channels all over as well as at the center of the device. In this approach, the sacrificial material can be removed uniformly in a short time. However, this approach suffers from an issue of damaging or mass loading on critical MEMS devices, such as film bulk acoustic resonators (FBARs), as the sealing material will get deposited on the MEMS devices through etch channels that present on the top of the MEMS devices. The other approach is to have etching channels at the side of the MEMS devices. This side etching channel approach may be good at preventing damage from mass loading, but has a disadvantage of a longer release time than regular approaches, as the sacrificial material located deep inside near the MEMS device cannot be efficiently removed through side channels.

[0004] Therefore, what is needed is a robust TFE structure and method which solves both the above drawbacks simultaneously, namely which prevents the mass loading on the MEMS devices and enables fast release of the sacrificial layer.

SUMMARY

[0005] According to a first aspect of the present application, there is provided a method for thin film encapsulation (TFE) of a microelectromechanical system (MEMS) device, including providing a substrate; forming a MEMS device on the substrate; forming one or more etching channels adjacent to the MEMS device; providing one or more cavities below the MEMS device; and forming one or more cavities above the MEMS device.

[0006]

What is claimed is:

1. A method for thin film encapsulation (TFE) of a microelectromechanical system (MEMS) device, comprising:

providing a silicon-on-insulator (SOI) substrate comprising a silicon substrate layer, an insulator layer and a silicon layer;

forming a MEMS device in the silicon layer of the SOI substrate;

forming one or more etching channels adjacent to the MEMS device;

then providing one or more cavities below the MEMS device; and

then forming one or more cavities above the MEMS device,

wherein forming the one or more etching channels comprises forming one or more sidewall etching channels in the substrate by partially etching the silicon layer at a periphery of the MEMS device.

2. The method for TFE of a MEMS device in accordance with claim 1, wherein forming the MEMS device comprising forming one or more etching channels in the MEMS device.

3. The method for TFE of a MEMS device in accordance with claim 4, wherein providing the one or more cavities below the MEMS device comprises removing the insulator layer below the MEMS device by etching the insulator layer below the MEMS device through the etching channels.

4. The method for TFE of a MEMS device in accordance with claim 4, wherein providing the one or more cavities below the MEMS device comprises providing the SOI substrate having one or more cavities pre-etched in the silicon substrate layer and the insulator layer.

5. The method for TFE of a MEMS device in accordance with claim 4, further comprising depositing a sacrificial layer over the MEMS device.

6. The method for TFE of a MEMS device in accordance with claim 8, wherein the sacrificial layer is deposited such that it covers the MEMS device, the etching channels adjacent to the MEMS device, and the sidewall etching channels.

7. The method for TFE of a MEMS device in accordance with claim 8, further comprising depositing a cap layer over the sacrificial layer.

8. The method for TFE of a MEMS device in accordance with claim 10, wherein the cap layer is deposited over the sacrificial layer to the extent that one or more exposures of the sacrificial layer are formed.

9. The method for TFE of a MEMS device in accordance with claim 11, wherein forming the one or more cavities above the MEMS device comprising providing one or more etchants to the one or more exposures of the sacrificial layer so as to remove the sacrificial layer.

10. The method for TFE of a MEMS device in accordance with claim 12, wherein the one or more etchants comprise an etch gas selected from a group comprising XeF2, V-HF and Ozone.

11. The method for TFE of a MEMS device in accordance with claim 10, further comprising providing a sealing layer over the cap layer, wherein the sealing layer extends to and sits in part on the silicon layer.

channels all over as well as at the center of the device. In this approach, the sacrificial material can be removed uniformly in a short time. However, this approach suffers from an issue of damaging or mass loading on critical MEMS devices, such as film bulk acoustic resonators (FBARs), as the sealing material will get deposited on the MEMS devices through etch channels that present on the top of the MEMS devices. The other approach is to have etching channels at the side of the MEMS devices. This side etching channel approach may be good at preventing damage from mass loading, but has a disadvantage of a longer release time than regular approaches, as the sacrificial material located deep inside near the MEMS device cannot be efficiently removed through side channels.

[0004] Therefore, what is needed is a robust TFE structure and method which solves both the above drawbacks simultaneously, namely which prevents the mass loading on the MEMS devices and enables fast release of the sacrificial layer.

SUMMARY

[0005] According to a first aspect of the present application, there is provided a method for thin film encapsulation (TFE) of a microelectromechanical system (MEMS) device, including providing a substrate; forming a MEMS device on the substrate; forming one or more etching channels adjacent to the MEMS device; providing one or more cavities below the MEMS device; and forming one or more cavities above the MEMS device.

