Claims

1. An engineered substrate structure comprising:

a ceramic substrate having a front surface characterized by a plurality of voids and a root mean square (RMS) roughness in a range of 50-600 nm, the ceramic substrate comprising a polycrystalline material;

a barrier layer encapsulating the ceramic substrate;

a first bonding layer comprising a bonding layer material and coupled to the barrier layer on the front surface of the ceramic substrate, the first bonding layer defining a plurality of fill regions filled with the bonding layer material in spaces of the plurality of voids;

a second bonding layer coupled to the first bonding layer; and

a substantially single crystalline silicon layer joined to the second bonding layer.

2. The engineered substrate structure of claim 1 wherein the ceramic substrate comprises polycrystalline aluminum nitride.

3. The engineered substrate structure of claim 1 wherein the barrier layer comprises silicon nitride.

4. The engineered substrate structure of claim 1 wherein the second bonding layer is characterized by an RMS roughness in a range of 0.5-5 nm.

5. The engineered substrate structure of claim 1 wherein the bonding layer material of the first bonding layer comprises silicon oxide, and the second bonding layer comprises silicon oxide.

6. The engineered substrate structure of claim 5 wherein the second bonding layer has a thickness of between 100 nm and 1,000 nm.

7. The engineered substrate structure of claim 1 wherein the second bonding layer comprises a different material than the bonding layer material of the first bonding layer.

8. The engineered substrate structure of claim 7 wherein the bonding layer material of the first bonding layer comprises silicon oxide, and the second bonding layer comprises diamond-like carbon (DLC).

9. The engineered substrate structure of claim 1 wherein the first bonding layer exposes at least a portion of the barrier layer between adjacent fill regions of the plurality of fill regions.

10. The engineered substrate structure of claim 9 further comprising a second barrier layer encapsulating the first bonding layer and the exposed portion of the barrier layer, wherein the second bonding layer is formed on the second barrier layer.

11. The engineered substrate structure of claim 1 further comprising an epitaxial silicon layer coupled to the substantially single crystalline silicon layer.

12. An engineered substrate structure comprising:

a ceramic substrate having a front surface characterized by a plurality of peaks and a root mean square (RMS) roughness in a range of 50-600 nm, the ceramic substrate comprising a polycrystalline material;

a bonding layer comprising a bonding layer material and coupled to the front surface of the ceramic substrate, the bonding layer defining fill regions filled with the bonding layer material between adjacent peaks of the plurality of peaks on the front surface of the ceramic substrate;

a barrier layer encapsulating the ceramic substrate and the bonding layer; and

a substantially single crystal layer coupled to the barrier layer.

13. The engineered substrate structure of claim 12 further comprising an adhesion promotion layer disposed between the front surface of the ceramic substrate and the bonding layer.

14. The engineered substrate structure of claim 12 wherein the ceramic substrate comprises polycrystalline aluminum nitride.

15. The engineered substrate structure of claim 12 further comprising an electrically conductive layer coupled to at least a portion of the barrier layer.

16. The engineered substrate structure of claim 12 further comprising a thermally conductive layer coupled to at least a portion of the barrier layer.

17. The engineered substrate structure of claim 12 further comprising a second bonding layer coupled to at least a portion of the barrier layer, and the substantially single crystal layer is coupled to the barrier layer through the second bonding layer.

18. The engineered substrate structure of claim 12 further comprising:

an electrically conductive layer coupled to at least a portion of the barrier layer;

a thermally conductive layer coupled to at least a portion of the electrically conductive layer; and

a second bonding layer coupled to at least a portion of the thermally conductive layer.

19. The engineered substrate structure of claim 12, wherein the substantially single crystal layer comprises silicon.