PORTABLE LIGHTING AND POWER-GENERATING SYSTEM

A portable lighting and clean-energy power-generating system is disclosed. The portable lighting and power system includes at least one light-emitting source, a power-generating source, a power storage device, and a processing system for controlling and managing power-generated by the power-generating source that are all are integrated into a flexible-layered structure. The components making up the portable lighting and power system can be embodied in a flexi-kit to provide modular capabilities.
Declarations under Rule 4.17:

— as to applicant’s entitlement to apply for and be granted a patent (Rule 4.17(iii))

— as to the applicant’s entitlement to claim the priority of the earlier application (Rule 4.17(iii))

— of inventorship (Rule 4.17(iv))

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TITLE OF THE INVENTION

PORTABLE LIGHTING AND POWER-GENERATING SYSTEM

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of U.S. provisional patent application number 61/253,203 filed on October 20, 2009, which is a continuation-in-part of U.S. utility patent application number 11/904,602 filed on September 27, 2007, which claims priority from provisional 60/847,484 filed on September 27, 2006.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not Applicable

TECHNICAL FIELD

The field of the invention is related to portable lighting and power systems and, more particularly, to portable lighting systems having integrated power-generating means that are integrated into a flexible-layered structure.

BACKGROUND OF THE INVENTION

Conventional solar power systems that rely on silicon-based photovoltaic cells or panels typically contain components that are heavy, fragile, and — due to weight — costly to transport overland. Furthermore, large solar power systems, which require a high-capacity, rechargeable battery, can affect and complicate transport by air, due to time delays and expense associated with Federal Aviation Administration regulations concerning the transport of rechargeable batteries across international boundaries.
To address the weight issues, flexible, multi-purpose, solar power chargers have been developed. However, conventional solar power chargers often require numerous ancillary attachments for sourcing power to different devices or loads. These attachments can be quite bulky, heavy, and breakable and can add to the complexity and cost of the system. Moreover, flexible, solar power chargers have no fixed application, which is to say that the power they generate cannot be optimized for illumination or other purposes, and their physical form is rigid and cannot be adjusted in response to specific lighting needs.

Portable, solar-powered, re-chargeable flashlights and lanterns have a relatively compact, fixed volume. However, they also include numerous breakable parts that can fail or be damaged in transport and/or during rugged use. Like solar power chargers, the physical form and light output of portable, solar-powered, re-chargeable flashlights and lanterns cannot be modified or adjusted in response to specific lighting needs.

One problem associated with these products, however, stems from their design as singular, non-related devices, which does not offer the user the benefit or advantages of functionality associated with a distributed system where units may be used individually and in digitally-linked networks of multiple units.

Indeed, as the existing paradigm of centralized distribution — and its corollary, the singular object appliance — becomes less sustainable, the benefits of using long-term, renewable solutions for power and lighting distribution becomes increasingly important. A new paradigm is required to provide the flexibility of performance that can be achieved in distributed systems of power generation and lighting.

SUMMARY OF THE INVENTION

A versatile, flexible and configurable, distributed, portable lighting and power-generating system is disclosed. The
system includes a power management and control system, which, along with the power-generating system, is integrated into a flexible-layered structure that is capable of providing form and optical enhancements to the portable lighting system while also protecting the same.

According to the present invention, small, compact, flexible photovoltaic materials, cells or panels are used for generating DC power. The flexible photovoltaic materials, cells or panels are integrated into the flexible-layered structure, to provide additional, planar structural support and/or tensile structural support for specific, desirable lighting system configurations.

A small, compact power management and control system is also integrated into the flexible-layered structure, to optimize energy harvesting, e.g., for a (USB or other) power port, and light output performance of individual lighting systems and further to enable lighting systems to be grouped or bundled together via wired linkages and digital protocols for additional desirable functional benefits. Additional efficiencies, for example, in charging multiple units and in light level management between units are achieved through the design of a digital system of distributed intelligence.

The flexible-layered structure protects the photovoltaic materials, cells or panels, the solid-state components, electrical wiring, and the power management and control system. The flexible-layered structure is made up of reflective, translucent, and/or opaque layers and is designed for rapid deployment and can be configured into a variety of optimally functional three-dimensional forms that provide light management benefits. In a modular kit form it can be integrated into any layered textile structure. As a result, the re-configurable forms can be used to reflect, focus, diffuse, and manage light output from the solid-state lighting source(s), which also are integrated in the flexible-layered structure.
Also disclosed is a self-structuring, portable lighting and charging system integrated into a flexible-layered structure, which includes an exterior face on one side and an interior face on an opposite side. The system includes a thin-film, flexible, power-generating source that is removably attachable to the exterior face; a reflective optics material that is disposed on the interior face; at least one light-emitting source that is proximate the interior face for directing light onto the reflective material; a power storage device; and a processing system for controlling and managing power-generated by the power-generating source. Preferably, the light-emitting source(s), the power-generating source, the power storage device, and the processing system are integrated into the flexible-layered structure. Moreover, the flexible-layered structure includes stiffening means for self-structuring the system and/or for orienting the light-emitting source(s) towards the reflective material.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be more fully understood by reference to the following Detailed Description of the invention in conjunction with the Drawing, of which:

FIG. 1 shows a plan view of a portable lighting system in a flexible-layered structure in accordance with the present invention;

FIG. 2 shows a plan view of the portable lighting system of FIG. 1 with first, second and third inner flaps folded in accordance with the present invention;

FIG. 3 shows a plan view of the portable lighting system of FIG. 2 with the fourth inner flap folded in accordance with the present invention;
FIG. 4 shows a plan view of the portable lighting system of FIG. 3 with the fifth flap folded in accordance with the present invention;

FIG. 5 shows a plan view of a completely-folded portable lighting system in accordance with the present invention;

FIG. 6 shows an illustrative schematic of the processing system for the power and control management system in accordance with the present invention;

FIG. 7 shows an illustrative schematic of a first mode of operation of the portable lighting system in accordance with the present invention;

FIG. 8 shows an illustrative schematic of a second mode of operation of the portable lighting system in accordance with the present invention;

FIG. 9 shows an illustrative schematic of a third mode of operation of the portable lighting system in accordance with the present invention;

FIG. 10 shows an illustrative schematic of a fourth mode of operation of the portable lighting system in accordance with the present invention;

FIG. 11 shows an illustrative schematic of the photovoltaic cells or panels in accordance with the present invention;

FIG. 12 shows an illustrative schematic of the photovoltaic cells or panels disposed on a back pack bag in accordance with the present invention;

FIG. 13 shows an illustrative diagram of the power control and management system in accordance with the present invention;

FIG. 14 shows an illustrative diagram of current flow for group power-pooling applications in accordance with the present invention;

FIG. 15 shows an illustrative diagram of group power-pooling applications in accordance with the present invention.
FIG. 16 shows an illustrative diagram of a portable lighting and power-generating system flex-kit in accordance with the present invention;

FIG. 17 shows the illustrative diagram of a portable lighting and power-generating system flex-kit of FIG. 16 with flaps folded to form a parabolic reflector in accordance with the present invention;

FIG. 18 shows a power-generating system that is integrated into a piece of clothing;

FIG. 19 shows a power-generating system that is integrated into a carry bag, shoulder bag or handbag;

FIG. 20A shows a power-generating system that is integrated into a blanket textile or non-woven substrate;

FIG. 20B shows the power-generating system of FIG. 20A in use;

FIG. 21 shows an illustrative embodiment of a light-emitting source;

FIG. 22 shows an illustrative modular wiring and bus diagram for the energy-generating sources that can be manufactured efficiently and used in a modular manner;

FIG. 23 shows illustrative drive electronics for the universal, self-structuring, clean energy portable lighting and energy harvesting system;

FIG. 24 shows an exterior face pattern of a first embodiment of a universal, self-structuring, clean energy portable lighting and energy harvesting system;

FIG. 25 shows the interior face pattern of the system shown in FIG. 24;

FIG. 26 shows the system shown in FIG. 24 and 25 in an upright standing position;

FIG. 27 shows an exterior face pattern of a second embodiment of a universal, self-structuring, clean energy portable lighting and energy harvesting system;
FIG. 28 shows the interior face pattern of the system shown in FIG. 27;
FIG. 29 shows the system shown in FIG. 27 and 28 in an upright, standing position;
FIG. 30 shows an exterior face pattern of a third embodiment of a universal, self-structuring, clean energy portable lighting and energy harvesting system;
FIG. 31 shows the interior face pattern of the system shown in FIG. 30;
FIG. 32 shows the system shown in FIG. 30 and 31 in an upright, standing position;
FIG. 33 shows an exterior face pattern of a fourth embodiment of a universal, self-structuring, clean energy portable lighting and energy harvesting system;
FIG. 34 shows the interior face pattern of the system shown in FIG. 33;
FIG. 35 shows the system shown in FIG. 33 and 34 in an upright, standing position;
FIG. 36 shows an exterior face pattern of a fifth embodiment of a universal, self-structuring, clean energy portable lighting and energy harvesting system;
FIG. 37 shows the interior face pattern of the system shown in FIG. 36;
FIG. 38 shows the system shown in FIG. 36 and 37 in an upright, standing position;
FIG. 39 shows a universal, self-structuring, clean energy portable lighting and energy harvesting system with a remote modular energy-generating source;
FIG. 40 shows a universal, self-structuring, clean energy portable lighting and energy harvesting system hanging from above;
FIG. 41 shows a universal, self-structuring, clean energy portable lighting and energy harvesting system hanging from a nail on a wall;
FIG. 42 shows an exterior side of a universal, self-structuring, clean energy portable lighting and energy harvesting system having a single lower flap;

