CLAIMS

1. A method of forming a dual pore sensor, comprising:

forming a film stack, wherein the film stack comprises:

a first silicon layer,

a first membrane layer disposed on the first silicon layer,

a second silicon layer disposed on the first membrane layer, and

a second membrane layer disposed on the second silicon layer;

etching the film stack to produce:

a first reservoir in the first silicon layer,

a first nanopore in the first membrane layer,

a second reservoir in the second silicon layer,

a second nanopore in the second membrane layer, and

a channel in fluid communication with the first and second reservoirs and the first and second nanopores;

depositing a protective oxide layer on the second membrane layer and inner surfaces of the first and second reservoirs and inner surfaces of the first and second nanopores;

depositing a dielectric layer on the protective oxide layer disposed on the second membrane layer and covering the second nanopore;

forming a metal contact which extends through the dielectric layer, the protective oxide layer, and the second membrane layer, and at least partially into the second silicon layer;

etching at least a portion of the dielectric layer to form a well above the second nanopore;

etching at least a portion of the first silicon layer to reveal at least a portion of the protective oxide layer deposited on the inner surfaces of the first reservoir; and

etching the protective oxide layer deposited on the inner surfaces of the first and second reservoirs and the inner surfaces of the first and second nanopores.

2. The method of claim 1, wherein the protective oxide layer comprises silicon oxide, a metal oxide, a metal silicate, or any combination thereof.

3. The method of claim 2, wherein the protective oxide layer is deposited by atomic layer deposition.

4. The method of claim 1, wherein each of the first nanopore and the second nanopore independently has a diameter in a range from about 0.5 nm to about 50 nm.

5. The method of claim 1, wherein the dielectric layer comprises a tetraethyl orthosilicate oxide, a silane oxide, a polyimide, or any combination thereof.

6. The method of claim 1, wherein the dielectric layer has a thickness in a range from about 1 μm to about 5 μm.

7. The method of claim 1, wherein forming the metal contact further comprises:

etching a contact hole through the dielectric layer, the protective oxide layer, and the second membrane layer, and partially into the second silicon layer; and

depositing a metal into the contact hole to form the metal contact comprising the metal.

8. The method of claim 1, wherein the metal contact extends parallel or substantially parallel to the channel.

9. The method of claim 1, wherein the portion of the dielectric layer is etched with a dry etch process to form the well above the second nanopore, and wherein the portion of the first silicon layer is etched with a wet etch process to reveal the portion of the protective oxide layer deposited on the inner surfaces of the first reservoir.

10. The method of claim 1, wherein the protective oxide layer is etched by a wet etch process.

11. The method of claim 1, further comprising depositing a spacer layer on at least the inner surfaces of the first and second nanopores after etching the protective oxide layer.

12. The method of claim 11, wherein the spacer layer comprises silicon oxide, a silicon nitride, a silicon oxynitride, or any combination thereof.

13. The method of claim 11, wherein the spacer layer is deposited by atomic layer deposition.

14. The method of claim 11, further comprising etching at least a portion of the spacer layer from the inner surfaces of the first and second nanopores within the channel.

15. The method of claim 11, further comprising etching at least a portion of the spacer layer from a lower surface of the first membrane or an upper surface of the second membrane.

16. A method of forming a dual pore sensor, comprising:

forming a film stack, wherein the film stack comprises:

a first silicon layer,

a first membrane layer disposed on the first silicon layer,

a second silicon layer disposed on the first membrane layer,

a second membrane layer disposed on the second silicon layer,

a first reservoir in the first silicon layer,

a first nanopore in the first membrane layer,

a second reservoir in the second silicon layer,

a second nanopore in the second membrane layer, and

a channel in fluid communication with the first and second reservoirs and the first and second nanopores;

depositing a protective oxide layer on the second membrane layer and inner surfaces of the first and second reservoirs and inner surfaces of the first and second nanopores;

depositing a dielectric layer on the protective oxide layer disposed on the second membrane layer and covering the second nanopore;

forming a metal contact which extends through the dielectric layer, the protective oxide layer, and the second membrane layer, and at least partially into the second silicon layer, wherein the metal contact comprises a metal;

etching at least a portion of the dielectric layer to form a well above the second nanopore;

etching at least a portion of the first silicon layer to reveal at least a portion of the protective oxide layer deposited on the inner surfaces of the first reservoir;

etching the protective oxide layer deposited on the inner surfaces of the first and second reservoirs and the inner surfaces of the first and second nanopores; and

depositing a spacer layer on at least the inner surfaces of the first and second nanopores.

17. The method of claim 16, wherein the spacer layer comprises silicon oxide, a silicon nitride, a silicon oxynitride, or any combination thereof, and wherein the spacer layer is deposited by atomic layer deposition.

18. The method of claim 16, further comprising etching at least a portion of the spacer layer from a lower surface of the first membrane or an upper surface of the second membrane.

19. The method of claim 16, wherein each of the first nanopore and the second nanopore independently has a diameter in a range from about 1 nm to about 50 nm.

20. The method of claim 16, wherein the dielectric layer has a thickness in a range from about 1 μm to about 5 μm.