CLAIMS

What is claimed is:

1. A graphene-based electrode, comprising:

a ferroelectric polymer; and

a graphene substrate, wherein the graphene substrate is coated with the ferroelectric polymer, wherein the graphene substrate is a graphene foam or a combination of a graphene foam and one or more of a graphene sheet, activated reduced graphene oxide, and a graphene composite, in which the graphene foam is a three-dimensional crystalline foam containing a group IV-B element and graphene formed from a carbon source, wherein the carbon source is carbon black, amorphous carbon, single-wall carbon nanotube, multi-wall nanotube, graphene oxide, graphite powder, or a combination thereof; the group IV-B element is silicon, germanium, tin, lead, or a combination thereof; and the three-dimensional crystalline foam is formed from a three-dimensional metal foam framework having a surface area of at least 500 m^2/g.

2. The graphene-based electrode of claim 1, wherein the graphene sheet is single-layer graphene or multi-layer graphene.

3. The graphene-based electrode of claim 1, wherein the graphene composite comprises a graphene foam and a carbon nanotube.

4. The graphene-based electrode of claim 1, wherein the ferroelectric polymer is a polymer or copolymer comprising vinylidene fluoride, trifluoroethylene, chlorotrifluoroethylene, tetrafluoroethylene, hexafluoropropylene, 1,1-chlorofluoroethylene, or a combination thereof.

5. The graphene-based electrode of claim 1, wherein the ferroelectric polymer is a blend comprising a ferroelectric polymer and a polar polymer.

6. The graphene-based electrode of claim 5, wherein the polar polymer is poly(methyl methacrylate), polyvinyl alcohol, poly(ethylene oxide), polyvinyl chloride, polyacrylonitrile, poly(ethyl methacrylate), or a combination thereof.

7. The graphene-based electrode of claim 1, wherein the ferroelectric polymer further comprises an electrolyte.

8. The graphene-based electrode of claim 1, wherein the graphene substrate is made by chemical vapor deposition (CVD) on a metal template.

9. The graphene-based electrode of claim 8, wherein the graphene substrate is coated with the ferroelectric polymer before the metal template is removed.

10. The graphene-based electrode of claim 1, wherein the graphene foam contains single-layer or multi-layer graphene.

11. The graphene-based electrode of claim 1, wherein the graphene composite is one of a polymer-graphene composite, a metal-graphene composite, a graphene-based composite, and a ceramic-based composite, or a combination thereof.

12. A supercapacitor for improved charge and energy storage, comprising:

a first graphene-based electrode containing a first graphene substrate and a first and a second surface, the first surface in contact with a first surface of a porous separator;

a second graphene-based electrode containing a second graphene substrate and a first and a second surface, the first surface in contact with a second surface of the porous separator;

wherein at least one of the first and the second graphene substrates is coated with a ferroelectric polymer;

a first metal electrode making contact with the second surface of the first graphene-based electrode; and

a second metal electrode making contact with the second surface of the second graphene-based electrode,

wherein the first graphene substrate and the second graphene substrate are the same graphene substrate or different graphene substrates, in which each graphene substrate is a graphene foam or a combination of a graphene foam and one or more of a graphene sheet, activated reduced graphene oxide, and a graphene composite; and each graphene substrate is a three-dimensional crystalline foam that contains a group IV-B element

and graphene formed from a carbon source, wherein the carbon source is carbon black, amorphous carbon, single-wall carbon nanotube, multi-wall nanotube, graphene oxide, graphite powder, or a combination thereof; the group IV-B element is silicon, germanium, tin, lead, or a combination thereof; and the three-dimensional crystalline foam is formed from a three-dimensional metal foam framework having a surface area of at least 500 m^2/g.

13. The supercapacitor of claim 12, wherein the ferroelectric polymer is a polymer or copolymer comprising polyvinylidene fluoride, trifluoroethylene, chlorotrifluoroethylene, tetrafluoroethylene, hexafluoropropylene, 1,1-chlorofluoroethylene, or a combination thereof.

14. The supercapacitor of claim 13, wherein the ferroelectric polymer is a blend comprising a ferroelectric polymer and a polar polymer.

15. The supercapacitor of claim 14, wherein the polar polymer is poly(methyl methacrylate), polyvinyl alcohol, poly(ethylene oxide), polyvinyl chloride, polyacrylonitrile, poly(ethyl methacrylate), or a combination thereof.

16. The supercapacitor of claim 13, wherein the ferroelectric polymer further comprises an electrolyte.

17. A method of making a supercapacitor of claim 12 for improved charge and energy storage, the method comprising:

a) preparing a first and a second graphene substrate for a first and a second graphene-based electrode, respectively, wherein each graphene substrate is a graphene foam or a combination of the graphene foam and one or more of a graphene sheet, activated reduced graphene oxide, and a graphene composite, and wherein each graphene-based electrode includes a first and a second surface;

b) coating throughout at least one of the first and the second graphene substrates with a ferroelectric polymer;

c) contacting the first surface of the first graphene-based electrode with a first surface of a porous separator;

d) contacting the first surface of the second graphene-based electrode with a second surface of the porous separator;

e) contacting a first metal electrode with the second surface of the first graphene-based electrode; and

f) contacting a second metal electrode with the second surface of the second graphene-based electrode,

whereby the supercapacitor is obtained.

18. The method of claim 17, wherein the graphene foam is prepared by:

mixing a carbon source and a skelet powder to obtain a uniform mixture,

applying pressure to the uniform mixture thus obtained to form a closed packed structure,

heating and applying pressure to the closed packed structure to form a graphene sheet layered around the skelet powder, and

dissolving the skelet powder in the closed packed structure in a chemical bath and removing the dissolved powder therefrom, thereby producing voids,

whereby the graphene foam is obtained.

19. The method of claim 18, wherein the carbon source is coated on a group IV-B element.

20. The method of claim 17, wherein the graphene composite contains the graphene foam and a carbon nanotube.