FIG. 43 shows an interior side of the universal, self-structuring, clean energy portable lighting and energy harvesting system of FIG. 42;

FIG. 44 shows the system of FIGs. 42 and 43 formed into a desktop lamp or task lamp configuration;

FIG. 45 shows the system of FIGs. 42 and 43 formed into a mobius lamp or hung ambient lighting system configuration;

FIG. 46 shows the system of FIGs. 42 and 43 formed into a ribbon lamp or standing ambient lantern/lighting source configuration;

FIG. 47 shows a master pattern for the system;

FIG. 48 shows the master pattern of FIG. 47 with the third flap overlapping the second flap;

FIG. 49 shows a reflective side of a solar reflector pattern;

FIG. 49A shows a plan view of an exemplary method of integrating the modular light-emitting source shown in FIG. 21 into a portion of one of the flaps;

FIG. 49B shows a side view of an exemplary method of integrating the modular light-emitting source shown in FIG. 21 into a portion of one of the flaps; and

FIG. 50 shows the pattern of FIG. 49 that has been formed into a solar reflector.

DETAILED DESCRIPTION OF THE INVENTION

U.S. provisional patent application number 61/253,203 filed on October 20, 2009, U.S. provisional patent application number 60/847,484 filed on September 27, 2006, and U.S. utility patent application 11/904,602 filed on September 27, 2007 are incorporated herein in their entirety by reference.
The disclosed portable lighting system integrates power generation, solid-state lighting, with a power management and control system in a robust, lightweight, self-contained, flexible-layered structure. The portable lighting system provides optical, structural, and functional benefits through its portability, modularity, and adaptability to ambient, indirect, and direct lighting needs.

**Flexible-layered Structure**

The structure of the portable lighting system is provided by a flexible-layered system. The flexible-layered system can be fabricated using sewing or "no sew" manufacturing methods, including, for example and without limitation, sonic-welding and heat lamination, to join, in a pre-defined master pattern, a plurality of flexible materials, each of which has or may have a different optical property, such as a white, translucent, light-diffusing material and a specular reflective material.

Because of the strength introduced into a textile by weaving, a flexible-layered structure of woven materials comprising either natural fibers or of man-made fibers or a flexible-layered structure comprising a combination of woven and non-woven fabric fibers is desirable. However, the flexible-layered structure can be practiced using non-woven fabrics, flexible plastics, natural or artificial leather materials, rubber materials or other flexible substrates, and the like. Optionally, the materials used for the flexible-layered structure can include integral hydrophobic, anti-microbial, and optical characteristics, which in some applications can be desirable for the system. The selected material for making the flexible-layered material can also be used in combination with reflective, opaque, and/or translucent textiles or non-woven layers.

Each layer of the flexible material is designed to unfold, e.g., along integral fold lines, into a flat or substantially flat master pattern. Flat patterns facilitate efficient solar
charging, as well as industrial manufacture, cutting, and combination of layers by at least one of lamination, cutting and sewing, heat-lamination, sonic-welding, and/or by other manual or computerized industrial processes known to those of ordinary skill in the art.

For shipping and transport purposes, the flexible-layered structure is designed to fold into a compact, rectangular or substantially rectangular package. The flexible-layered structure (and its modular set of components) is further designed to fold in such a way as to facilitate its attachment to and detachment from, for example, a carry bag, a back pack, a head dress, a scarf, a satchel, a briefcase, a saddle bag, and other like portable equipment or clothing.

The flexible-layered structure is further designed to expose photovoltaic cells or panels, which are physically integrated with, upon or into the flexible-layered structure, to radiation, e.g., sunlight, while the flexible-layered structure is being transported while attached to any of the above-mentioned clothing and/or portable equipment. Advantageously, exposing photovoltaic cells or panels to radiation, charges a re-chargeable energy storage device also integrated onto, into or with the system. Optionally, the flexible-layered structure can be purposely integrated into or attached onto in a convenient and purposeful manner the design of a piece of portable equipment or clothing.

For example, referring to FIG. 1 through FIG. 5, an illustrative master pattern for the portable lighting system 32 is shown in various folding stages, ranging from unfolded (FIG. 1) to completely-folded (FIG. 5). Those skilled in the art can appreciate that the size and shape of the master pattern for the portable lighting system 32, the size and number of flaps and folds, and the relative locations of the flaps and folds can vary appreciably. Equally as variable is the material used and layered in connection with each flap.
The master pattern for the portable lighting system includes a first flap, a second flap, a third flap, a fourth flap, a fifth flap, a left-center flap, a right-center flap, and a front controller board sleeve. For illustrative purposes only, the first flap, second flap, third flap, fourth flap, left-center flap, and right-center flap are depicted (shaded) as having a reflective material showing while the fifth flap and the front controller board sleeve are depicted (no shading) as having a translucent and/or opaque material showing.

A top-left vertical fold separates the fourth flap from the left-center flap; a center vertical fold separates the left-center flap from the right-center flap; and a top-right vertical fold separates the right-center flap from the fifth flap. Top-left and top-right horizontal folds separate the left-center flap and right-center flaps, respectively, from the third flap.

Bottom vertical fold separates the first flap from the front controller board sleeve. The front controller board sleeve is not connected to the second flap. Bottom horizontal fold separates the first flap from the fourth flap. Bottom horizontal fold separates the front controller board sleeve from the left-center flap. Bottom horizontal fold separates the second flap from the right-center flap.

As shown in FIG. 2, the first and second flaps and the front controller board sleeve can be folded along respective bottom horizontal folds so that the bottom vertical fold is in registration with the top-left fold, exposing the outer portion of the first flap, the rear controller board sleeve, and the outer portion of the second flap. Similarly, the third flap can be folded along the top-left and top-right horizontal folds, exposing the outer portion of the third flap. For illustrative purposes only, the
outer portion 36 of the first flap 27, the rear controller board sleeve 35, the outer portion 28B of the second flap 28, and the outer portion 34 of the third flap 14 are depicted as having a translucent or opaque material showing.

As shown in FIG. 3, the fourth flap 15 and the first flap 27 can then be folded along the top-left vertical fold 18 and the bottom vertical fold 26, exposing the outer portion 37 of the fourth flap 15. For illustrative purposes only, the outer portion 37 of the fourth flap 15 is depicted as having a translucent or opaque material showing. Then, as shown in FIG. 4, the fifth flap 31 can be folded along the top-right vertical fold 25, exposing the outer portion 31B of the fifth flap 31. For illustrative purposes only, the outer portion 31B of the fifth flap 31 is also depicted as having a translucent or opaque material showing.

Finally, as shown in FIG. 5, the whole can be folded along the center vertical fold 19, exposing the center outer flap 42 and at least one of the photovoltaic cells or panels 40 disposed thereon. For illustrative purposes only, the center outer flap 42 is depicted as having a translucent or opaque material showing.

The free end 5 of a draw string 6 that is disposed through a plurality of drawstring loops 7-12 can then be pulled taut to tighten the whole.

The folded and flat or substantially flat features of the flexible-layered structure allow users to deploy the portable lighting system 32 rapidly by unfolding it from its transport position (FIG. 5) and re-folding it into a variety of three-dimensional forms, each form designed to accommodate different lighting tasks in a system of soft optics.

Due to the flexible-layered structure, the portable lighting system 32 can also be folded, overlapped upon itself, and/or rolled up by the user into a myriad of form geometries designed to propagate and distribute the solid-state lighting to accomplish different lighting tasks and needs. Advantageously, the various folded, overlapped, and rolled forms of the portable lighting
system 32 function as a flexible, soft optical system that provides the user with reflective and diffusing surfaces to distribute, balance, and manage light output.

For example, referring to FIG. 7, the portable lighting system 32 is shown in one mode of operation in which the first flap 27 and the front controller board sleeve 29 are oriented orthogonally or substantially orthogonally to the fourth 15, left-center 16, and right-center flaps 17. Such an orientation is possible if the first flap 27 and the front controller board sleeve 29 are placed in the plane of a flat or substantially flat horizontal surface, such as a table, a floor or the ground, and the fourth 15, left-center 16, and right-center flaps 17 are perpendicular to the plane of the flat or substantially flat horizontal surface.

