In a third example, a composition can include hydrogenated graphite comprising a plurality of flakes. The flakes can have at least one flake in 10 having a size in excess of 10 square micrometers, an average thickness of 10 atomic layers or less, and a defect density characteristic of μ-Raman spectra of the hydrogenated graphite collected at 532 nm excitation with a resolution better than 1.8 reciprocal centimeters and an excitation power below 2 mW at the focus of an 100X objective having an average D/G area ratio being between 0.2 and 4, wherein the majority of the defects are reversible hydrogenation of sp3-hybridized carbon sites away from the edges of the flakes. In one aspect, the present disclosure refers to an electrode comprising a composition, the composition comprising: hydrogenated graphite comprising a plurality of flakes having at least one flake in 10 having a size in excess of 10 square micrometers, an average thickness of 10 atomic layers or less, and a defect density characteristic of μ-Raman spectra of the hydrogenated graphite collected at 532 nm excitation with a resolution better than 1.8 reciprocal centimeters and an excitation power below 2 mW at the focus of an 100X objective having an average D/G area ratio being between 0.2 and 4, wherein the majority of the defects are reversible hydrogenation of sp3-hybridized carbon sites away from the edges of the flakes, wherein the composition is a composite and at least 5%, for example, at least 10%, of sp3 hybridized carbon sites of the composition are one or more of: a) functionalized with a non-hydrogen chemical group, b) cross-linked with sp3 hybridized carbon sites of another flakes, or c) otherwise chemically modified.

In a third example, a composition can include a reversibly hydrogenated graphite comprising a plurality of flakes having at least one flake in 10 having a size in excess of 10 square micrometers, a coefficient of determination value of 2D single peak fitting of μ-Raman spectra of the graphite after thermal treatment in inert atmosphere at 2 mbar and 800 °C, collected at 532 nm excitation with a resolution better than 1.8 reciprocal centimeters, of larger than 0.99 for more than 50 % of the spectra, and a defect density characteristic of μ-Raman spectra of the hydrogenated graphite collected at 532 nm excitation with a resolution better than 1.8 reciprocal centimeters and an excitation power below 2 mW at the focus of an 100X objective having an average D/G area ratio being between 0.2 and 4. The majority of the defects are reversible hydrogenation of sp3-hybridized carbon sites away from the edges of the flakes. In one aspect, the present disclosure refers to an electrode comprising a composition comprising: a reversibly hydrogenated graphite comprising a plurality of flakes having at least one flake in 10 having a size in excess of 10 square micrometers, a coefficient of determination value of 2D single peak fitting of μ-Raman spectra of the graphite after thermal treatment in inert atmosphere at 2 mbar and 800 °C, collected at 532 nm excitation with a resolution better than 1.8 reciprocal centimeters, of larger than 0.99 for more than 50 % of the spectra, and a defect density characteristic of μ-Raman spectra of the hydrogenated graphite collected at 532 nm excitation with a resolution better than 1.8 reciprocal centimeters and an excitation power below 2 mW at the focus of an 100X objective having an average D/G area ratio being between 0.2 and 4, wherein the majority of the defects are reversible hydrogenation of sp3-hybridized carbon sites away from the edges of the flakes, wherein the composition is a composite and at least 5%, for example, at least 10%, of sp3 hybridized carbon sites of the composition are one or more of: a) functionalized with a non-hydrogen chemical group, b) cross-linked with sp3 hybridized carbon sites of another flakes, or c) otherwise chemically modified.

The third example and the fourth example can include one or more of the following features. More than 60%, for example, more than 80%, or more than 85 % of μ-Raman spectra of the graphite can have the coefficient of determination value larger than 0.99. More than 40%, for example, more than 50% or more than 65 % of the μ-Raman spectra of the graphite can have the coefficient of determination value larger than 0.995. At least one flake in six can have a size in excess of 10 square micrometers, for example, at least one flake in four. At least one flake in ten can have a size in excess of 25 square

WHAT IS CLAIMED IS:

1. An electrode comprising a composition, the composition comprising:

hydrogenated graphite comprising a plurality of flakes having

at least one flake in 10 having a size in excess of 10 square micrometers,

an average thickness of 10 atomic layers or less, and

a defect density characteristic of μ-Raman spectra of the hydrogenated graphite collected at 532 nm excitation with a resolution better than 1.8 reciprocal centimeters and an excitation power below 2 mW at the focus of an 100X objective having an average D/G area ratio being between 0.2 and 4, wherein the majority of the defects are reversible hydrogenation of sp3-hybridized carbon sites away from the edges of the flakes, wherein the composition is a composite and at least 5%, for example, at least 10%, of sp3 hybridized carbon sites of the composition are one or more of:

a) functionalized with a non-hydrogen chemical group,

b) cross-linked with sp3 hybridized carbon sites of another flakes, or

c) otherwise chemically modified.

