

VERTICAL MICRO CAVITY (VMC) AND METHODS OF USING IT FOR PRODUCTION OF ELECTRICITY

TECHNOLOGICAL FIELD

- 5 The present invention is generally in the field of the production of electrical energy from optical cavities by photo-transducing materials.

BACKGROUND ART

References considered to be relevant as background to the presently disclosed subject matter are listed below:

- 10 [1] R. Brandenberger *et al.*, "Graviton to photon conversion via parametric resonance", Physics of the Dark Universe 40 (2023) 101202.
- [2] J. Adam *et al.* (STAR Collaboration) "Measurement of $e^+ e^-$ Momentum and Angular Distributions from Linearly Polarized Photon Collisions", Phys. Rev. Lett 127, 2021.
- 15 [3] A. C. Elbeze "On the existence of another source of heat production for the earth and planets, and its connection with gravitomagnetism" SpringerPlus.2013 2, 513. doi: 10.1186/10.1186/2193-1801-2-513 (2013).
- [4] Sagnac, Georges (1913). "On the proof of the reality of the luminiferous aether by the experiment with a rotating interferometer", Comptes Rendus, 157: 1410–1413.
- 20 [5] Albert Einstein 1907 "Über das Relativitätsprinzip und die aus demselben gezogenen Folgerungen", Jahrbuch der Radioaktivität und Elektronik, 4, 411-462.

BACKGROUND

This section intends to provide background information concerning the present application, which is not necessarily prior art.

- 25 There are different techniques to capture and store photons inside a trap/retaining device configured to confine/store photons for a certain period of time. Photons are massless and difficult to capture and retain. For example, some known photons trapping techniques; cavity quantum electrodynamics (CQED) using an optical cavity that can trap photons for relatively long time periods, Anderson localization using disordered mediums having a random
- 30 distribution of impurities capable of causing photon scatterings and storage, nano-plasmonics

using nanoscale metal structures having very high refractive index capable of bending and trapping light rays.

Optical resonance cavities (also known as resonating cavities or optical resonators) utilize reflective elements to confine light within their cavities by causing multiple reflection of the light inside the cavity. The repeated reflection of the light waves inside the cavity causes wave pattern modes with characteristic resonance frequencies determined by the length of the cavity and optical properties of the transmissive medium within the gap between the reflective elements. The wave modes inside the cavity can be decomposed into longitudinal wave modes that differ in their frequency, and transverse wave modes that have different sectional intensity patterns. Many types of optical cavities are designed to achieve standing wave modes.

Optical resonant cavities typically define a small space enclosed by reflective elements/mirrors fixed at their ends in resonance with the frequency of the photons they are designed to trap, such that when photons enter the cavity they are reflected back and forth therebetween, thereby trapping the photons thereinside for relatively long time periods. For example, a Fabry-Perot cavity utilizes a pair of mirrors that are separated by a small distance and aligned such that they reflect light back and forth between them, thereby creating a standing wave of light, which frequency is determined by the distance between the mirrors. As another example, some optical cavities are filled with a material that has a high refractive index for the photons to travel more slowly inside the cavity, thereby supposedly increasing the length of the cavity and trapping photons thereinside with a wider range of wave modes.

Electricity can be produced from light photons by devices (*e.g.*, solar cells) exploiting the photoelectric and/or photovoltaic effect, for example. Photoelectric based devices utilize the emission of electrons from metal surfaces, when they absorb enough light energy to overcome the electrons' binding energy, to generate electric power. In photovoltaic based devices, an electric current is formed in a semiconductor material exposed to light energy due to the separation and migration of charge carriers (electrons and holes) in the semiconductor material. Solar modules (generally referred to herein as photo-transducer material or layer) are electrical power sources comprising a plurality of photo transducer solar cells *e.g.*, exploiting the photoelectric or photovoltaic effect, configured to convert light energy into electricity.

US Patent Publication No. 2009/101192 discloses color photovoltaic (PV) devices formed using interferometric stacks tuned to reflect color covering the front side or back side of a PV cell, device, panel, or array. Interferometric stacks covering PV devices include interferometric modulators (IMODs), or dichroic pair stacks. Such devices can be configured

to reflect enough light of selected wavelengths so as to impart a color, while transmitting enough light to the PV active material so as to generate useful electricity.

