphene structure; the bottom electrode being electrically coupled with one of the first and second electrically conductive structures, the top electrodebeing electrically coupled with the other of the first and second electrically conductive structures; and

wherein the first and second electrically conductive structures are configured to provide an electric field across the graphene structure.

Claim 2: The method of claim 1 wherein the switch is formed in an opening over the bottom electrode, and wherein the switch is the only switch formed in the opening over the bottom electrode.

Claim 3: The method of claim 1 wherein the switch is one of a pair of switches that are formed in a common opening over a pair of bottom electrodes.

Claim 4: The method of claim 1 wherein the switch is one of a plurality of switches that are formed in a common opening over a plurality of bottom electrodes.

Claim 5: A method of forming a switch, comprising:

forming first and second electrically conductive structures over a bottom electrode and laterally spaced from one another; the first electrically conductive structure directly contacting the bottom electrode, and the second electrically conductive structure not directly contacting the bottom electrode;

forming a dielectric liner along a sidewall of one of the first and second electrically conductive structures, a portion of the bottom electrode being exposed after formation of the dielectric liner;

forming a graphene structure along the dielectric liner, the graphene structure being electrically coupled with the bottom electrode;

forming a top electrode over the graphene structure and the first and second electrically conductive structures; the top electrode being electrically coupled with the graphene structure, directly contacting the second electrically conductive structure, and not directly contacting the first electrically conductive structure; and

wherein the first and second electrically conductive structures are configured to provide an electric field across the graphene structure.

Claim 6: The method of claim 5 wherein the first and second electrically conductive structures are formed simultaneously.

Claim 7: The method of claim 5 wherein the first and second electrically conductive structures are formed sequentially relative to one another.

Claim 8: A method of forming switches, comprising:

forming a pair of spaced apart bottom electrodes over a base;

forming a first dielectric material over the bottom electrodes;

forming an opening extending through the first dielectric material to the bottom electrodes;

forming a pair of upwardly-extending electrically conductive structures along sidewalls of the opening, one of the upwardly-extending electrically conductive structures being directly against one of the bottom electrodes and the other of the upwardly-extending electrically conductive structures being directly against the other of the bottom electrodes;

forming second dielectric material along sidewalls of the upwardly-extending electrically conductive structures, portions of the bottom electrodes being exposed after formation of the second dielectric material;

forming a pair of graphene structures extending upwardly from the exposed portions of the bottom electrodes;a first of the graphene structures being electrically coupled with, and directly over, one of the bottom electrodes;a second of the graphene structures being electrically coupled with, and directly over, the other of the bottom electrodes;

forming third dielectric material along sidewalls of the graphene structures;

forming a pair of downwardly-extending electrically conductive structures along the third dielectric material;

forming fourth dielectric material between thedownwardly-extending electrically conductive structures; and

forming a pair of top electrodes over the graphene structures and the downwardly-extending electrically conductive structures; one of the top electrodes being electrically coupled withthe first graphene structure and with one of the downwardly-extending electrically conductive structures, and the other of the top electrodes being electrically coupled with the second graphene structure and with the other of the downwardly-extending electrically conductive structures.

Claim 9: The method of claim 8 wherein the forming of the upwardly-extending electrically conductive structures comprises:

deposition of electrically conductive material along the sidewalls of the opening and across a bottom of the opening;

anisotropically etching the electrically conductive material; and

recessing the electrically conductive material relative to a top of the opening so that upper surfaces of the upwardly-extending electrically conductive structures are below the top of the opening.

Claim 10: The method of claim 9 wherein the forming of the second dielectric material comprises:

deposition of the second dielectric material along and over the upwardly-extending electrically conductive structures, and across a bottom of the opening; and

anisotropically etching the second dielectric material to form dielectric liners along sidewalls of the upwardly-extending electrically conductive structures, and to form dielectric spacers over the upwardly-extending electrically conductive structures.

Claim 11: The method of claim 10 wherein the top electrodes are formed directly on the dielectric spacers.

Claim 12: The method of claim 10 wherein the forming of the graphene structures comprises:

deposition of seed material along sidewalls of the dielectric liners and dielectric spacers; and

epitaxial growth of graphene along the seed material.

Claim 13: The method of claim 12 further comprising anisotropically etching the seed material to remove the seed material from over tops of the dielectric spacers prior to growing the graphene.

Claim 14: The method of claim 12 wherein the graphene grows over tops of the dielectric spacers, and further comprising anisotropically etching the graphene to remove the graphene from over the tops of the dielectric spacers.