In FIG. 7, the right-center flap 17 is disposed about the center vertical fold 19 relative to the left-center flap 16 so that all or some portion of the second flap 28 is disposed over or on top of the front controller board panel 29. The fifth flap 31 is shown in an arcuate orientation.

Lighting sources or light-emitting devices 1 and 2, such as light-emitting diodes (LED), integrated into or integral with the positionable, second flap 28 and the third flap 14 can, for example, reflect light off of the surface of the fifth flap 31, for example to modify glare from a point source, to create back-lighting, indirect lighting, direct lighting, and the like. Flexible wires or similar stiffeners (not shown) can be integrated, for example, into the flexible materials of the various flaps and/or folds of the portable lighting system 32 to enable users to vary the position of the individual lighting sources 1 and 2.

Referring to FIG. 1 and FIG. 8, an integrated tension system is shown. The integrated tension system includes a pull cord 6 that has a free, proximal end 5 and a fixed or anchored, distal end 13. The pull cord 6 can be routed through a plurality of
loops 7-12 that are fixedly attached, e.g., sewn, heat-laminated, sonic-welded, and the like, to the rear controller board sleeve 35 and the outer portions 36, 28B, and 31B of the first 27, second 28, and fifth flaps 31B, respectively.

The integrated tension system enables users to draw the flexible-layered structure together, creating folds in the layered textile material, to stabilize the flexible-layered structure against the plane of a flat or substantially flat horizontal surface, such as a table, a floor or the ground. Using the pull cord 6 to draw the flexible-layered structure together also enables users to position an integral, light-diffusing layer of material across or over one or more lighting source 1 or 2, to mitigate the glare of the lighting sources 1 or 2, to create diffusing or/and ambient light conditions.

Optionally, one or more slits 33 through the flexible-layered structure can be included. As shown in FIG. 9, the draw cord 6 can be drawn through the slit(s) 33 to provide a cylindrical shape to the flexible-layered structure. The free end 5 of the pull cord 6 can then be attached to, e.g., a branch, a joist, a beam, a ceiling, and the like, to provide a hanging lighting source.

In another application, as shown in FIG. 10, after the system 32 has been completely folded, all or some portion of the third flap 14 can be pulled out to expose one of the lighting sources 1. The compact whole can be used in applications where a lantern or a flashlight would typically be used.

Inclusion of at least one hole in or opening through the flexible-layered structure (not shown), and further positioned with respect to the lighting sources 1 and 2, enables the user to reverse the directionality of each lighting source 1 and 2 by bending the lighting source 1 or 2 upon itself and directing its light through the hole or opening. For example, introduction of a grommet ring in the flexible-layered structure enables the user to reverse and/or re-direct the position and orientation of the
lighting source(s) 1 or 2. As a result, the user can direct the light onto the reflective or translucent surface of some portion of the flexible-layered structure, whereby the light can be reflected and/or diffused without changing the selected folded form and configuration of the same.

In short, the flexible-layered structure provides a multiplicity of different configurations, suitable for direct, indirect, and/or ambient tasks. Users can select various combinations of optical reflectivity and/or diffusion as the reflective and diffusing layers of the flexible-layered structure are deployed singly and/or in combination with folded, overlapped, and/or rolled portions of the flexible-layered structure as well as the orientation of the integrated, solid-state lighting sources. For example, these orientations can include, by example and not limitation, table top-mounted direct and indirect task lighting, wall-mounted or hanging lighting systems, horizontal lighting surfaces, self-supporting lighting having soft, diffusing or reflecting light baffles of flexible material, and so forth.

Solid-state Light-emitting Source

At least one solid-state light-emitting source 1 or 2 can be integrated into the flexible-layered structure to provide lighting. For example, high-brightness light-emitting diodes (LED) made by Philips Lumileds Lighting Company of San Jose, California (LUXEON I) are suitable for use as light-emitting sources. Solid-state light-emitting sources 1 and 2 can also include light-emitting fibers that are woven into the flexible-layered material; flat or substantially flat organic LEDs that are woven into the flexible-layered material; light-emitting strips of electroluminescent film that are woven into the flexible-layered structure, and/or inorganic, flat or substantially flat solid-state lighting devices that are disposed between layers of the flexible-layered structure.
The solid-state light-emitting source(s) 1 and 2 can be positioned by the user via a flexible positioning structure and associated hardware, which can be integrated into the flexible-layered structure, e.g., via sewing or non-sewing manufacturing techniques. The integrated positioning mechanism for the solid-state light-emitting source 1 and 2 can include a flexible wire structure, a tensile cord system, a lightweight, plastic mechanism with articulated joint(s), or similar structures that allow the user to manipulate the orientation of the solid-state light-emitting source(s) 1 and 2 within the flexible-layered structure.

As previously mentioned, introduction of a grommet ring in the flexible-layered structure enables the user to reverse and/or re-direct the position and orientation of the solid-state light-emitting source(s) 1 and 2. As a result, the user can direct the light onto the surface of some portion of the flexible-layered structure, whereby the light can be reflected and/or diffused by the flexible-layered structure without changing the selected folded form and configuration of the same.

For example, when inorganic LEDs are used, the LEDs can be structured and arranged so that they are releasably connectable to, e.g., snap into, a fastening device that has been laminated onto the outer surface of the textile fabric. The fastening feature facilitates rapid upgrade and/or replacement when required. The fastening device, which is laminated onto the outer surface of the textile fabric, can be designed to align the LED 1 and 2 with a hole or opening that is purposely disposed in and through the flexible-layered structure, to receive the protective LED lens. Preferably, wire leads 43 and 46 leading to and from inorganic LED sources 1 and 2 can be integrated, e.g., using a seam in the fabric, using a laminated, flat wire housing, and the like.

For heat removal, the inorganic LEDs 1 and 2 can be mechanically fastened to a heat-dissipating device (not shown) such as a heat sink. Each heat sink is structured and arranged to
be releasably attachable to its respective LEDs 1 and 2. The heat sink can include a flexible, woven, coiled wire fabricated from a highly thermally-conductive material, e.g., copper, aluminum, carbon fiber, carbon-metal composite, metal, metal alloy, and the like. The woven, coiled wire provides flexibility and dissipates heat from the LEDs 1 and 2.

Although the invention has been described for generic light-emitting devices, one specific application envisioned with the present invention includes application of a light-emitting device that emits light in the ultraviolet (UV) spectrum, for purposes of purifying water, sterilizing medical equipment, solar cooking, and the like. Another envisioned application includes using light-emitting devices that emit light in the infra-red or the red spectrum, for purposes of facilitating and accelerating the healing of wounds.

Referring to FIG. 21, a high-brightness LED 201 suitable for integration in the systems described herein is shown. The light-emitting source 201 can be mounted onto a paddle-shaped PCB 238. The paddle-shaped PCB 238 helps to absorb and distribute excess heat generated by the LED 201, by means of the design of its internal vias, i.e., holes, and an internal layer of copper. The thin end of the paddle-shaped PCB 238 is structured and arranged as a strain relief for LED wire terminals 216 and can be protected by means of shrink wrap or other mechanical fastener. Advantageously, the paddle-shaped PCB 238 enables users to grasp and reposition the LED 201.

Photovoltaic Cells or Panels and Power Storage Device

The power source for the portable lighting system 32 must provide renewable power to drive the solid-state, light-emitting sources that are integrated into or with the flexible-layered structure and related control and power management systems under all conditions. Photovoltaic cells or panels such as conventional, flexible, amorphous silicon photovoltaic cells or
panels, copper indium gallium diselenide (CIGS) -based photovoltaic cells, dye-based organic photovoltaic cells, and the like, provide non-exhaustible power by converting the sun's radiation into electrical power. For example, a multi-cell CIGS-based photovoltaic cells or panels such as part/model number 29007 manufactured by Global Solar Energy, Inc. of Tucson, Arizona are suitable for use in the present invention.

Referring to FIG. 11 and FIG. 12, active, flexible photovoltaic cells or panels can be divided into multi-panel portions 39 and 40. The multi-panel portions 39 and 40 can be laminated onto or sewn into the flexible-layered structure, e.g., the center flap 42, and electrically coupled to a common electrical bus 44 within the flexible-layered structure. For example, the photovoltaic cells or panels 39 and 40 can be laminated into a single, flexible, flat or substantially flat plane so that the cells or panels 39 and 40 can be integrated into a multiplicity of portable electronic equipment.

Integration of the multi-panel portions 39 and 40 into the flexible-layered structure should further enable and not hinder folding, to minimize surface area during transport. Moreover, the multi-panel portions 39 and 40 should be able to be manipulated with respect to each other and arranged to provide, e.g., a more-rigid, 90-degree structure, for supporting an upright portion of the less-rigid flexible-layered structure such as shown in FIG. 7 and FIG. 8. Although embodiments that require folding will be described in detail, the scope of the present invention includes embodiments having a cell or panel that does not require a fold.

