CLAIMS

1. An article, comprising:

a selected surface having: a first plurality of a first-tier nanostructure; and a second plurality of a second-tier nanostructure,

wherein the first-tier nanostructure includes:

a cell wall, the cell wall being columnar; and

a core, the core being surrounded by the cell wall and recessed inwardly to define a stepped surface relative to a general plane of the selected surface, the stepped surface and the cell wall defining a cell cavity with a cell opening at the selected surface, the cell opening having a cell diameter,

and wherein the second plurality of a second-tier nanostructure is disposed on at least the cell wall of the first-tier nanostructure, the second plurality of the second-tier nanostructure extending into the cell cavity such that the cell cavity includes a plurality of sub-cavities, the plurality of sub-cavities being characterized by nanoscale dimensions smaller than the cell diameter,

and wherein the core is predominantly formed of a first phase of an additively formed aluminum alloy, and wherein the cell wall is predominantly formed of a second phase of the additively formed aluminum alloy, wherein the second-tier nanostructure is composed of boehmite.

2. The article according to claim 1, wherein the cell opening is in fluidic communication with the plurality of sub-cavities.

3. The article according to claim 1 or claim 2, wherein the selected surface comprises a network of a plurality of the cell opening, and wherein adjacent ones of the plurality of the cell opening are separated by contiguous ones of a plurality of the cell wall.

4. The article according to any one of claims 1 to 3, wherein the first phase of the additively formed aluminum alloy is more reactive in an etchant than the second phase of the additively formed aluminum alloy in the etchant.

5. The article according to any one of claims 1 to 4, wherein the additively formed aluminum alloy is formed from a powder of AlSi10Mg, and wherein the second phase of the additively formed aluminum alloy has a higher silicon content relative to the first phase of the additively formed aluminum alloy.

6. The article according to any one of claims 1 to 5, wherein the second-tier nanostructure comprises an oxide of the additively formed aluminum alloy.

7. The article according to any one of claims 1 to 5, wherein the second plurality of the second-tier nanostructure comprises the second phase of the additively formed aluminum alloy.

8. The article according to claim 7, wherein the second-tier nanostructure is monolithic with the cell wall of at least one of the first plurality of the first-tier nanostructure.

9. The article according to any one of claims 1 to 8, wherein the selected surface is characterized by a surface property resulting from a functionalization of at least the second plurality of the second-tier nanostructure.

10. The article according to any one of claims 1 to 9, the article comprising a heat exchanger having: a coolant flow channel; and an external surface of the coolant flow channel, wherein at least a part of the external surface is configured as the selected surface.

11. A method, comprising:

etching a selected surface of an article using an etchant to form a first plurality of a first-tier nanostructure, wherein the first-tier nanostructure includes:

a cell wall, the cell wall being columnar; and

a core, the core being surrounded by the cell wall and recessed inwardly to define a stepped surface relative to a general plane of the selected surface, the stepped surface and the cell wall defining a cell cavity with a cell opening at the selected surface, the cell opening having a cell diameter; and

forming a second plurality of a second-tier nanostructure on at least the cell wall of the first-tier nanostructure, the second plurality of the second-tier nanostructure extending into the cell cavity such that the cell cavity includes a plurality of sub-cavities, the plurality of sub-cavities being characterized by nanoscale dimensions smaller than the cell diameter,

wherein the core is predominantly formed of a first phase of an additively formed aluminum alloy, and wherein the cell wall is predominantly formed of a second phase of the additively formed aluminum alloy, wherein the forming of the second plurality of the second-tier nanostructure comprises boehmitizing the selected surface after the etching.

12. The method according to claim 11, wherein the etching comprises a preferential etching of the first phase of the additively formed aluminum alloy over the second phase of the additively formed aluminum alloy.

13. The method according to claim 11 or claim 12, wherein the etching comprises a preferential etching of the core over the cell wall, forming a network of a plurality of the cell opening, and wherein adjacent ones of the plurality of the cell opening are separated by contiguous ones of a plurality of the cell wall.

14. The method according to any one of claims 11 to 13, wherein the forming of the second plurality of the second-tier nanostructure comprises a self-limiting formation of the second plurality of the second-tier nanostructure.

15. The article according to any one of claims 11 to 14, wherein the second-tier nanostructure is monolithic with the cell wall of at least one of the first plurality of the first-tier nanostructure.

16. The method according to claim 14, wherein the forming of the second plurality of the second-tier nanostructure comprises heat treatment of the selected surface before the etching.

17. The article according to any one of claims 11 to 16, wherein the second plurality of the second-tier nanostructure comprises the second phase of the additively formed aluminum alloy.

18. The method according to claim 11, wherein the second-tier nanostructure is composed of boehmite.

19. The method according to any one of claims 11 to 18, wherein the additively formed aluminum alloy is formed from a powder of AlSi10Mg, and wherein the second phase of the additively formed aluminum alloy has a higher silicon content relative to the first phase of the additively formed aluminum alloy.

20. The method according to any one of claims 11 to 19, further comprising functionalizing the selected surface, the selected surface being characterized by a surface property resulting from a functionalization of at least the second plurality of the second-tier nanostructure.

21. The method according to claim 20, wherein the functionalizing comprises silanizing the selected surface.

22. An article, comprising:

a selected surface having: a first plurality of a first-tier nanostructure; and a second plurality of a second-tier nanostructure,

wherein the first-tier nanostructure includes:

a cell wall, the cell wall being columnar; and

a core, the core being surrounded by the cell wall and recessed inwardly to define a stepped surface relative to a general plane of the selected surface, the stepped surface and the cell wall defining a cell cavity with a cell opening at the selected surface, the cell opening having a cell diameter,

and wherein the second plurality of a second-tier nanostructure is disposed on at least the cell wall of the first-tier nanostructure, the second plurality of the second-tier nanostructure extending into the cell cavity such that the cell cavity includes a

plurality of sub-cavities, the plurality of sub-cavities being characterized by nanoscale dimensions smaller than the cell diameter,

and wherein the core is predominantly formed of a first phase of an additively formed aluminum alloy, and wherein the cell wall is predominantly formed of a second phase of the additively formed aluminum alloy,

and wherein the article comprises a heat exchanger having:

a coolant flow channel; and

an external surface of the coolant flow channel, wherein at least a part of the external surface is configured as the selected surface.

23. A method, comprising:

etching a selected surface of an article using an etchant to form a first plurality of a first-tier nanostructure, wherein the first-tier nanostructure includes:

a cell wall, the cell wall being columnar; and

a core, the core being surrounded by the cell wall and recessed inwardly to define a stepped surface relative to a general plane of the selected surface, the stepped surface and the cell wall defining a cell cavity with a cell opening at the selected surface, the cell opening having a cell diameter; and

forming a second plurality of a second-tier nanostructure on at least the cell wall of the first-tier nanostructure, the second plurality of the second-tier nanostructure extending into the cell cavity such that the cell cavity includes a plurality of sub-cavities, the plurality of sub-cavities being characterized by nanoscale dimensions smaller than the cell diameter,

wherein the core is predominantly formed of a first phase of an additively formed aluminum alloy, and wherein the cell wall is predominantly formed of a second phase of the additively formed aluminum alloy,

and wherein the forming of the second plurality of the second-tier nanostructure comprises a self-limiting formation of the second plurality of the second-tier nanostructure,

and wherein the forming of the second plurality of the second-tier nanostructure comprises heat treatment of the selected surface before the etching.