CLAIMS

What is claimed is:

1. A sulfur-doped nanoporous carbon material comprising a pore structure, the pore structure comprising a fibrillar morphology and an array of pores that surround elemental sulfur.

2. A sulfur-doped nanoporous carbon material comprising:

    a pore structure comprising a fibrillar morphology;

    a Young modulus of at least about 0.2 GPa; and

    a density between about 0.10 g/cc and about 1.5 g/cc.

3. A nanoporous carbon material doped with sulfur comprising:

    a pore structure comprising a fibrillar morphology;

    an electrical conductivity of at least about 1 S/cm; and

    a density between about 0.10 g/cc and about 1.5 g/cc.

4. The nanoporous carbon material of claim 1 and/or claim 2, wherein the carbon material has an electrical conductivity of at least about 1 S/cm.

5. The nanoporous carbon material of claim 1 and/or claim 3, wherein the carbon material has a Young modulus of at least about 0.2 GPa.

6. The nanoporous carbon material of one or more of claims 1 to 3, wherein the nanoporous carbon material comprises a carbon aerogel.

7. The nanoporous carbon material of one or more of claims 1 to 3, wherein the pore structure is characterized by pores surrounding the sulfur.

8. The nanoporous carbon material of claim 7, wherein the pores form interconnected structures around the sulfur, characterized by a plurality of connection points between the sulfur and pore walls of each pore in which the sulfur is surrounded.

9. The nanoporous carbon material of one or more of claims 1-3, wherein the carbon material is doped with about 5%-90% of sulfur by weight of the carbon material.

10. The nanoporous carbon material of one or more of claims 1-3, wherein the carbon material has a pore volume of at least 0.3 cc/g.

11. The nanoporous carbon material of one or more of claims 1-3, wherein the pore structure comprises a full width at half max of about 50 nm or less.

12. The nanoporous carbon material of one or more of claims 1-3, wherein the pore structure comprises a pore size at max peak from distribution of about 100 nm or less.

13. The nanoporous carbon material of one or more of claims 1-3, wherein the fibrillar morphology of the nanoporous carbon material includes an average strut width of about 2-10 nm.

14. A sulfur-containing, monolithic polyimide-derived carbon aerogel composite formed of a nanoporous carbon material, wherein the composite is free of binders and wherein elemental sulfur is surrounded within pores of the monolithic polyimide-derived carbon aerogel composite.

15. A collector-less, binder-less, interconnected cathode material for a lithium-sulfur battery comprising an open-cell, monolithic, polyimide-derived nanoporous carbon aerogel having a fibrillar network and an array of pores; and elemental sulfur surrounded by the array of pores.

16. A method of forming a continuous porous carbon sulfur composite, the method comprising:

providing a polyimide precursor;
imidizing the polyimide precursor chemically or thermally;
drying the imidized mixture to yield a continuous porous polyimide;
pyrolyzing the porous polyimide to yield a continuous porous carbon; and
incorporating sulfur onto or into the continuous porous carbon to yield the continuous porous sulfur composite that is greater than 0% and less than about 95% by weight sulfur and with a porosity between about 10% and about 90%.

17. The method of claim 16, wherein the porous carbon sulfur composite is a monolith.

18. The method of claim 16, wherein the porous carbon sulfur composite is a freestanding structure.

19. The method of claim 16, wherein the porous carbon sulfur composite is prepared on a substrate.

20. The method of one or more of claims 16-19, wherein the porous carbon sulfur composite is reinforced with a non-woven material.

21. The method of one or more of claims 16-19, wherein the porous carbon sulfur composite is reinforced with a woven material.

22. The method of claim 16, wherein the composite comprises an aerogel.

23. The method of claim 16, wherein the maximum pyrolysis temperature is between about 750°C and about 1600°C.

24. The method of claim 16, wherein the sulfur is incorporated onto or into the continuous porous carbon by melt infusion.

25. The method of claim 16, wherein the sulfur is incorporated onto or into the continuous porous carbon by surface treating the continuous porous carbon with chemical functional groups having an affinity for sulfur and polysulfides.