US Patent Publication No. 2010/096006 discloses devices incorporating an interferometric stack in a photovoltaic device and method of manufacturing a photovoltaic device comprising an interferometric stack. In one example, a photovoltaic device includes a photovoltaic active layer, an absorber layer, and a first optical resonant cavity layer. The optical resonant cavity layer is disposed between the absorber layer and photovoltaic active layer forming an interferometric modulator. The interferometric modulator is configured to reflect a uniform color. In another example, a method of manufacturing a photovoltaic device includes depositing a photovoltaic active layer on an interferometric stack. The interferometric stack can include an absorber layer and a first optical resonant cavity. The photovoltaic active layer is deposited on the optical resonant cavity and the formed photovoltaic device reflects a uniform color.

US Patent Publication No. 2007/113887 discloses a photovoltaic cell with a resonance cavity. A first structure of reflection is attached toward one side of the resonance cavity and configured for reflecting light beams from the resonance cavity. The second structure of reflection is attached toward other side of the resonance cavity and configured for reflecting light beams from exterior and the resonance cavity. Thus, photons will be absorbed efficiently within the resonance cavity and converted into electrons.

US Patent Publication No. 2010/224248 discloses solar modules and related manufacturing methods. In one embodiment, a solar module includes: (1) a photovoltaic cell; and (2) a resonant cavity waveguide optically coupled to the photovoltaic cell, the resonant cavity waveguide including: (a) a top reflector; (b) a bottom reflector; and (c) an emission layer disposed between the top reflector and the bottom reflector with respect to an anti-node position within the resonant cavity waveguide, the emission layer configured to absorb incident solar radiation and emit radiation that is guided towards the photovoltaic cell, the emitted radiation including an energy band having a spectral width no greater than 80 nm at full width at half maximum.

US Patent Applications No. 2010/096006 discloses devices incorporating an interferometric stack in a photovoltaic device and method of manufacturing a photovoltaic device comprising an interferometric stack. In one example, a photovoltaic device includes a photovoltaic active layer, an absorber layer, and a first optical resonant cavity layer. The optical resonant cavity layer is disposed between the absorber layer and photovoltaic active layer forming an interferometric modulator. The interferometric modulator is configured to reflect a

uniform color. In another example, a method of manufacturing a photovoltaic device includes depositing a photovoltaic active layer on an interferometric stack. The interferometric stack can include an absorber layer and a first optical resonant cavity. The photovoltaic active layer is deposited on the optical resonant cavity and the formed photovoltaic device reflects a uniform color.

International patent publication No. WO 2022/249112 discloses a film for a photovoltaic cell having increased absorptivity and emissivity, and methods for producing such a film.

US patent publication No. 2013/284264 discloses solar modules including spectral concentrators. In one embodiment, a solar module includes a set of photovoltaic cells and a spectral concentrator optically coupled to the set of photovoltaic cells. The spectral concentrator is configured to: (1) collect incident solar radiation; (2) convert the incident solar radiation into substantially monochromatic, emitted radiation; and (3) convey the substantially monochromatic, emitted radiation to the set of photovoltaic cells..

In US patent publication No. 2020/209656 discloses a single-photon light source comprises a photonic crystal structure the lattice of which extends in at least two dimensions and includes a crystal defect defining an optical waveguide for guiding optical radiation emitted within the photonic crystal. An electric field generator is operable to apply an electric field to the photonic crystal. A light emitter selected from: a quantum dot; a quantum well; a light-emitting diode (LED), is arranged within the photonic crystal for responding to the electric field to acquire an excited state and by decaying from the excited state thereby emitting optical radiation into the photonic crystal for guiding by the optical waveguide. The single-photon light source may be used as part of a quantum key distribution transmitter. An integrated single-photon detector is disclosed as part of a quantum key distribution receiver..

GENERAL DESCRIPTION

Attempts to combine photovoltaic materials with optical cavities usually utilize photovoltaic structures enclosed between reflective elements of the optical cavity, for production of electrical energy from photons trapped inside the optical cavities. These configurations are designed for absorbance of the light photons in the photovoltaic structures inside the cavities, but they inevitably spoil the quality (Q) factor of the optical cavities due to the presence of optical media having poor transmissive properties therewithin, which reduces the number of times the light photons can be reflected back and forth therein.

