Claims

1. A shape memory ceramic structure comprising:

an aggregate population of crystalline particles;

each crystalline particle in the population of crystalline particles comprising a shape memory ceramic particle material and having a crystalline particle extent between about 0.5 microns and about fifty microns; and

at least a portion of the population of crystalline particles having a crystalline structure selected from the group consisting of oligocrystalline and monocrystalline.

2. The shape memory ceramic structure of claim 1 wherein the shape memory ceramic material comprises an element selected from the group consisting of zirconium, cerium, and oxygen.

3. The shape memory ceramic structure of claim 1 wherein the shape memory ceramic material comprises ZrO_2.

4. The shape memory ceramic structure of claim 1 wherein the shape memory ceramic material comprises ZrO_2 doped with at least one dopant selected from the group consisting of Ce, Y, Ca, Mg, Ti, Ge, La, Pb, Nb, Ta, Mn.

5. The shape memory ceramic structure of claim 1 wherein the shape memory ceramic material comprises a shape memory ceramic material selected from the group consisting of Al_2SiO_5, Ca_2SiO_4, Mg_2SiO_4, and $MgSiO_3$.

6. The shape memory ceramic structure of claim 1 wherein each crystalline particle in the population of crystalline particles has a particle geometry selected from the group consisting of solid spherical, hollow

spherical, tabular, equant, polyhedral, and hollow spherical with at least one pore geometries.

7. The shape memory ceramic structure of claim 1 wherein each crystalline particle in the population of crystalline particles has a particle geometry selected from the group consisting of cuboid, cubic, tetragonal, and trapezoidal geometries.

8. The shape memory ceramic structure of claim 1 wherein each crystalline particle in the population of crystalline particles has a particle geometry including a plurality of surface faces, with two of the surface faces being parallel to each other.

9. The shape memory ceramic structure of claim 1 wherein each crystalline particle in the population of crystalline particles has a symmetric polyhedral geometry.

10. The shape memory ceramic structure of claim 1 wherein each crystalline particle in the population of crystalline particles has a crystalline particle extent that is between about 1 micron and about 10 microns.

11. The shape memory ceramic structure of claim 1 wherein each crystalline particle in the population of crystalline particles has a crystalline particle extent that is no more than about 5 microns.

12. The shape memory ceramic structure of claim 1 wherein each crystalline particle in the population of crystalline particles has a spherical geometry with a spherical particle diameter and an oligocrystalline structure having an average grain size, and wherein the spherical particle diameter is no more than about ten times the average grain size.

13. The shape memory ceramic structure of claim 1 wherein each crystalline particle in the population of crystalline particles has an oligocrystalline structure and includes no more than five grains.

14. The shape memory ceramic structure of claim 1 wherein each crystalline particle in the population of crystalline particles has a monocrystalline structure and has an extent that is no more than about 5 microns.

15. The shape memory ceramic structure of claim 1 wherein the population of crystalline particles is arranged as an aggregation of loose particles contained in a vessel.

16. The shape memory ceramic structure of claim 1 wherein the population of crystalline particles is arranged as a coating of crystalline particles on a surface.

17. The shape memory ceramic structure of claim 1 wherein the population of crystalline particles is arranged as a bulk compact comprising the population of crystalline particles and a polymer binder.

18. The shape memory ceramic structure of claim 1 wherein the population of crystalline particles is arranged as a bulk compact comprising the population of crystalline particles, the bulk compact being wrapped in a fabric.

19. The shape memory ceramic structure of claim 1 wherein the population of crystalline particles is arranged as a bulk compact comprising the population of crystalline particles, the bulk compact being coated with a layer of metal.

20. The shape memory ceramic structure of claim 1 wherein the population of crystalline particles is arranged in a bulk composite comprising the population of crystalline particles and a matrix material selected from the group consisting of polymer matrix and metal matrix.

21. The shape memory ceramic structure of claim 20 wherein the bulk composite further comprises fibers selected from the group consisting of carbon fibers, Kevlar fibers, glass fibers, carbon nanotube twisted fibers, and graphene twisted fibers.

22. The shape memory ceramic structure of claim 1 wherein the population of crystalline particles is arranged as a cubic bulk composite.

23. The shape memory ceramic structure of claim 1 wherein the population of crystalline particles is formed by spray drying a slurry including a shape memory ceramic particle powder and a polymer binder.

24. The shape memory ceramic structure of claim 23 wherein the polymer binder comprises polyvinyl alcohol with a molecular weight of about 35,000.

25. The shape memory ceramic structure of claim 23 wherein the spray drying is carried out at an inlet temperature between about 130°C and about 160°C.

26. The shape memory ceramic structure of claim 1 wherein the population of crystalline particles is formed by sintering a mixture of the shape memory ceramic particle material powder and a polymer powder, with a weight percentage of the polymer powder to the shape memory ceramic powder in the mixture being between about 1wt% and about 15wt%.

27. The shape memory ceramic structure of claim 26 wherein the polymer powder comprises a powder of a polymer containing six-membered aromatic rings.

28. The shape memory ceramic structure of claim 26 wherein sintering comprises heating the mixture at a sintering temperature between about 1000°C and about 1600°C.

29. The shape memory ceramic structure of claim 28 wherein sintering comprises ramping temperature of the mixture to the sintering temperature at a ramp rate of at least about 5°C/min.