Deposited Thin Film Void-Column Network Materials

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Abstract:
A novel porous film is disclosed comprising a network of silicon columns in a continuous void which may be fabricated using high density plasma deposition at low temperatures, i.e., less than about 250[degree(s)] C. This silicon film is a two-dimensional nano-sized array of rodlike columns. This void-column morphology can be controlled with deposition conditions and the porosity can be varied up to 90%. The simultaneous use of low temperature deposition and etching in the plasma approach utilized, allows for the unique opportunity of obtaining columnar structure, a continuous void, and polycrystalline column composition at the same time. Unique devices may be fabricated using this porous continuous film by plasma deposition of this film on a glass, metal foil, insulator or plastic substrates.

What is claimed is:

1. A nano-scale composition comprising:
   a) a plurality of polycrystalline or amorphous rod-like structure units penetrating a continuous void, and
   b) a substrate to which said plurality of rod-like structure units are uniformly orientated and adhered. (Main Claim)
2. A composition according to claim 1 wherein said composition is deposited.
3. A composition according to claim 2 wherein said composition is formed by means comprising vapor deposition.
4. A composition according to claim 3 wherein said deposited composition is formed by means comprising use of a high-density plasma.
5. A composition according to claim 2 wherein said means of deposition controls the spacing, height, and/or diameter of said basic structure units.
6. A composition according to claim 2 wherein said continuous void comprises up to 90% of its volume7. A composition according to claim 2 wherein said basic structure units have a diameter from 1 to 100 nm.
8. A composition according to claim 2 wherein said composition has a thickness greater than 10 nm.
9. A composition according to claim 2 wherein said basic structure units are agglomerated in adjustably sized columnar-like clusters penetrating a continuous void and adhering to said substrate.
10. A composition according to claim 2 wherein said basic structure units are comprised of silicon, germanium, carbon, hydrogen, other inorganics, or mixture thereof.
11. A composition according to claim 2 wherein said substrate comprises semiconductors, glasses, plastics, polymers, metals, ceramics, insulators, or mixtures thereof.
12. A composition according to claim 11 wherein said substrate is a semiconductor.
13. A composition according to claim 11 wherein said substrate is glass.
14. A composition according to claim 11 wherein said substrate is

plastic.

15. A composition according to claim 11 wherein said substrate is a metal.
16. A composition according to claim 2 wherein said continuous void contains solid or liquid material, atoms, molecules, or mixtures thereof.
17. A composition according to claim 16 wherein said void contains organic or inorganic material or mixtures thereof.
18. A composition according to claim 17 wherein material or mixture thereof is selected from the group of molecules, polymers, electrolytes, solutions, metals, metal alloys, semiconductors, doped insulators, dielectrics, and carbon forms.
19. A composition according to claim 2 wherein said continuous void is capable of adsorbing solid or liquid material, atoms, molecules, or mixtures thereof.
20. A composition according to claim 19 wherein said void is capable of adsorbing organic or inorganic material or mixtures thereof.
21. A composition according to claim 19 wherein material or mixture thereof is selected from the group of molecules, polymers, electrolytes, solutions, metals, metal alloys, semiconductors, doped insulators, dielectrics, and carbon forms.
22. A composition according to claim 18 wherein said composition has photovoltaic properties.
23. A composition according to claim 18 wherein said composition has light emission properties.
24. A composition according to claim 18 wherein said composition has controllable light transmitting properties.
25. A composition according to claim 18 wherein said composition has tailorable chemical properties.
26. A composition according to claim 21 wherein said composition has photovoltaic properties.
27. A composition according to claim 21 wherein said composition has light emission properties.
28. A composition according to claim 21 wherein said composition has controllable light transmitting properties.
29. A composition according to claim 21 wherein said composition has tailorable chemical properties.
30. A composition according to claim 2 for use in a device selected from the group consisting of: microfluidic devices; fuel cells ; sorting structures; gas/vapor sensors; mass spectroscopy/laser desorption; micro-electro-mechanical devices; thermal/dielelectric isolation; analytical devices; airgap devices; separation layers; sacrificial layers, chemical delivery, chromatography, or combinations thereof.
31. A composite structure which comprises:
a substrate; anda porous film comprising a plurality of polycrystalline or amorphous rod-like units extending therefrom into a void having a porosity of up to 90%.
32. The composite structure of claim 31, further comprising a substrate coating layer such that said porous film is disposed on said substrate coating layer.
33. The composite structure of claim 32, wherein said substrate coating layer is at least one coating material selected from the group consisting of: insulators, nitrides, and oxides.
34. The composite structure of claim 32, wherein said coating layer is at least one active material selected from the group consisting of: piezoelectrics, ferroelectrics, metals, and semiconductors.

35. The composite structure of claim 31, further comprising a capping layer, such that said porous film is disposed between said capping layer and said substrate.
36. The composite structure of claim 35, wherein said capping layer is at least one insulation material selected from the group consisting of: insulators, nitrides, and oxides.
37. The composite structure of claim 35, wherein said capping layer is at least one active material selected from the group consisting of: piezoelectrics, ferroelectrics, metals, and semiconductors.
38. The composite structure of claim 35, wherein said porous film has a thickness greater than about 10 nm.
39. The composite structure of claim 31 wherein said rodlike perturbations have a diameter of between about 1 to 50 nm.
40. The composite structure of claim 39, wherein said rodlike perturbations are found in clusters with a diameter between about 50 to 500nm.
41. The composite structure of claim 31, wherein said substrate is selected from the group consisting of: glass, metal foil, insulation material, plastic material, and semiconductor-containing material.
42. A sensor which comprises a composite structure having:
a substrate; and
a porous film comprising a plurality of polycrystalline or amorphous rod-like units extending therefrom into a void having a porosity of up to 90%.
43. The sensor of claim 42, wherein said sensor is capable of monitoring lateral resistivity, optical, or dielectric response.
44. A gas detector which comprises a composite structure having:
a substrate; and
a porous film comprising a plurality of polycrystalline or amorphous rod-like units extending therefrom into a void having a porosity of up to 90%.
45. An analytical device which comprises a composite structure having:
a substrate; and
a porous film comprising a plurality of polycrystalline or amorphous rod-like units extending therefrom into a void having a porosity of up to 90%.
46. The analytical device of claim 45, wherein said device is capable of desorption mass spectroscopy.
47. A composition according to claim 1 wherein each said unit has a diameter that is essentially uniform with height.
48. A composition according to claim 1, wherein said units have regular spacing and uniform height.
49. A composition according to claim 1, wherein said structure units have a diameter between 1 and 50 nm.
50. A composition according to claim 1, wherein said structure units are in a two-dimensional periodic array.
51. A composition according to claim 1 wherein said composition is formed by means comprising use of a highly reactive or dense plasma system.
52. A composition according to claim 4, wherein said high density plasma is selected from the group consisting of: electron cyclotron resonance plasma enhanced chemical vapor deposition; helicon plasma; helical resonator; inductively coupled plasma; transformer coupled plasma; electron beam plasma; and any combinations thereof.
53. The composite structure according to claim 31, wherein said film is disposed on said substrate by deposition at a temperature of less than 250[degree(s)] C.