structures can be employed for many applications, e.g., as mechanical actuators, as mechanical couplings, as armor materials for dissipating energy when the oligocrystalline ceramic material is impacted or loaded, and in biomedical devices, as well as a host of other applications.

[0063] It is recognized that those skilled in the art may make various modifications and additions to the embodiments described above without departing from the spirit and scope of the present contribution to the art. Accordingly, it is to be understood that the protection sought to be afforded hereby should be deemed to extend to the subject matter claims and all equivalents thereof fairly within the scope of the invention.

We claim:

1. A mechanical structure comprising:

a crystalline ceramic material that is capable of undergoing a reversible martensitic transformation and forming martensitic domains, during such martensitic transformation, that have an average elongated domain length; and the crystalline ceramic material being configured as an oligocrystalline ceramic material structure having a total structural surface area that is greater than a total grain boundary area in the oligocrystalline ceramic material structure, the oligocrystalline ceramic material structure including an oligocrystalline ceramic structural feature having an extent that is less than the average elongated domain length of the crystalline ceramic material.

2. The mechanical structure of claim 1 wherein the crystalline ceramic material comprises an element selected from the group consisting of zirconium, magnesium, and oxygen.

3. The mechanical structure of claim 2 wherein the crystalline ceramic material comprises ZrO_2.

4. The mechanical structure of claim 3 wherein the crystalline ceramic material comprises ZrO_2 doped with a dopant selected from the group consisting of cerium, yttrium, hafnium, calcium, ytterbium, europium, and magnesium.

5. The mechanical structure of claim 1 wherein the oligocrystalline ceramic material structural feature is less than 100 microns in extent.

6. The mechanical structure of claim 1 wherein the oligocrystalline ceramic material structural feature is less than 50 microns in extent.

7. The mechanical structure of claim 1 wherein the oligocrystalline ceramic material structural feature is no greater than 5 microns in extent.

8. The mechanical structure of claim 1 wherein the crystalline ceramic material is capable of undergoing a reversible martensitic transformation and can be transformed fully to martensite at a temperature that is greater than 20°C.

9. The mechanical structure of claim 1 wherein the crystalline ceramic material structure is capable of undergoing a reversible martensitic transformation that produces a martensitic transformation strain level in the oligocrystalline ceramic material structure that is greater than 1%.

10. The mechanical structure of claim 1 wherein the crystalline ceramic material structure is capable of undergoing a reversible martensitic transformation that produces a martensitic transformation strain level in the oligocrystalline ceramic material structure that is greater than 2%.

11. The mechanical structure of claim 1 wherein the oligocrystalline ceramic material structure is capable of undergoing a reversible martensitic transformation that can dissipate energy during a martensitic transformation with a merit index value, $E^{1/2}(\Delta W/\pi W_{max})$, that is at least about 1.8, where E is Young's modulus for the ceramic material, ΔW is dissipated energy per unit volume of the crystalline ceramic material for one martensitic transformation cycle, and W_{max} is maximum stored mechanical energy per unit volume of the crystalline ceramic material for one martensitic transformation cycle.

12. The mechanical structure of claim 1 wherein the oligocrystalline ceramic material structure comprises a planar geometry selected from the group consisting of plate, layer, film, coating, and free-standing membrane, with a thickness of the planar geometry being the oligocrystalline ceramic material structural feature extent that is less than the crystalline ceramic material average elongated domain length.

13. The mechanical structure of claim 1 wherein the oligocrystalline ceramic material structure comprises a cylindrical geometry selected from the group consisting of pillar, wire, fiber, and wire-like cylindrical object, with a diameter of

the cylindrical geometry being the oligocrystalline ceramic material structural feature extent that is less than the crystalline ceramic material average elongated domain length.

14. The mechanical structure of claim 12 wherein the oligocrystalline ceramic material structure is capable of undergoing a reversible martensitic transformation that can dissipate energy during a martensitic transformation with a merit index value that is at least about 2.5.

15. The mechanical structure of claim 1 wherein the oligocrystalline ceramic material structure comprises a beam geometry selected from the group consisting of cantilever beam and doubly-supported beam, with a thickness of the beam geometry being the oligocrystalline ceramic material structural feature extent that is less than the crystalline ceramic material average elongated domain length.

16. The mechanical structure of claim 1 wherein the oligocrystalline ceramic material structure comprises an open cell foam geometry, with a thickness of an internal foam strut being the oligocrystalline ceramic material structural feature extent that is less than the crystalline ceramic material average elongated domain length.

17. The mechanical structure of claim 1 wherein the oligocrystalline ceramic material structure comprises a tube, with a thickness of a tube wall being the oligocrystalline ceramic material structural feature extent that is less than the crystalline ceramic material average elongated domain length.

18. The mechanical structure of claim 1 wherein the oligocrystalline ceramic material structure is arranged for accepting mechanical input at the oligocrystalline ceramic material structural feature for controlling martensitic transformation of the oligocrystalline ceramic material structure.

19. The mechanical structure of claim 1 wherein the oligocrystalline ceramic material structure is capable of undergoing at least two martensitic transformation

cycles without cracking.

20. The mechanical structure of claim 1 further comprising a mechanical input at the oligocrystalline ceramic material structural feature for cyclical mechanical actuating of the oligocrystalline ceramic material structural feature by martensitic transformation.