2. An electrode comprising a composition comprising:

a reversibly hydrogenated graphite comprising a plurality of flakes having

at least one flake in 10 having a size in excess of 10 square micrometers,

a coefficient of determination value of 2D single peak fitting of μ-Raman spectra of the graphite after thermal treatment in inert atmosphere at 2 mbar and 800 °C, collected at 532 nm excitation with a resolution better than 1.8 reciprocal centimeters, of larger than 0.99 for more than 50 % of the spectra, and

a defect density characteristic of μ-Raman spectra of the hydrogenated graphite collected at 532 nm excitation with a resolution better than 1.8 reciprocal centimeters and an excitation power below 2 mW at the focus of an 100X objective having an average D/G area ratio being between 0.2 and 4, wherein the majority of the

defects are reversible hydrogenation of sp3-hybridized carbon sites away from the edges of the flakes, wherein the composition is a composite and at least 5%, for example, at least 10%, of sp3 hybridized carbon sites of the composition are one or more of:

a) functionalized with a non-hydrogen chemical group,

b) cross-linked with sp3 hybridized carbon sites of another flakes, or

c) otherwise chemically modified.

3. The electrode of either claim 1 or 2, wherein more than 60%, for example, more than 80%, or more than 85 % of μ-Raman spectra of the graphite have the coefficient of determination value larger than 0.99.

4. The electrode of any one of claims 1 to 3, wherein more than 40%, for example, more than 50% or more than 65 % of the μ-Raman spectra of the graphite have the coefficient of determination value larger than 0.995.

5. The electrode of claim 1 to 4, wherein at least one flake in six has a size in excess of 10 square micrometers, for example, at least one flake in four.

6. The electrode of any of claims 1 to 5, wherein at least one flake in ten has a size in excess of 25 square micrometers, for example, at least two flakes in ten.

7. The electrode of any of claims 1 to 6, wherein the average thickness is seven atomic layers or less, for example, five atomic layers or less.

8. The electrode of any of claims 1 to 7, wherein the defect density is characteristic of at least 50% of the μ-Raman spectra collected at 532 nm excitation with a resolution better than 1.8 reciprocal centimeters and an excitation power below 2 mW at the focus of an 100X objective having a D/G area ratio above 0.5, for example, at least 80% or at least 95% of the collected spectra having a D/G area ratio above 0.5.

9. The electrode of any of claims 1 to 8, wherein the defect density is characteristic of at least 50% of the collected spectra having a D/G area ratio above 0.8,

for example, at least 60% or at least 90% of the collected spectra having a D/G area ratio above 0.8.

10. The electrode of any of claims 1 to 9, wherein the defect density is characteristic of the average D/G area ratio being between 0.4 and 2, for example, between being 0.8 and 1.5.

11. The electrode of any of claims 1 to 10, wherein at least 60%, for example, at least 75% of the defects are reversible hydrogenation of sp3-hybridized carbon sites away from the edges of the flakes.

12. A battery or an electrochemical capacitor comprising the electrode of any one of claims 1 to 11, for example, wherein the battery is a lithium battery, a lithium-ion battery, a silicon anode battery, or a lithium sulfur battery.

13. A method comprising:

expanding graphite to graphene, wherein graphite particles and at least one electrolyte are introduced into at least one container and the graphite, through the application of an electrical voltage to at least one anode and at least one cathode is expanded,

wherein the cathode contains or consists of diamond and hydrogen is produced at the cathode; and

thermally treating the graphene to yield a dried hydrogenated graphite material.

14. Method according to claim 13, characterized in that hydrogen is intercalated in the graphite particles and/or chemisorbed on the graphite particles, so that graphene flakes are exfoliated from the graphite particles.

15. Method according to any one of claims 13 or 14, characterized in that the anode is separated from the cathode by a separator.

16. Method according to claim 15, characterized in that the separator contains or consists of diamond and/or polytetrafluoroethylene and/or Al2O3 and/or ceramic and/or quartz and/or glass.

17. Method according to one of claims 13 to 16, characterized in that the separator is shifted so that the distance between the cathode and the separator changes during operation of the apparatus.

18. Method according to any one of claims 13 to 17, characterized in that an electrical voltage from 12 V to 45 V, or an electric voltage from 15 V to 30 V is applied between the anode and cathode.

19. Method according to any one of claims 13 to 18, characterized in that graphite particles are supplied continuously to the container and/or that graphene flakes are removed continuously from the container.

20. Method according to any one of claims 13 to 19, further comprising photo-treating the graphene flakes for dehydrogenation, for example, wherein the photo-treating including illuminating the graphene flakes with visible light, UV, or microwaves, wherein more that 50% of hydrogenated sp3 hybridized carbon sites are de-hydrogenated.

21. Method according to any one of claims 13 to 20, further comprising subsequently thermally treating the graphene flakes at a temperature from 300°C to 650°C, and for a period of from 15 min to 40 min.

22. Method according to one of claims 13 to 21, characterized in that the graphene flakes have an average surface area of more than 50 µm2 or of more than 100 µm2.

23. Method according to one of claims 13 to 22, further comprising subjecting the dried hydrogenated graphite material to a dehydrogenating thermal treatment that yields a dry dehydrogenated graphite material.