The present application discloses opto-electric power sources utilizing specially designed photon trapping and storing structures (also referred to herein as photons retaining assemblies) configured for increased photon storage time periods and amplification of the trapped photons, and generation of electricity from the trapped photons by photo-transducer material/layer(s) externally optically coupled thereto. Optionally, but in some embodiments preferably, each, or a group, of the photons retaining assemblies is at least partially wrapped by the photo-transducer material/layer(s) *e.g.*, surrounding at least lateral sides of the photons retaining assemblies, and is possible embodiment also covering top and/or bottom sides thereof.

In possible embodiments the photons retaining assemblies are implemented by a plurality of optical resonant microcavities (*e.g.*, having thickness of few micrometers or nanometers and a diameter of few tens of micrometers or nanometers) arranged to form a three-dimensional array having multiple columns of the photons retaining assemblies arranged in one or more rows, where each column comprising few hundreds (or about a thousand) of the photons retaining assemblies stacked one on top of the other.

In this arrangement, light photons escaping out of one of the photons retaining assemblies are likely to be absorbed in one or more photons retaining assemblies adjacently located thereto in the same column of photons retaining assemblies, or in an adjacently located column of the photons retaining assemblies, such that only small amounts of the light photons can escape out of the three-dimensional array of photons retaining assemblies. In possible embodiments the light photons that are likely to escape the array of photons retaining assemblies are the photons which undergone multiple prolonged bouncing in one or more of the photons retaining assemblies until their energies are sufficiently amplified. These light photons, as they escape the array of photons retaining assemblies, are absorbed in the photo-transducer material/layer(s) at least partially surrounding the array of photons retaining assemblies.

The columns of photons retaining assemblies can be optically coupled to one, two, or more, reflective elements (mirrors) at their extremities configured to reflect light photons escaping the three-dimensional array of photon trapping and storing structures back into its optical resonant microcavities. Each array of the optical resonant microcavities can be similarly at least partially wrapped by the photo-transducer material/layer(s) for surrounding at least lateral sides of the array of photons retaining assemblies, and is possible embodiment also top and/or bottom sides thereof.

In possible embodiments, each three-dimensional array of the photons retaining assemblies is optically coupled to one or more light (*e.g.*, laser LEDs) sources configured to periodically or intermittently introduce light beams into the photons retaining assemblies of the

array. One or more control circuitries can be used to activate the one or more light sources whenever it is determined that the electrical power produced by the photo-transducer material/layer(s), that at least partially surrounds the photons retaining assemblies, is diminishing (*e.g.*, beyond a certain threshold level). This way, the array of photons retaining assemblies can be periodically or intermittently replenished with new light photons, to prevent undesired diminish or stoppages in the electrical power production by the photo-transducer material/layer(s).

For example, each three-dimensional array of the photons retaining assemblies can be formed on a substrate (printed circuit board – PCB) comprising one or more of the light sources configured to introduce light beams into the photons retaining assemblies of the array. The substrate can further include one or more of the control circuitries configured to periodically or intermittently activate the one or more light sources *e.g.*, whenever it is determined that the electrical power produced by the photo-transducer material/layer(s), that at least partially surrounds the photo-transducer material/layer(s), is reduced below a predetermined threshold.

Optionally, each column of the three-dimensional array of photons retaining assemblies is optically coupled to a respective light source *e.g.*, provided in the substrate. Each column of the three-dimensional array of photon trapping and storing structures can be similarly coupled to respective one, two, or more, reflective elements (mirrors) at its extremities configured to reflect light photons escaping the three-dimensional array back into the column of the photons retaining assemblies.

Opto-electric power sources disclosed herein utilize photon trapping and storing structures configured to cause back and forth bouncing of light photons in a direction that substantially coincides with the direction of the earth/planet gravity field, and therefore referred to herein as vertical-bounce photon trapping and storing structures, or vertical-bounce photons retaining assemblies. The multiple interactions of the light photons bouncing inside the vertical-bounce photon trapping and storing structures with the gravity field of the planet/earth amplify the power and/or number of light photons trapped inside the vertical-bounce photon trapping and storing structures, thereby facilitating escape of high energy photons out of the vertical-bounce photon trapping and storing structures and/or emergence of new light photons bouncing thereinside to continuously proceed and repeat this process. The vertical-bounce photons retaining assemblies can be arranged in columns, arrays and/or matrices, as disclosed herein.

