CLAIMS

1. A multi-layer energy apparatus comprising:

a transparent or semi-transparent substrate;

a solar-cell layer coupled to the substrate, the solar-cell layer comprising a plurality of solar cells for receiving light through the substrate and converting energy of the received light to a first electrical energy;

an energy-storage layer coupled to the solar-cell layer, the energy-storage layer comprising one or more energy-storage units for storing a second electrical energy; and

a converter layer coupled to the energy-storage layer, the converter layer comprising one or more power converters electrically connected to the solar-cell layer and the energy-storage layer for receiving the first electrical energy and the second electrical energy therefrom and outputting a third electrical energy through an output thereof,

wherein the solar-cell layer comprises:

an anode sublayer coupled to the substrate;

a sublayer of Zinc oxide (ZnO) coupled to the anode sublayer;

a sublayer of poly(ethylenimine) and poly(ethylenimine) ethoxylated (PEIE) coupled to the sublayer of ZnO;

a sublayer of organic solar cells coupled to the sublayer of PEIE;

a sublayer of Molybdenum trioxide (MoO_3) coupled to the sublayer of solar cells; and a cathode sublayer coupled to the sublayer of MoO_3.

2. The multi-layer energy apparatus of claim 1, wherein the substrate comprises a layer of glass.

3. The multi-layer energy apparatus of claim 1, wherein the substrate comprises a flexible, transparent or semi-transparent material.

4. The multi-layer energy apparatus of claim 1, wherein the substrate comprises a transparent or semi-transparent plastic material.

5. The multi-layer energy apparatus of claim 1, wherein the substrate comprises at least one of polyethylene terephthalate (PET) and poly(ether sulfones) (PES).

6. The multi-layer energy apparatus of any one of claims 1 to 5, wherein the solar-cell layer comprises a printed or deposited layer on the substrate.

7. The multi-layer energy apparatus of any one of claims 1 to 6, wherein the energy-storage layer comprises a printed or deposited layer on the solar-cell layer.

8. The multi-layer energy apparatus of claim 1, wherein the anode sublayer comprises indium tin oxide (ITO).

9. The multi-layer energy apparatus of any one of claims 1 to 8, wherein the cathode sublayer comprises silver (Ag) or aluminum (Al).

10. The multi-layer energy apparatus of any one of claims 1 to 9, wherein the sublayer of solar cells comprises polymer solar cells.

11. The multi-layer energy apparatus of any one of claims 1 to 9, wherein the sublayer of solar cells comprises a sublayer of bulk heterojunctions (BHJs).

12. The multi-layer energy apparatus of any one of claims 1 to 11, wherein the energy-storage layer comprises at least one of one or more battery cells and one or more semiconductor capacitors.

13. The multi-layer energy apparatus of claim 12, wherein each of the one or more battery cells comprises:

a first current-collector sublayer;

an anode sublayer coupled to the first current-collector sublayers;

a solid-state electrolyte sublayer coupled to the anode sublayer;

a cathode sublayer coupled to the solid-state electrolyte sublayer; and

a second current-collector sublayer coupled to the cathode sublayer.

14. The multi-layer energy apparatus of claim 13, wherein at least one of the first and the second current-collector sublayers comprises aluminum.

15. The multi-layer energy apparatus of claims 13 or 14, wherein the solid-state electrolyte sublayer comprises $LiBrF_4$ with Al_2O_3 and a first semi-interpenetrating polymer network (semi-IPN) skeleton material.

16. The multi-layer energy apparatus of claims 13 or 14, wherein the solid-state electrolyte sublayer is made of 1 Molar (mol per liter) $LiBF_4$ in Sebaconitrile (SBN) and a first semi-IPN skeleton material at a ratio of 85/15 weight-by-weight (w/w), mixed with about 300 Molar Al_2O_3 at a ratio of 60/40 w/w.

17. The multi-layer energy apparatus of any one of claims 13 to 16, wherein the anode sublayer comprises activated $Li_4Ti_5O_{12}$ (LTO) with a first carbon material and a second semi-IPN skeleton material.

18. The multi-layer energy apparatus of any one of claims 13 to 17, wherein the cathode sublayer comprises activated $LiCoO_2$ (LCO) with a second carbon material and a third semi-IPN skeleton material.

19. The multi-layer energy apparatus of claims 17 or 18, wherein the first and/or the second carbon comprises at least one of single-walled carbon nanotubes (SWCNT) and carbon powder.

20. The multi-layer energy apparatus of claim 19 dependent from claim 17, wherein the activated LTO is SWCNT-coated LTO.

21. The multi-layer energy apparatus of claim 19 dependent from claim 18, wherein the activated LCO is SWCNT-coated LCO.

22. The multi-layer energy apparatus of any one of claims 16 to 21, wherein the semi-IPN skeleton material comprises an ultraviolet (UV) curable polymer.

23. The multi-layer energy apparatus of claim 22, wherein the UV-curable polymer comprises ethoxylated trimethylolpropane triacrylate (ETPTA) incorporating 1.0 weight percent (wt%) 2-hydroxy-2-methylpropiophenone (HMPP) and poly(vinylidene fluoride-co-hexafluoropropylene) (PVdF-HFP) with HFP of six mole percent (mol%) and ETPTA/PVdF-HFP at a ratio of 75/25 weight-by-weight (w/w).

24. The multi-layer energy apparatus of any one of claims 12 to 23, wherein each of the one or more semiconductor capacitors comprise n aluminum gallium arsenide (AlGaAs) sublayers interleaved with (n+1) gallium arsenide (GaAs) sublayers, n>0 being an integer, with each AlGaAs layer sandwiched between two neighboring GaAs layers.

25. The multi-layer energy apparatus of any one of claims 1 to 24, wherein the converter layer comprises a multi-input electronic power converter having a solar-input converter, a battery-input converter, and an output converter.

26. The multi-layer energy apparatus of claim 25, wherein at least one of the solar-input converter, the battery-input converter, and the output converter comprises coils winding about a ferromagnetic or ferrimagnetic core.

27. The multi-layer energy apparatus of claim 25, wherein at least one of the solar-input converter, the battery-input converter, and the output converter comprises a core layer made of a ferrite material and sandwiched between two wiring layers; wherein each of the wiring layers comprises electrically conductive wirings on a base; and wherein the wirings of the two wiring layers are interconnected through one or more vias thereon to form the coils winding about the ferrite core.