CLAIMS

We claim:

1. A method of supplying energy from an energy storage device to a load, comprising:

providing a circuit including a first energy storage device charged to a first voltage level, the first energy storage device including first and second electrodes with a dielectric film positioned there between, the dielectric film comprising an entropic material, and the first electrode charged positively or negatively with respect to the second electrode; and applying a reversed polarization electric potential to the first electrode of the first energy storage device in a first mode of operation of the circuit for a discharge period of time, thereby supplying power from the first energy storage device to a load connected to the second electrode of the first energy storage device.

2. The method of supplying energy from an energy storage device to a load according to claim 1, wherein the reversed polarization electric potential is less than the first voltage level and less than a voltage that would be generated by the first energy storage device in a high impedance state.

3. The method of supplying energy from an energy storage device to a load according to claim 1, wherein the first electrode is charged positively with respect to the second electrode, and wherein applying the reversed polarization electric potential to the first electrode comprises applying a negative voltage to the first electrode.

4. The method of supplying energy from an energy storage device to a load according to claim 1, wherein the circuit comprises a plurality of first energy storage devices connected in series.

5. The method of supplying energy from an energy storage device to a load according to claim 1, wherein the circuit further includes a second energy storage device charged to a first voltage level and coupled in series with the first energy storage device, a first switch operable to connect the second energy storage device to ground and a second switch operable to connect the second energy storage device to the load, and wherein applying a reversed polarization electric potential to the first electrode of the first energy storage device in the first mode of operation of the circuit comprises actuating the first switch to connect the second energy storage device to ground and actuating the second switch to connect the second energy storage device to the load.

6. The method of supplying energy from an energy storage device to a load according to claim 5, wherein the second energy storage device includes first and second electrodes with a dielectric film positioned there between, the dielectric film comprising an entropic material.

7. The method of supplying energy from an energy storage device to a load according to claim 1, wherein providing a circuit comprising a first energy storage device charged to a first voltage comprises:

connecting the first energy storage device to ground; and applying a charge voltage to the first energy storage device for a period of time effective to charge the first energy storage device to the first voltage.

8. The method of claim 7, further comprising:

monitoring a charge current of the first energy storage device while applying the charge voltage; comparing the charge current to a selected minimum value; and when the charge current is at or below the selected minimum level, switching the circuit to a second mode of operation in which the circuit is in a high-impedance state so that the first energy storage device does not receive the charge voltage and so that substantially no energy is supplied from the first energy storage device to the load.

9. The method of supplying energy from an energy storage device to a load according to claim 1, further comprising:

switching the circuit to a second mode of operation for at least a threshold recovery period of time to provide a voltage recovery period during which the circuit is in a high-impedance state so that substantially no energy is supplied from the first energy storage device to the load and the entropic material is restored to a desired level of entropic equilibrium; and repeatedly switching the circuit between the first and second modes of operation without recharging the first energy storage device from an external power source.

10. The method of supplying energy from an energy storage device to a load according to claim 9, wherein the discharge period of time and the recovery period of time collectively constitute a duty cycle, and wherein the discharge period of time is 0.1-99.9% of the duty cycle.

11. The method of supplying energy from an energy storage device to a load according to claim 9, wherein the energy storage device is disconnected from the load while in the second mode of operation, the method further comprising reconnecting the energy storage device to the load before switching the circuit from the second mode of operation to the first mode of operation.

12. The method of supplying energy from an energy storage device to a load according to claim 9, further comprising:

monitoring a voltage of the first energy storage device with a controller while in the first mode of operation until the voltage reaches a desired discharge voltage level; switching the circuit from the first mode of operation to the second mode of operation with the controller when the desired

discharge voltage level is reached; monitoring the voltage of the first energy storage device with the controller while in the second mode of operation until the voltage reaches a desired recovery voltage level; and switching the circuit from the second mode of operation to the first mode of operation with the controller when the desired recovery voltage level is reached.

13. The method of supplying energy from an energy storage device to a load according to claim 9, further comprising:

(a) receiving, with a controller, a time value for the discharge period of time;

(b) receiving, with the controller, a time value for the recovery period of time;

(c) monitoring the discharge period of time with the controller while the circuit is in the first mode of operation;

(d) switching the circuit from the first mode of operation to the second mode of operation with the controller when the time value for the discharge period of time is reached;

(e) monitoring the recovery period of time with the controller while the circuit is in the second mode of operation;

(f) receiving, with the controller, current and voltage levels of the first energy storage device after the time value for the recovery period of time is reached;

(g) comparing, with the controller, the current and voltage levels to target values of the current and voltage levels to provide target value comparisons; and

(i) updating, with the controller, the time values for the discharge period of time and the recovery period of time based at least in part on the target value comparisons.

14. The method of supplying energy from an energy storage device to a load according to claim 13, further comprising:

(j) switching the circuit from the second mode of operation to the first mode of operation with the controller; and

(k) repeating steps (c)-(i).