During periods of no or limited sunlight, for example, due to meteorological disturbances, photovoltaic cells or panels cannot produce electricity and are of limited value. Accordingly, an auxiliary, power storage device, such as a rechargeable battery, is desirable to drive the solid-state, light-emitting devices and other solid-state devices. The power storage device, e.g., rechargeable battery, can be coupled to the photovoltaic
cells or panels so that when the photovoltaic cells or panels are not generating energy to drive any of the solid-state devices or other loads, the energy generated can be stored in the rechargeable battery for later use.

More particularly, the rechargeable battery can have a thin form, such as a lithium polymer battery, a lithium phosphate battery such as the Lithiumion battery made by A123, or a lithium ion battery, which can be integrated into or between flexible layers. For example, rechargeable lithium ion, thin-form batteries in the 4.2V to 1.8Ah capacity range, such as Model #UBBPO-1 manufactured by Ultralite Batteries, Inc. of Newark, NY, are suitable for this use.

Power generated by the photovoltaic cells or panels can be provided to the electrical bus associated with the flexible-layered structure, to the rechargeable battery or to both the electrical bus and the rechargeable battery. To simplify the design and cost of the flexible-layered structure, however, power generated by the photovoltaic cells or panels can be fed just to the rechargeable battery. Consequently, power to the flexible-layered structure is always delivered from the rechargeable battery.

Although the primary power source and auxiliary power storage device of the invention have been described in connection with applications internal to the flexible-layered structure, external functionalities for the power sources can include generating electrical power to drive sensors, digital electronics, radios, digital communications systems, medical equipment, and other loads. When plural flexible-layered structures are combined, the combined photovoltaic cells or panels and/or rechargeable batteries can be used, for example, to recharge batteries for cellular phones, recharge batteries for personal (laptop) computers, and other, relatively-larger, 12- to 24-watt applications, and, in medical applications, to recharge batteries for hearing aids and to drive medical field equipment, such as...
digital thermometers, pulse oximeters, field-testing equipment, small medicine refrigeration systems, and the like.

FIG. 22 shows an illustrative wiring and busing diagram of a thin-film, flexible solar panel 226 manufactured by a deposited, printed structure in an organic photovoltaic process, by a thin-layer amorphous silicon process, and/or by a laminated structure processes, such as the CIGS-based panels manufactured by Global Solar Electronics. The wiring design offers the advantages of enabling a single manufacturing unit of solar panels to be sub-divided into a single module 235, into a module pair 230, or multiple modules, according to need. This in turn enables greater flexibility of use for solar power applications that would otherwise be provided by current thin-film manufacturing processes. In this design, positive and negative wires 225 are looped through adjacent modules, enabling all cuts 239 of the thin-film solar panel 226 to yield convenient positive end terminals 232 and negative end terminals 234.

Control and Power Management System

Referring to FIG. 1 and FIG. 6, the control and power management system 3 will be described. The control and power management system 3 includes digital electronics and microcontrollers that are adapted to optimize the performance of the solid-state light-emitting sources 1 and 2 and other devices and actuators integrated into the flexible-layered system. The control and power management system 3 is structured and arranged to be disposable and transportable in a thin, lightweight case (not shown), e.g., made of corrugated plastic, laminated in at least two plys for strength. The case (not shown) is dimensioned to be insertable in, for example, a pocket or sleeve 29 (FIG. 1) that is disposed between outer and inner flaps or layers of the flexible-layered structure. At least one mechanical fastener 30, e.g., a snap, a button, Velcro®, an interlocking slide fastener,
and the like, can be provided in connection with the pocket or sleeve 29 for closure and rapid rechargeable battery access.

The control and power management system 3 includes a processing system 48 and a rechargeable battery 89. The processing system 48 can include a microprocessor 80, printed circuit board or the like. Optionally, it can also include a boost component that enables appropriate power from the solar panel(s) to the battery or/and from the battery to the USN power port.

The processing system 48 also includes software and/or electronic hardware for controlling the output, e.g., intensity, of the light-emitting sources 1 and 2, for modulating the pulse width of the duty cycles of the light-emitting sources 1 and 2, and for charging the rechargeable battery 89. An internal electrical bus 49 electrically couples the processing system 48 to the rechargeable battery 89. An external electrical bus 44 electrically couples the processing system 48 and battery 89 to the light-emitting sources 1 and 2, e.g., via to wiring 43 and 46, respectively.

Referring to FIG. 6 and FIG. 13, the control and power management system 3 is actuated by a switch, such as a flexible, tactile, membrane switch 79, or other low profile, electronic actuation device for turning ON and OFF the control and power management system 3. The flexible membrane switch 79 is integrated into the top surface of the laminated case of the control and power management system 3. The flexible switch 79 is electrically coupled to the processing system 48 via wire leads 51.

A highlighted or easily recognizable user interface, i.e., a push point 52, for the membrane switch 79 can be provided in the top layer of the flexible-layered structure, e.g., using an integral marking system of the drive pocket or pouch 29. The location of the push point 52 is arranged so that the push point 52 aligns or is in registration with the membrane switch 79 when
the control and power management system 3 is inserted in the front controller board sleeve 29 provided in the flexible-layered structure.

When the switch 79 is ON, electrical power generated by the photovoltaic cells or panels 39 and 40 is provided to the light-emitting sources 1 and 2. When the switch 79 is OFF, electrical power generated by the photovoltaic cells or panels 39 and 40 is used to recharge the rechargeable battery 89. Those of ordinary skill in the art can appreciate that it may be desirable to control the distribution of the power generated by the photovoltaic cells or panels 39 and 40 and delivered to the light-emitting sources 1 and 2 using pulse width modulation for which pulse width modulators 83 are provided in the control and power management system 3. Those of ordinary skill in the art can also appreciate the need for filters, circuits, switching devices, and other electronic devices 97 and 98 to affect and optimize the delivery of power to the light-emitting source 1 and 2.

The control and power management system 3 further includes a battery indicator 87, e.g., a multi-color or single color LED, that is used in conjunction with the battery charging function 82 of the processing system 48. The battery indicator 87 can also be disposed near the top layer of the laminated case so as to be visible to provide a visual signal as to whether or not the battery 89 is charging or whether or not the photovoltaic cells or panels 39 and 40 are capable of charging the battery 89.

By example, the logic circuitry for the battery charge function 82 can include a sensing device that is coupled to the photovoltaic cells or panels 39 and 40 (the "PV sensing device 122") and a sensing device that is coupled to the battery 89 (the "battery sensing device 123"). The sensing devices 122 and 123 sample, for example, the voltage levels associated with the photovoltaic cells or panels 39 and 40 and the battery 89, respectively. Based on the results of the sampling, power...
generated by the photovoltaic cells or panels 39 and 40 is or is not delivered to the battery 89.

If there is insufficient sunlight to power the photovoltaic cells or panels 39 and 40, then there is no power being generated and the PV sensing device 122 outputs a voltage LO signal (logic 0) to an AND logic circuit 124. However, if there is sufficient sunlight and the photovoltaic cells or panels 39 and 40 are generating power, then the PV sensing device 122 will provide a voltage HI signal (logic 1) to the AND logic circuit 124.

In the illustrative battery charge controller 82 shown in the microprocessor 80 in FIG. 13, an OR logic circuit is shown between the outputs of the PV sensing device 122 and the power bus 119 on an input side and the AND logic circuit 124 on an output side, to allow battery charging via power-pooling even when there is no sunlight.

With respect to the battery sensing device 123, if a system's battery 89 is partially- or completely-discharged, a first solid-state device 102 coupled to the battery sensing device 123 will output a voltage HI signal (logic 1) to the control gate or the base of the charge controller 88 and to the power-pooling controller 85, while a second solid-state device 103 coupled to the battery sensing device 123 will output a voltage LO signal (logic 0) to the AND logic circuit 124 and to the power-pooling controller 85. The voltage HI signal from the first solid-state device 102 at the control gate or base will activate, drive high, and/or close the control gate or base, thereby coupling the charge controller 88 to the power bus 119. The voltage LO signal from the second solid-state device 103 will cause the battery indicator 87 to flash or blink, indicating that the battery 89 is low and in need of recharging.

Optionally, the battery sensing device 123 can be adapted to sense plural voltage thresholds that can be used to provide battery indicator 87 signals of different intensity and/or of
different color as a function of the level of charge in the battery 89.

When the battery sensing device 123 detects that the battery 89 is fully- or adequately charged, the first solid-state device 102 outputs a voltage LO signal (logic 0) to the control gate or the base of the charge controller 88 and to the power-pooling controller 85 and the second solid-state device 103 outputs a voltage HI signal (logic 1) to the AND logic circuit 124 and to the power-pooling controller 85. The voltage LO signal from the first solid-state device 102 at the control gate or base will deactivate, drive low, and/or open the control gate or base, thereby de-coupling the charge controller 88 from the power bus 119. The voltage HI signal from the second solid-state device 103 will cause the battery indicator 87 to stop flashing, indicating that the battery 89 can be recharged, and will activate, drive high, and/or close the control gate or base, thereby coupling the boost converter 90 to the power bus 119.