~~**[0006]** According to a second aspect of the present application, there is provided a thin film encapsulated microelectromechanical system (MEMS) device which includes a MEMS device formed on a substrate; one or more cavities formed above and/or below the MEMS device; a cap layer formed over the MEMS device; and a sealing layer formed over the cap layer; wherein one or more etching channels are formed adjacent to the MEMS device and under the cap layer.~~

What is claimed is:

1. A method for thin film encapsulation (TFE) of a microelectromechanical system (MEMS) device, comprising:

providing a silicon-on-insulator (SOI) substrate comprising a silicon substrate layer, an insulator layer and a silicon layer;

forming a MEMS device in the silicon layer of the SOI substrate~~on the substrate~~;

forming one or more etching channels adjacent to the MEMS device;

then providing one or more cavities below the MEMS device; and

then forming one or more cavities above the MEMS device,

wherein forming the one or more etching channels comprises forming one or more sidewall etching channels in the substrate by partially etching the silicon layer at a periphery of the MEMS device.

~~2. The method for TFE of a MEMS device in accordance with claim 1, wherein forming the one or more etching channels comprises forming one or more sidewall etching channels in the substrate.~~

~~3.~~2. The method for TFE of a MEMS device in accordance with claim 1, wherein forming the MEMS device comprising forming one or more etching channels in the MEMS device.

~~4. The method for TFE of a MEMS device in accordance with claim 2, wherein providing the substrate comprises providing a silicon-on-insulator (SOI) substrate comprising a silicon substrate~~

~~layer, an insulator layer and a silicon layer, and wherein forming the MEMS device comprises forming the MEMS device in the silicon layer of the SOI substrate.~~

~~5.~~3. The method for TFE of a MEMS device in accordance with claim 4, wherein providing the one or more cavities below the MEMS device comprises removing the insulator layer below the MEMS device by etching the insulator layer below the MEMS device through the etching channels.

~~6.~~4. The method for TFE of a MEMS device in accordance with claim 4, wherein providing the one or more cavities below the MEMS device comprises providing the SOI substrate having one or more cavities pre-etched in the silicon substrate layer and the insulator layer.

~~7. The method for TFE of a MEMS device in accordance with claim 4, wherein forming the one or more sidewall etching channels comprises partially etching the silicon layer at a periphery of the MEMS device.~~

~~8.~~5. The method for TFE of a MEMS device in accordance with claim 4, further comprising depositing a sacrificial layer over the MEMS device.

~~9.~~6. The method for TFE of a MEMS device in accordance with claim 8, wherein the sacrificial layer is deposited such that it covers the MEMS device, the etching channels adjacent to the MEMS device, and the sidewall etching channels.

~~10.~~7. The method for TFE of a MEMS device in accordance with claim 8, further comprising depositing a cap layer over the sacrificial layer.

~~11.~~8. The method for TFE of a MEMS device in accordance with claim 10, wherein the cap layer is deposited over the sacrificial layer to the extent that one or more exposures of the sacrificial layer are formed.

~~12.~~9. The method for TFE of a MEMS device in accordance with claim 11, wherein forming the one or more cavities above the MEMS device comprising providing one or more etchants to the one or more exposures of the sacrificial layer so as to remove the sacrificial layer.

~~13.~~10. The method for TFE of a MEMS device in accordance with claim 12, wherein the one or more etchants comprise an etch gas selected from a group comprising XeF2, V-HF and Ozone.

~~14.~~11. The method for TFE of a MEMS device in accordance with claim 10, further comprising providing a sealing layer over the cap layer, wherein the sealing layer extends to and sits in part on the silicon layer.

~~15. A thin film encapsulated microelectromechanical system (MEMS) device comprising:~~

~~a MEMS device formed on a substrate;~~

~~one or more cavities formed above and/or below the MEMS device;~~

~~a cap layer formed over the MEMS device; and~~

~~a sealing layer formed over the cap layer;~~

~~wherein one or more etching channels are formed adjacent to the MEMS device and under the cap layer.~~

~~16. The thin film encapsulated MEMS device in accordance with claim 13, wherein the substrate comprises a silicon-on-insulator (SOI) substrate comprising a silicon layer, an insulator layer and a substrate layer.~~

~~17. The thin film encapsulated MEMS device in accordance with claim 15, wherein the one or more etching channels comprise one or more side etching channels formed in the silicon layer of the SOI substrate.~~

~~18. The thin film encapsulated MEMS device in accordance with claim 16, wherein the one or more side etching channels are partially etched in the silicon layer at a periphery of the MEMS device.~~