In possible embodiments a plumb line coupled to the vertical-bounce photons retaining assembly, or to a two-dimensional array or a three-dimensional array of such vertical-bounce photons retaining assemblies, can be used to guarantee that the direction of motion of the

photons bouncing thereinside substantially coincides with the direction of the earth/planet gravity field. Optionally, a plumb line and/or gyroscopic sensor is used to measure and align the orientation of the vertical-bounce photons retaining assemblies, to set the direction of motion of the photons bouncing thereinside to substantially coincide with the direction of the earth/planet gravity field *e.g.*, using a closed loop control scheme and orientation adjusting actuators coupled thereto.

In some embodiments the vertical-bounce photons retaining assemblies are implemented by photonic crystals configured to trap and/or generate light photons to bounce thereinside in a direction that substantially coincides with the direction of the gravity field of the planet/earth. This is achieved in some embodiments by aligning the direction of spins of the atoms of the photonic crystal in a desired direction (*e.g.*, by applying an external magnetic and/or electric field). This way, the light photons trapped inside the photonic crystal can be caused to repeatedly bounce in a direction substantially coinciding with the direction of the gravitation field of the planet/earth, thereby amplifying the energy of the trapped light photons and/or generating new light photons to repeatedly bounce thereinside in the same direction so as to continuously repeat this process.

In possible applications, the spins of the atoms of the photonic crystal are set into a desired direction (*e.g.*, substantially parallel to/coinciding with the direction of the planet/earth's gravity field) by applying a very strong magnetic field (*e.g.*, of the order of the one Tesla in the desired spin direction). The setting of the spin direction of the atoms of the photonic crystals can be carried out once during production under manufacture/laboratory conditions.

Light photons which energy been substantially amplified inside the vertical-bounce photons retaining assemblies can then escape out of the photonic crystals and become absorbed in the photo-transducer material/layer(s) at least partially surrounding the vertical-bounce photons retaining assemblies. In some embodiments the photonic crystals are configured from a certain type of charge carrying (*e.g.*, p-type or n-type) semiconductor, which can be employed for affecting release of electrons responsive to the high energy photons generated thereinside, and/or for generating new photons by application of electric field/current thereto. This configuration is utilized in some embodiments to produce electric current by combining p-type and n-type semiconductor photonic crystals to form a depletion region adjusted to permit migration of charge carriers between the p-type and n-type semiconductor photonic crystals, and/or *vice versa*.

As another example, in some embodiments the vertical-bounce photon trapping and storing structures are implemented by optical resonant (*e.g.*, a Fabry-Perot) cavity units

configured such that the optical axis of the reflectors of the optical resonant cavity coincides with the direction of the earth's gravity (referred to herein as vertical-bounce optical resonant cavity). In such possible embodiments the reflectors of the optical resonant cavities are mounted substantially perpendicular to the direction of the earth/planet's gravity field (*e.g.*, such that their reflector/side surface are substantially parallel to the earth/planet surface), so that the bouncing direction of the light photons trapped therein coincides with the direction of the gravity field of the planet/earth.

Concaved reflectors can be used in the optical resonant cavity of possible embodiments to cause the trapped light photons bouncing therein to gradually converge their motion trajectories to the optical axis of the concave reflectors/mirrors, and thereby coincide with the direction of the gravity field of the planet/earth. In preferred embodiments the vertical-bounce optical resonant cavity comprises a resonant vacuum gap (*e.g.*, of few micrometers) defined between a pair of high reflectance reflectors/mirrors for relatively prolonged storage times periods of the trapped light photons in the resonant cavity.