More specifically, the AND logic circuit 124 outputs a voltage HI (logic 1) to a second control gate or base of the charge controller 88. The voltage HI signal from the AND logic circuit 124 will activate, drive high, and/or close the control gate or base, thereby coupling the charge controller 88 to the photovoltaic cells or panels 39 and 40. When the battery 89 is fully-charged, the battery indicator 87 turns off and the charge controller 88 uncouples the battery 89 from the photovoltaic cells or panels 39 and 40.

The sensing devices 122 and 123 shown in FIG. 13 are digital-type devices. Those of ordinary skill in the art can appreciate that analog sensing devices could also be used. However, because the sensing devices 122 and 123 are digital analog-to-digital converters 92 and 86 are needed.

When the rechargeable battery 89 and the photovoltaic cells or panels 39 and 40 are each able to deliver power to the portable lighting system 32, a switching device is needed. An illustrative
Switching device is shown in Fig. 13. The switching device includes a pair of solid-state switches 99 and 100, which for illustrative purposes only are shown as MOSFETs. One of the solid-state switching devices 99 is electrically coupled to the battery 89 and the other state switching devices 100 is electrically coupled to the power bus 119. A solid-state device 120 outputs a voltage HI (logic 1) signal, which activates, drives high, and/or closes the gate or base to solid-state switching device 100 and de-activates, drives low, and/or opens the gate or base to solid-state switching device 99, when the battery 89 is to be de-coupled from the light sources 1 and 2 and outputs a voltage LO (logic 0) signal, which activates, drives high, and/or closes the gate or base to solid-state switching device 99 and de-activates, drives low, and/or opens the gate or base to solid-state switching device 100, when the battery 89 is to be coupled to the light sources 1 and 2.

Having described a portable lighting and power system embodied in a master pattern 32, a more flexible embodiment ("flex-kit") having modular components that may be inter-exchanged to facilitate integration of the system into clothing, bags, and other portable equipment will now be described. Referring to Fig. 16 and Fig. 17, the flex-kit includes a flexible-layered structure similar to that previously described and a selectively attachable/detachable photovoltaic cell or panel sleeve 55. The flex-kit further includes a electronic control system drive, one or more light-emitting sources and corresponding heat sinks.

The flexible-layered structure can include a first inner flap 76, a second inner flap 74, and a control and power management system sleeve 65. For illustrative purposes only, the first and second inner flaps 76 and 74 are depicted as having a reflective material showing and the control and power management system sleeve 65 is depicted as having a translucent or opaque material showing.
The first inner flap 76 can include two portions that are separate by a gap about which the two portions can be folded or overlapped. The first inner flap 76 is separated from the second inner flap 74 by the central fold 75. A closing flap 68 separates the second inner flap 74 from the control and power management system sleeve 65. Clasp holes 77 and 78 can be provided in the two portions, for example, to attach the two portions together to form a parabolic reflector (FIG. 17).

The photovoltaic cell or panel sleeve 55 is structured and arranged for accommodating a plurality of photovoltaic cells or panels 53 and 54.

The flex-kit control and power management system 3 can be the same as the one previously described, but which is capable of sliding in and out of the control and power management system sleeve 65. The external power bus 44 of the control and power management system 3 is electrically coupled to the photovoltaic cells or panels 53 and 54, e.g., via wire leads 56-59, for harvesting energy and also to the solid-state, light-emitting source 1 and 2, e.g., via wire leads 62, 63, 70, and 71. Wiring holes 64, 67, and 69 can be provided in the flexible-layered structure for the purpose of routing wire leads 56-59, 62, 63, 70, and 71. Optionally, wire leads 62 and 63 can be enclosed or encased in a wire sleeve 61 and wire leads 70 and 71 can be enclosed or encased in a wire sleeve 72. Stiffeners (not shown) can also be included in the wire sleeves 61 and 72, to enable users to orient the lights sources 1 and 2 as desired.

Applications

Having described a portable lighting system and power-generating system therefore that can be integrated into a flexible-layered structure, various applications of the system will now be described to show some of its myriad uses.

As a portable lighting system, the flexible-layered structure can be folded for ease of transport and unfolded for use
in an area where electricity may be absent or frequently interrupted. Portions of the flexible-layered structure can be folded, rolled, overlapped, and/or fastened together by the user. Fastening methods include Velcro®, snaps, tie downs, buttons, and other mechanical attachments. The weight, relative-stiffness, and flat-form of the control and power management system and/or the photovoltaic cells or panels can be used as structural planes to provide rigidity to the device, e.g., the control and power management system can be used as a shear plane, in such a way as to bring the photovoltaic cells or panels from a substantially flat orientation to a more perpendicular orientation where they can modulate and direct light output.

The portable lighting systems can be used individually or can be coupled together and used collectively in groups. In a group arrangement, system and internal device redundancy, which is a disadvantage of fixed-building, integrated or "centralized" power and lighting systems, is greatly reduced due to the grouped systems' portability and their ability to be configured to support direct, indirect, and ambient lighting.

Referring to FIG. 14 and FIG. 15, individual portable lighting systems 114, 115, 116, and 117 can be electrically and operationally coupled for group use. In a group use or "power-pooling mode" of operation, a plurality of portable lighting systems 114, 115, 116, and 117 can be electrically coupled, which advantageously allows each of the coupled systems 114, 115, 116, and 117 to charge (or be charged) more efficiently and more uniformly than would be the case if they were charged individually. Systems 114, 115, 116, and 117 can be joined in a "daisy chain configuration", e.g., using a multi-conductor data/power bus 119 and 118, to facilitate transferring power from fully- or partially-charged systems to systems with under-charged or drained batteries 89.

Also embedded in the microcontroller 80 of each system 114, 115, 116, and 117 is software and/or hardware for performing a
power-pooling function. Referring to FIG. 13, the power-pooling device or controller 85 of each system 114, 115, 116, and 117 samples the battery voltage of its own battery 89 via a power-pooling battery sensing device (not shown) or, alternatively, is adapted to process signals from the first and second solid-states devices 102 and 103 to couple or de-couple the battery 89 to the power bus 119 via a converter 90 for purposes of delivering charge to other batteries or receiving charge from other batteries.

For illustrative purposes only, the converter 90 shown in FIG. 13 is a boost converter. The converter 90 should be able to provide regulated voltage of about 6V so that the batteries 89, when fully charged, can reach about 4.2V. If a battery with a capacity less than 4.2V is used, the boost converter may be adapted to boost the power port to about 5V.

For example, if the sensed battery voltage of a discrete system 114 is above a pre-selected and adjustable minimum power threshold, e.g., 50-percent charged, the power-pooling device or controller 85 corresponding to that system 114 couples its respective battery 89 to the power bus 119 via its boost converter 90, to share the "sharing" system's power above the minimum threshold with the batteries 89 of one or more of the other systems 115, 116, and/or 117. More particularly, when the battery sensing device 123 senses that the battery 89 is adequately charged, the first solid state device 102 outputs a voltage LO signal (logic 0) and the second solid state device 103 outputs a voltage HI signal (logic 1). As previously described, the voltage LO signal de-activates, drives low, and/or opens the gate or base to the charge controller 88, preventing power flow from the power bus 119 to the battery 89. The voltage HI signal activates, drives high, and/or closes the gate or base to the boost converter 90, allowing power flow from the battery 89 to the power bus 119.

If, on the other hand, the sensed battery voltage of a discrete system 115, 116, and/or 117 is below the pre-selected and adjustable minimum power threshold, e.g., 50-percent charged, the
power-pooling device or controller 85 corresponding to that system
115, 116, and/or 117 couples its respective battery 89 to the
power bus 119 via its charge controller 88, to receive power from
the "sharing" system up to the minimum threshold. More
particularly, when the battery sensing device 123 senses that the
battery 89 is inadequately charged, the first solid state device
102 outputs a voltage HI signal (logic 1) and the second solid
state device 103 outputs a voltage LO signal (logic 0). As
previously described, the voltage LO signal de-activates, drives
low, and/or opens the gate or base to the boost converter 90,
preventing power flow from the battery 89 to the power bus 119.
The voltage HI signal activates, drives high, and/or closes the
gate or base to the charge controller 88, allowing power flow from
the power bus 119 to the battery 89.

Once the sensed voltage of the "sharing" system 114 is drawn
down to a stored voltage equal to the minimum power threshold
and/or the other systems 115, 116, and/or 117 no longer need
additional power, the power-pooling device 85 of the "sharing"
system 114 automatically signals the charge controller 88 and
boost converter 90 to isolate its respective battery 89 from the
power bus 119 altogether.

