CLAIMS

What is claimed is:

1. An electrochromic device, the device comprising:

at least one electrode including graphene and at least one ferroelectric material; and

an electrochromic active layer, the electrochromic active layer configured to vary between an opaque and transparent state via the application of an electric field between two electrodes comprising the at least one electrode that includes graphene and at least one ferroelectric material;

the at least one ferroelectric material of the at least one electrode being configured to apply a nonvolatile electric field across the electrochromic active layer such that the electrochromic device is configured to remain transparent with no external power source.

2. The electrochromic device of Claim 1, wherein the at least one electrode comprises two electrodes, each of the two electrodes including graphene and at least one ferroelectric material.

3. The electrochromic device of Claim 1, wherein the at least one electrode comprises at least one ferroelectric material layer located between a first layer of graphene and a second layer of graphene.

4. The electrochromic device of Claim 1, wherein the at least one electrode comprises two electrodes, a first electrode of the two electrodes including graphene and at least one ferroelectric material, and a second electrode of the two electrodes comprising only graphene.

5. The electrochromic device of Claim 1, wherein the electrochromic active layer comprises a liquid crystal material.

6. The electrochromic device of Claim 5, wherein the electrochromic active layer comprises the liquid crystal material dispersed in a polymer.

7. The electrochromic device of Claim 1, wherein the electrochromic active layer comprises a suspending polymer material.

8. The electrochromic device of Claim 1, wherein the ferroelectric material comprises a ferroelectric polymer.

9. The electrochromic device of Claim 8, wherein the ferroelectric material comprises at least one of a fluoropolymer ferroelectric material and a co-fluoropolymer ferroelectric material.

10. The electrochromic device of Claim 1, wherein the ferroelectric material comprises lead zirconate titanate.

11. The electrochromic device of Claim 1, wherein the electrochromic device is configured to permit recovery of energy stored in alignment of ferroelectric dipoles within the ferroelectric material.

12. The electrochromic device of Claim 1, wherein the graphene of the at least one electrode comprises a material selected from the group consisting of: monolayer graphene; bi-layer graphene; multilayer graphene; an interconnected graphene-based mesh network; and a graphene composite.

13. The electrochromic device of Claim 1, further comprising a substrate.

14. The electrochromic device of Claim 13, wherein the substrate comprises a flexible substrate.

15. The electrochromic device of Claim 1, wherein the device is flexible.

16. The electrochromic device of Claim 13, wherein the substrate comprises at least one of an air gap and a thermal insulator between at least two layers of the substrate.

17. The electrochromic device of Claim 1, wherein the electrochromic active layer comprises at least one dye molecule.

18. The electrochromic device of Claim 13, wherein the device comprises only one substrate, and wherein a surface of the device comprises graphene.

19. The electrochromic device of Claim 13, wherein the device comprises two substrates.