15. The method of supplying energy from an energy storage device to a load according to claim 1, wherein the circuit comprises an array of first energy storage devices, the array comprising m rows connected in parallel of n energy storage devices connected in series, wherein m and n independently are integers greater than one, the method further comprising:

connecting the load to a first row of the array via a multi-position switch;

applying the reversed polarization electric potential to a first electrode of a first energy storage device in the first row of the array for a first discharge period of time, thereby supplying power from the first row of the array to the load;

after the first discharge period of time, connecting the load to a subsequent row of the array via the multi-position switch; and

applying the reversed polarization electric potential to a first electrode of a first energy storage device in the subsequent row of the array for a subsequent discharge period of time, thereby supplying power from the subsequent row of the array to the load.

16. The method of supplying energy from an energy storage device to a load according to claim 1, wherein the entropic material (i) is electrically insulative and/or exhibits a high permittivity, and (ii) comprises a plurality of polymeric molecules.

17. The method of supplying energy from an energy storage device to a load according to claim 16, wherein the polymeric molecules have one or more polar functional groups, ionizable functional groups, or a combination thereof.

18. The method of supplying energy from an energy storage device to a load according to claim 16, wherein the polymeric molecules comprise proteins.

19. The method of supplying energy from an energy storage device to a load according to claim 1, wherein the entropic material is a sterically constrained dielectric material comprising a plurality of polymeric molecules having one or more polar functional groups, ionizable functional groups, or a combination thereof, the energy storage device having an energy storage capacity, in the absence of the energy storage device having been charged and/or discharged, of at least 1 Wh/kg based solely on the weight of the sterically constrained dielectric film disposed between the electrically conductive first and second electrodes.

20. The method of supplying energy from an energy storage device to a load according to claim 19, wherein at least 1% of the plurality of polymeric molecules are bound to the first electrode or to an insulative layer disposed between the first electrode and the dielectric film.

21. The method of supplying energy from an energy storage device to a load according to claim 1, wherein the first energy storage device further comprises:

a first insulative layer disposed between the first electrode and the dielectric film;

a second insulative layer disposed between the second electrode and the dielectric film;

or

a first insulative layer disposed between the first electrode and the dielectric film and a second insulative layer disposed between the second electrode and the dielectric film.

22. The method of supplying energy from an energy storage device to a load according to claim 21, wherein the first insulative layer, the second insulative layer, or the first insulative layer and the second insulative layer comprise polymerized p-xylylene.

23. A circuit, comprising:

a first energy storage device including first and second electrodes with a dielectric film positioned there between, the dielectric film comprising an entropic material, and the first electrode charged positively or negatively with respect to the second electrode;

a second energy storage device including first and second electrodes with a dielectric film positioned there between, the first electrode charged positively or negatively with respect to the second electrode;

a first multi-position switch connected to the first electrode of the first energy storage device and adapted to (i) couple the first electrode of the first energy storage device to a charge voltage source, (ii) couple the first electrode of the first energy storage device to a load, or (iii) place the first energy storage device in a high-impedance state so that substantially no energy is supplied from the first energy storage device to a load;

a second multi-position switch connected to the second electrode of the second energy storage device and adapted to couple the second electrode of the second energy storage device to a load or to ground; and

a third multi-position switch connected to the first electrode of the second energy storage device and adapted to (i) couple the first electrode of the second energy storage device to a charge voltage, (ii) couple the first electrode of the second energy storage device to ground, or (iii) place the second energy storage device in a high-impedance state in conjunction with the second multi-position switch positioned to connect the second electrode of the second energy storage device to ground.

24. The circuit of claim 23, wherein the dielectric film of the second energy storage device comprises an entropic material.

25. The circuit of claim 23, further comprising a controller operable to actuate the first, second, and third multi-position switches.

26. A circuit, comprising:

a first array of energy storage devices, the first array comprising $m_1$ rows in parallel of $n_1$ energy storage devices connected in series, wherein $m_1$ and $n_1$ are integers, each energy storage device of the first array including first and second electrodes with a dielectric film positioned there between, the dielectric film comprising an entropic material, and the first electrode of each energy storage device charged positively or negatively with respect to the second electrode;

a second array of energy storage devices, the second array comprising $m_2$ rows in parallel of $n_2$ energy storage devices connected in series, wherein $m_2$ and $n_2$ are integers, each energy storage device of the second array including first and second electrodes with a dielectric film positioned there between, the first electrode of each energy storage device charged positively or negatively with respect to the second electrode;

a first input multiplexer connected to ground and to the first array;

a second input multiplexer connected to the second array;

a first multi-position switch coupled to the first array and adapted to (i) couple the first array to a charge voltage source, (ii) couple the first array to a load, or (iii) place the first array in a high-impedance state so that substantially no energy is supplied from the first array to a load;

a second multi-position switch coupled to the second input multiplexer and adapted to (i) couple the second input multiplexer to a charge voltage source, or (ii) couple the second input multiplexer to ground;

a third multi-position switch coupled to a first side of the second array and adapted to (i) couple the first side of the second array to a load, (ii) couple the first side of the second array to ground, or (iii) place the second array in a high-impedance state in conjunction with the second multi-position switch positioned to connect the second input multiplexer to ground; and

a controller operable to control the first and second input multiplexers and to actuate the first, second, and third multi-position switches.