Optionally, power-pooling between systems 114, 115, 116, and
117 can be adapted to cease if an external device, such as a
cellular telephone, a laptop computer, and the like, were coupled
to one of the systems in the connected chain. For example, if an
external device is coupled to one of the systems among the chained
systems, the power-pooling device or controller 85 of that
particular system or the power-pooling devices or controller 85 of
all of the system will no longer deliver or receive power via the
power bus 119. Instead, the particular system will deliver power
to the interrupting, external load.

Alternatively, power-pooling may also be initiated via a
"time sharing" method in which a discrete system receives power
from one or more "sending" systems 114 for a pre-established and
adjustable period of time. As a result, the "receiving" system is charged by one or more of the "sending" systems in the group of connected systems. The power transfer continues for pre-established and adjustable period of time, which, generally, but not exclusively, is measurable in seconds. Optionally, "receiving" system status can rotate from system to system, to top off and optimize each system.

Grouped, portable lighting systems can also be combined to produce more evenly distributed illumination through dynamic power sharing between systems. "Power sharing" allows a group of users or a single user, such as a doctor, to deploy and couple a plurality of grouped systems, which can generate equal light levels for consistent illumination. Indeed, when plural systems are coupled in a group, via the data/power bus 118 and 119 and the switch or switches 79 are turned ON, each system in turn communicates its battery power level to the power-pooling device 85 of every other system in the group.

These data are used by each of the processors 80 or, optionally, by one of the processors 80 that has been adapted to be a master processor, to determine an optimal light level for all loads given the available, collective group power. Systems that are unable to meet this optimal light level individually, e.g., due to low battery levels, will receive power from one or more of the more-fully charged systems via the power transfer method described above in connection with "power-pooling".

FIGs. 18-20 show a few of the myriad of applications of the power-generating source to, for example, a piece of clothing (FIG. 18), e.g., a shirt, blouse, coat, vest, and the like; a carrying bag (FIG. 19), e.g., a lady's handbag, a computer bag, a beach bag, and so forth; and a blanket (FIG. 20A). FIG. 20B shows an exemplary use of the blanket of FIG. 20A.
Universal, Self-structuring, Clean-Energy Lighting and Charging System

"Soft optics" is a term of art that refers to planar or substantially planar, flat patterns of reflective textiles and/or non-woven textiles that are adapted to "pop up", forming useful, three-dimensional forms, e.g., reflectors, solar concentrators, textile lanterns, and other optical forms, through inherent and integrated self-structuring capabilities. As previously discussed, the flat or substantially flat, two-dimensional surfaces can be optimized as textile patterns for mass manufacturing.

Embodiments of universal, self-structuring, lighting and charging systems are shown in FIGs. 23-46. The design of each modular system 200 combines the inherent flexibility of one or more thin-film, solar energy panels 203 that is removably attachable to a first, exterior face 215 with a deformable, self-structuring, curvable, flexible, layered structure having an optically-reflective interior face 228. One or more light-emitting sources 201, e.g., light emitting diodes (LEDs), are integrated into the curvable form, which is adaptable to reflect and to concentrate light from the light source 201 as desired.

As described in greater detail above, the thin-film, solar energy panel(s) 203 absorbs photovoltaic (PV) energy from the sun. The PV energy can be stored, e.g., in a battery or other energy-storing device 218, and/or can be used for lighting or to power other loads electrically coupled to the system 200. The thin-film, solar energy panel(s) 203 is structured and arranged to generate and deliver power ranging from about 1 Watt to several Watts. The solar energy panel(s) 203 includes a surface area of a pre-designated, standardized length and width. Although the solar energy panels 203 shown in the drawings depict a pair of panel modules that are oriented vertically, those of ordinary skill in the art can appreciate that the solar energy panel(s) 203 can be a single module or more than two modules and, moreover, that the
panels 203 can be oriented horizontally as well as at any orientation between horizontal and vertical.

Preferably, the solar energy panel 203 is rectangular in shape and advantageously dimensioned to facilitate rolling the system 200 about itself; conforming one or more of its edges along a curve; and so forth, as is possible with a flexible material e.g., to create a circular, conical, cylindrical, or mobius curve form. By assuming one of these or another form, the systems 200 function as lamp shades, to diffuse the point source light emitted by the light source (s) 201, or as lanterns to concentrate and distribute the light via reflection to illuminate a point or an area.

The thin-film panel 203 is integrated into a layered system that can include at least one of a textile, a non-woven material, a flexible material, and so forth. Layering of the panel 203 can be provided using one or more of sewing, lamination, sonic welding, mechanical fastening and so forth. An interior stiffening layer (not shown) can be provided.

In an energy-charging or energy-storing mode of operation, i.e., "energy harvesting", the system 200 can be mechanically coupled to or placed on or integrated within an object so that the solar energy panel 203 is advantageously facing or substantially facing the PV energy source, i.e., the sun. The size, weight, versatility, and flexibility of the system 200 promote attaching the system 200 to a myriad of mobile and stationary objects, e.g., walls, trees, rocks, tents, backpacks, clothing, and the like. See, e.g., FIGs. 18-20. Means for attaching the system 200 are limitless but can include — for illustration and not for the purposes of limitation — grommets, mechanical fasteners, hanging or lashing cable systems, hook and loop attaching systems, and the like. The orientation of the system 200 on the stationary or mobile object can be substantially horizontally, substantially vertically or any combination thereof.
"Energy harvesting" includes charging an energy storage device 218 that are organic to or integrated into the system 200 as well as to charging energy storage devices that are external to but electrically coupled to the system 200, e.g., through a USB outlet 221, power inlet/outlet portal 222, and the like. Illustrative examples of energy storage devices that can be charged by the system 200 include, without limitation: camera batteries, AA cell batteries, AAA-cell batteries, cell phone batteries, PDA batteries, game station or personal entertainment system batteries, global positioning system (GPS) batteries, and so forth. In addition to charging or re-charging such energy storage devices, the system 200 is further capable of directly powering cell phones, PDAs, game stations, GPS systems, and any other USB-enabled device via the USB port 221, the power inlet/outlet portal 222, and the like.

The design of the system 200 combines energy harvesting, which occurs on a first side 215 with reflective optics on a second, opposite side 228 within a small, compact footprint. The design enables rapid transformation from the energy harvesting mode of operation to a light-emitting mode of operation due to its self-structuring capability.

In order to control "energy harvesting" and to distribute power to the light-emitting device(s) 201, energy storage device 218, external loads, and the like, drive electronics 250 are needed. Some of the particulars of the drive electronics 250 have been discussed in greater detail above. Preferably, the electronics 250 include a pulse width modulation (PWM) or similar controller in order to maximize the illumination time of the light source(s) 201. The drive electronics 250 can also include a boost power converter (not shown) that is structured and arranged to convert relatively low, voltage generated by the solar panels 203 or from the energy-storage devices 218 to an output voltage suitable for a USB-enabled device.
Referring to FIG. 23, the drive electronics 250 include a plug-in printed circuit board (PCB) module 225 that is suitable for 2 Watt (2W) and 4 Watt (4W) solar energy-generating systems 200. This ensures flexibility of use without cost premiums associated with different charge control circuits. The PCB module 225 includes memory, e.g., RAM and ROM, and a processing unit that are adapted to perform all of the functions described herein. The PCB module 225 is protected by a relatively hard structure 223, that encases the circuits, devices, systems, and wiring.

More specifically, the PCB 225 can be protected by a layered, flat-cut corrugated structure 223 that offers good rigidity and high compressive strength. In manufacture, the structure 223 can be rapidly cut by means of laser cutting equipment, without investments in tooling for dies and/or custom moldings. This offers cost and manufacturing advantages over a standard 'posted' electronics structure or hard plastic shell enclosure. Indeed, each layer runs in the opposite direction for strength, some layers have cut-out portions to accommodate the height (vertical dimension) of the internal battery 218 and of selected other electrical components that make up the PCB 225. The various corrugated structure layers that protect the PCB 25 can be fastened together by means of a mechanical fastener 224, e.g., a hook and loop strip and so forth.

Software and/or hardware are/is provided that are/is executable on the processing unit (controller) of the drive electronics 250. The software/hardware can be adapted to create a hard ON/OFF switch 220 function, e.g., to prevent false positives. A false positive occurs in the absence of a hard ON/OFF switch 220 whereby the drive electronics 250 can be turned ON by accident during movement, draining the battery 218. Thus, software/hardware applications prevent unwanted drainage of stored battery power and extend LED 201 lifetime, e.g., by PWM.
Optionally, the drive electronics 250 can include a digital timer (not shown) that tracks accumulated hours of LED light usage and clean energy use. This information may be downloaded, e.g., via the USB port 221, to extract, inter alia, carbon trading value.

A processing function maximizes stored internal power further allowing for direct-drive power output to match standard USB output, i.e., approximately 5 Volts (V) at 150 mA, via the USB port 221. This feature and the USB port 221 enable any USB-enabled device, such as a cell phone, battery charger, GPS, game or personal entertainment systems, medical device, and so forth, to be re-charged directly from the solar panel 203, by-passing the energy storage device 218. In another embodiment, during periods of limited light, power to a USB-enabled device can be provided directly from the internal battery 218, providing a consistent power out from the re-chargeable energy power source 218 that is not dependent on sunlight and/or the sun's orientation with respect to the solar panel 203 surface.

At least one modular port 222 electrically coupled to the PCB 225 enables components and external loads to be electrically coupled to the system 200. This provides greater flexibility. Examples of these modular ports can include a simple, male/female connector, such as for a solar power port 222, a port for an audio headphone (not shown), a rapid removal connector type 229 for an LED 201 and the like.

FIGs. 24-46 show various embodiments of a system 200. Essentially, as shown in FIG. 47 and FIG. 48, each embodiment shows a rectangular or substantially rectangular, flat or substantially flat master pattern. The master pattern includes a first portion, i.e., a first flap 229, and a lower, forming portion that includes a second flap 209 and a third flap 210. Those skilled in the art can appreciate that the size and shape of the master pattern for the portable lighting system 200, the size and number of flaps and folds, and the relative locations of the
flaps and folds can vary appreciably. Equally as variable is the material used and layered in connection with each flap.

A horizontal fold 206 separates the first flap 229 from the lower, forming portion, i.e., the second and third flaps 209, 210, and a slit 213 separates the second flap 209 from the third flap 210. The horizontal fold 206 facilitates placing the first flap 229 in a different plane than at least one of the second and third flaps 209, 210. The slit 213 provides an axis about which the second and third flaps 209, 210 can be folded or overlapped. This basic form provides optical variant designs, to produce integration advantages derived from different pattern forms, different locations of the drive electronics 250 and LED light source (s) 201, and different means of self-structuring. Although the invention is primarily shown and described with patterns that are rectangular or substantially rectangular (for ease of manufacturing and limitation of material waste), non-polygonal patterns, such as circular or oval patterns can also be used, to provide, inter alia, a reflective structure having conical or parabolic forms.

At least one of the flaps 209, 210 in the lower, forming portion includes a control and power management system sleeve or pouch area 202 that is adapted to accommodate the drive electronics 250 and energy storage device 218. Wiring 216 for electrically coupling the drive electronics 250 and battery 218 to the light source (s) 201 is or can be integrated into the fabric of the corresponding flap.

Access to the pouch area 202 can be provided through the slit 213, e.g., between the plies of the reflective textiles and/or non-woven textiles. Optionally, a separate access 233 for inserting or removing a USB smart stick into the USB portal 221 or for inserting or removing another input/output device into another portal 222 in the drive electronics 250 can be provided. The means for accessing the pouch area 202 can be closed and secured to protect the drive electronics 250 from the
environment and/or to prevent the drive electronics 250 from falling out, e.g., using metal or plastic fasteners, a metal or plastic zipper, magnets, hook and loop strips, and the like.

A light-emitting source 201 is integrated into at least one of the flaps 209, 210, 228. FIG. 36 shows an embodiment with a light-emitting source 201 integrated into the first flap 228. FIG. 24 shows an embodiment with a light-emitting source 201 integrated into the third flap 210. Preferably, the light-emitting source 201 is arranged in a portion of the flaps that includes internal stiffeners and that are adapted to maintain the light-emitting source 201 and the portion of the flap at some angle to the plane of the flap when the light-emitting source 201 and flap are folded about the fold 207. Stiffeners can include, without limitation, a plastic, mesh, or metal insert, a wire armature, an articulating hinge, and so forth. Those of ordinary skill in the art can appreciate that stiffeners are not required as will be discussed below in connection with FIGs. 33-35.

FIG. 49A and FIG. 49B, respectively, provide plan and side views of an exemplary method of integrating the modular light-emitting source 201 shown in FIG. 21 into a portion of one of the flaps. Those skilled in the art can appreciate that there are a myriad of ways of disposing a light-emitting source 201 within a pocket-like sleeve 237. The pocket-like sleeve 237 can include stiffeners so that when a potion 231 of the pocket-like sleeve 237 is folded about a fold line 206, the portion folded 231 serves to retain the light-emitting source 201 at some angle above the plane of the flap. Additionally, the pocket-like sleeve 236 can include lines of fastening 236, to further define the position of the light-emitting source 201 and to minimize movement thereof.

FIGs. 24-26 show a first system 200 in which the drive electronics 250, the energy storage device 218, and the light-emitting source 201 are all integrated into either the second flap
209 or the third flap 210. The slit 213 enables the user to position the third flap 210 above the second flap 209 or vice versa. In either instance, the overlap pulls the ends of the first flap 228 towards each other, introducing tension into the energy-generating source 203. The inherent bending resistance of the energy-generating source 203 introduces surface tension into the flexible material as the energy-generating source 203 tries to return to its planar shape, which produces a self-structuring capability.

As illustratively shown, wiring 216 electrically couples the PCB 225 to the light source 201 within the third flap 210. Wiring 219 also electrically couples the PCB 225 to the energy storage device 218. Additional wiring (not shown) electrically couples the PCB 225 to the energy-generating source 203. A marked area 214 on the third flap 210 is provided to be in registration with the ON/OFF switch 220.

The controller or processor on the PCB 225 is adapted to control the flow of power from the energy-generating source 203 to the energy storage device 218 or to the light-emitting source 201, between the energy storage device 218 and the light-emitting source 201, and so forth. Optionally, as shown in FIG. 39, the energy-generating source 203 can be located remote from the light-emitting source 201, drive electronics 250, and reflective material 228. Wiring 217 electrically couples the PCB 225 to the remote energy-generating source 203.

Stiffeners can be integrated throughout the third flap 210 or within a specific area, e.g., proximate the light-emitting source 201. Stiffeners can include, without limitation, a plastic, mesh, or metal insert, a wire armature, an articulating hinge, and so forth. The stiffeners are structured and arranged to enable the user to bend the stiffeners and the light-emitting source 201 about a fold 207 so that (as shown in FIG. 26), the light-emitting source 201 is disposed above the plane of the overlap flaps 209, 210.
Light from the light-emitting source 201 is reflected by the specular reflective material that is disposed on or integrated into the first flap 228. Suitable specular reflective materials can include, without limitation, a metal-spluttered, e.g., aluminum-spluttered, non-woven or textile material (such as those manufactured by PGI, Inc.), a metal-spluttered or metal-deposited laminated surface, a metallic plastic laminated surface, a reflective, micro-etched plastic material (such as optical films manufactured by General Electric or 3M), and the like. Optionally, specular reflective material can also be disposed on or integrated into the second and third flaps 209, 210.

The reflected light and the self-structure produce a lantern-like device. A hook or loop strip 205 can be provided to hang the lantern. Examples of hanging lanterns are shown in FIG. 40 (suspended from above) and FIG. 41 (hanging from a vertical support).

FIGs. 27-29 show a second system 200 in which the drive electronics 250 and the energy storage device 218 are integrated into the second flap 209 while the light-emitting source 201 is all integrated into the third flap 210. The flap 210 having the light-emitting source 201 shown is triangular or substantially triangular in shape, making the slit 213 larger and more open. Notwithstanding, the slit 213 enables the user to position the third flap 210 above the second flap 209 or vice versa. In either instance, the overlap places the energy-generating source 203 into tension. Bending resistance in the energy-generating source 203 creates the self-structuring capability.

Stiffeners can be integrated throughout the third flap 210 or within a specific area, e.g., proximate the light-emitting source 201. The stiffeners are structured and arranged to enable the user to bend the stiffeners and the light-emitting source 201 so that, the light-emitting source 201 is disposed above the plane of the overlap flaps 209, 210. Light from the light-emitting source 201 is reflected by the reflective material 228.
Optionally, specular reflective material can also be disposed on or integrated into the second and third flaps 209, 210. The reflected light and the self-structure produce a lantern-like device. A hook or loop strip 205 can be provided to hang the lantern.

Optionally, at the end of the second flap 209, proximate the light-emitting source 201, a light filter 229, e.g., a translucent vinyl filter or lens, and a securing loop 230 can be provided. The light filter 229 can be folded over the light-emitting source 201 and secured within the securing loop 230. Red light filters 229, for example, are particularly useful to users who desire to preserve their vision purple.

FIGs. 30-32 show a third system 200 that is substantially the same as that shown in FIGs. 24-26 with the addition of an extension 231 on which the light-emitting source(s) 201 is integrated. Stiffeners can be integrated throughout the second flap 209 or within a specific area, e.g., proximate the light-emitting source 201. The stiffeners are structured and arranged to enable the user to bend the stiffeners and the light-emitting source 201 about a fold 207 so that, the light-emitting source 201 is disposed above the plane of the overlap flaps 209, 210.

Light from the light-emitting source 201 is reflected by the reflective material 228. Optionally, specular reflective material can also be disposed on or integrated into the second and third flaps 209, 210. The reflected light and the self-structure produce a lantern-like device. A hoof or loop strip 205 can be provided to hang the lantern.

FIGs. 33-35 show a fourth system 200 substantially the same as that shown in FIGs. 30-32 having a longer extension 231 on which the light source(s) 201 is integrated. Optionally, in lieu of stiffeners, the extension 231 is adapted to include a plurality of hook and corresponding loop portions 204 that are arranged so that the light-emitting source(s) 201 can be elevated above the plane of the overlapping flaps 209, 210. This embodiment allows
for the integration of the flap 215 to be attached onto or into, for example, a carry bag, as suggested in Fig. 19. The extended strap 231 and the LED 201 are adapted to attach onto the carry bag itself or onto its carrying strap to enhance way-finding and/or to illuminate a reflective surface on the carry bag, to improve nighttime safety of the user.

FIGs. 36-38 show a fifth system 200 substantially the same as that shown in FIGs. 24-26 except that the light-emitting source 201 and wiring 216 are integrated into the first flap 228. Stiffeners can be integrated throughout the first flap 228 or within a specific area, e.g., proximate the light-emitting source 201. The stiffeners are structured and arranged to enable the user to bend the stiffeners and the light-emitting source 201 so that, the light-emitting source 201 is disposed above the plane of the first flap 228, parallel or substantially parallel to the overlapping flaps 209, 210.

FIGs. 41-45 show embodiments in which there are no plural lower, forming flaps but, rather, a single lower flap 211. Referring to FIG. 42, the light-emitting source 201 and wiring 216 and the energy-generating source 203 and wiring 217 are disposed in and/or integrated into the first flap 228. The drive electronics 250 and the energy storage device 218 are integrated into the lower flap 211. Stiffeners can be integrated throughout the first flap 228 or within a specific area, e.g., proximate the light-emitting source 201. The stiffeners are structured and arranged to enable the user to bend the stiffeners and the light-emitting source 201 about a fold 207 so that, the light-emitting source 201 is disposed where desired.

FIG. 43 shows an embodiment of FIGs. 41 and 42 that has been formed by bending the light-emitting source 201 towards a planar or substantially planar lower flap 211. Light from the light-emitting source 201 is reflected by the reflective material 228. Optionally, specular reflective material can also be disposed on or integrated into the lower flap 211. The reflected light and
the self-structure produce a desk lamp-like or task lighting structure.

FIG. 45 shows an embodiment of FIGs. 41 and 42 that has been formed by bending the system 200 into a mobius curve, creating one or two curved surfaces for lighting in a hanging or wall-mounted system or a standing, upright lighting system. FIG. 46 shows an embodiment of FIGs. 41 and 42 that has been formed by bending the system 200 into a ribbon with the light-emitting source 201 disposed below and inside of the reflective material 228, to provide an ambient or diffused lighting system.

FIG. 49 and FIG. 50 show, respectively, a pattern 310 for a solar reflection and a formed solar reflector 300 resulting from said pattern 310. The pattern 310 includes a plurality of folds 306 and 308, a plurality of openings 304, and a central opening 302. The first plurality of folds 308 is provided between adjacent first portions 301 and the second plurality of folds 306 is provided between a first portion 301 that is adjacent to a second portion 303 in which the surface area of the second portion 303 is greater than the surface area of the first portion 301.

More specifically, the first and second portions 301 and 303 and the first and second pluralities of folds 308 and 306 are structured and arranged so that when adjacent first portions 301 are folded about each first fold 308, they create a fin 307 as shown in FIG. 50 and that when an adjacent first portion 301 and an adjacent second portion 303 are folded about each second fold 306, they create an elongate portion 309. Furthermore, when folded, the free ends 311 of the second portion 303 form an open end 305 that is opposite the central opening 302.

In operation, the central opening 302 is positioned so as to align with the rays of the sun. The rays enter the plenum portion 315 of the solar reflector 300 and are reflected and deflected by the reflective material disposed on or integrated into the inner surface 312 of the solar reflector 300. The reflected light exits the open end 305 of the solar reflector 300.
It will be apparent to those skilled in the art that modifications to and variations of the disclosed method and system are possible without departing from the inventive concepts disclosed herein, and therefore the invention should not be viewed as limited except to the full scope and spirit of the appended claims.
What I claim is:

1. A self-structuring, portable lighting and power system integrated into a flexible-layered structure, the flexible-layered structure having an exterior face on one side thereof and an interior face on an opposite side thereof, the system comprising:
   - a thin-film, flexible, power-generating source that is removably attachable from or integrated within the exterior face;
   - a reflective optics material that is disposed on the interior face;
   - at least one light-emitting source that is proximate the interior face for directing light onto the reflective material;
   - a power storage device; and
   - a processing system for controlling and managing power-generated by the power-generating source,

   wherein each of the at least one light-emitting source, the power-generating source, the power storage device, and the processing system are integrated into the flexible-layered structure, which further includes stiffening means for self-structuring the system and/or for orienting said at least one light-emitting source.

2. The portable lighting system as recited in claim 1, wherein the at least one light-emitting source is selected from the group consisting of a high-brightness light-emitting diodes; light-emitting fibers that are woven into the flexible-layered material; flat or substantially flat organic light emitting diodes that are woven into the flexible-layered material; light-emitting strips of electroluminescent film that are woven into the flexible-layered structure; inorganic, flat or substantially flat solid-state lighting devices that are disposed between layers of the flexible-layered structure a light-emitting device that emits light in the
infrared-to-red spectrum or a light-emitting device that emits light in the ultraviolet spectrum.

3. The portable lighting system as recited in claim 1, wherein the power-generating source includes at least one photovoltaic cell or panel selected from the group consisting of amorphous silicon photovoltaic cells or panels, copper indium gallium diselenide-based photovoltaic cells or dye-based organic photovoltaic cells.

4. The portable lighting system as recited in claim 1, wherein the power storage device is a rechargeable battery.

5. The portable lighting system as recited in claim 1, wherein the processing system is adapted to deliver power generated by the power-generating source to the power storage device.

6. The portable lighting system as recited in claim 1, wherein the processing system is adapted to perform pulse width modulation on power delivered to the at least one lighting source.

7. The portable lighting system as recited in claim 1, wherein the flexible-layered structure is a layered textile structure of woven or non-woven, natural or man-made fibers that have been joined using sewing, sonic-welding or heat lamination manufacturing techniques.

8. The portable lighting system as recited in claim 7, wherein the woven or non-woven, natural or man-made fibers are materials selected from the group consisting of flexible plastic sheets, natural leather materials, artificial leather materials, reflective textile materials, opaque textile materials, translucent textile materials, light-diffusing materials, and specular reflective materials.
9. The portable lighting system as recited in claim 1, wherein the flexible-layered structure includes a plurality of flaps and folding areas that can be folded, rolled, or overlapped.

10. The portable lighting system as recited in claim 9, wherein the power generating source is attached to a first flap that is separated from a second flap portion by a folding area, the second flap portion comprising:
   a second flap; and
   a third flap, the third flap being separated from the second flap by a slit that facilitates positioning the second flap on top of the third flap or positioning the third flap on top of the second flap.

11. The portable lighting system as recited in claim 10, wherein the at least one of the second flap and the third flap includes a control and power management system sleeve that is adapted to hold the processing system and the power storage device.

12. The portable lighting system as recited in claim 10, wherein the at least one light-emitting source is removably attached to at least one of the first flap, the second flap, and the third flap.

13. The portable lighting system as recited in claim 12, wherein the at least one of the first flap, the second flap, and the third flap includes one or more stiffeners for orienting the at least one light-emitting source.

14. The portable lighting system as recited in claim 1, wherein the processing system includes at least one of:
   a USB portal for electrically coupling a USB device to the processing system via a bus; and
a power outlet for electrically coupling an external load to the processing system via a bus.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - H01 L 31/042 (2010.01)
USPC - 136/244

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8) - H01L 31/04, 31/042, 31/045 (2010.01)
USPC - 136/243-45, 252, 263, 293; 362/192, 227, 249.01, 249.02, 249.03, 249.04, 551, 555

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
MicroPatent, Google Patents, Google Scholar

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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<tbody>
<tr>
<td>X</td>
<td>US 2008/0079368 A1 (KENNEDY et al) 03 April 2008 (03.04.2008) see document</td>
<td>1-14</td>
</tr>
<tr>
<td>A</td>
<td>US 2006/0130894 A1 (GU et al) 22 June 2006 (22.06.2006) see document</td>
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<td>A</td>
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<tr>
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<td>US 6,046,401 A (MCCABE) 04 April 2000 (04.04.2000) see document</td>
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Further documents are listed in the continuation of Box C.

* Special categories of cited documents:
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Date of mailing of the international search report 02 DEC 2010

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