As explained above, the light photons trapped inside the vertical-bounce photons retaining assemblies disclosed herein are made to interact with the planet's gravitational field, whose direction is collinear with the bouncing direction of the light photons trapped therein. When the trapped light photons interact with the gravitational field [1] [2] (*i.e.*, a reaction occurring between the Earth's gravitational field and the energies of the light photons bouncing in the vertical-bounce photons retaining assembly, they gain energy as they bounce back and forth in the direction of the planet's gravitational field. In this configuration the bouncing light photons lose energy when they move in a direction opposite to the direction of the planet's gravitational field, and gain energy when they move in the direction of the planet's gravitational field. This phenomenon is similar to the Sagnac effect [5], and it is easily interpreted by considering Einstein's equivalence principle [6], in accordance with which the acceleration produced at the edge of a rotating disc of radius R can be considered to be identical to the action of a gravitational field Υ (*i.e.*, being equal to the product $R \cdot \omega$, wherein R is the radius of the rotating disc and ω is its' angular velocity) produced by a mass M (see *e.g.*, **Fig. 6**).

The total sum of the energies thus acquired by the trapped light photons during a complete bounce cycle in the vertical-bounce photons retaining assemblies hereof gives a total positive energy gain for the trapped light photons due to the interaction with the gravity field. The energy thus acquired by the trapped light photons present in the vertical-bounce photons retaining assemblies is calculated easily with the GEAR mathematical model (which physical and mathematical frameworks are described in [3]).

This way, light photons trapped inside the vertical-bounce photons retaining assemblies hereof interact with the gravitational field of the earth/planet for amplifying the power and/or number of light photons trapped thereinside.

In some embodiments the vertical-bounce photon trapping and storing structures of the
5 opto-electric power sources are configured to form an array/matrix (*e.g.*, a three-dimensional matrix formed by two-dimensional arrays, each comprising several hundreds vertical-bounce photon trapping and storing structures) of optical resonant cavities optically coupled to the photo-transducer material/layer(s) for conversion of light photons lost by/escaping the optical cavities (these photons represent a minority of the photons trapped inside the optical cavities)
10 into a stream of electrons (*e.g.*, utilizing photovoltaic cells). The electrons' stream generated by the opto-electric power source can be stored in a high value capacitive element of an electricity supply system.

In possible embodiments, the vertical-bounce photon trapping and storing structures are implemented by photonic crystals of very small dimensions (*e.g.*, of a few micrometers)
15 enriched with atoms (impurities) having spontaneous emission-absorption properties of photons. These atom-photon pairs are configured for a vertical bounce of photons, which is achieved in some embodiments by using electro-magnetic field that aligns the spin of the atom-photon pairs with the vector acceleration of the earth.

A plurality of the opto-electric power sources disclosed herein can be packaged and
20 electrically (*e.g.*, serially and/or in parallel) connected to provide a stable and reliable electric power source usable for powering electrical appliances.

In one aspect there is provided an opto-electric power source comprising one or more photon trapping and storing structures configured for back and forth bouncing light photons trapped inside a vacuum cavity thereof, and photo-transducer material/layer(s) at least partially
25 wrapping the one or more photon trapping and storing structures for generation of electrical power from photons escaping the photon trapping and storing structures. The photon trapping and storing structures are configured in some embodiments to cause back and forth bouncing of light photons in a direction that substantially coincides with a direction of a gravity field.

The photon trapping and storing structures can be arranged to form a flat two-
30 dimensional array, or one or more stacks of the photon trapping and storing structures, or of the flat two-dimensional arrays, such that they are optically coupled and stacked one on top of the other for light photons escaping one of the plurality of the photon trapping and storing structures to be absorbed in another one of the plurality of the photon trapping and storing structures in the stack.

Optionally, the photo-transducer material/layer(s) at least partially wraps the flat two-dimensional array, or the one or more stacks, of the photon trapping and storing structures. The opto-electric power source comprises in some embodiments top and bottom reflective elements optically coupled to top and bottom extremities of the one or more stacks of the photon trapping and storing structures respectively, for reflecting light photons escaping the stacks of photon trapping and storing structures back into the stacks.

In possible applications the opto-electric power source comprises one or more light photon sources (*e.g.*, a celestial source/the sun, synchrotron radiation, electric light source, radioluminescence compositions, or suchlike) optically coupled to the stacks of the photon trapping and storing structures for introducing beams of (*e.g.*, light) photons thereinto. The opto-electric power source can have control circuitry configured to receive a measure of electric power produced by the photo-transducer material/layer(s), and activate the one or more light photon sources whenever the measure of electric power is below a determined value, for introducing light photons thereinto.

Optionally, but in some embodiments preferably, the photon trapping and storing structures are implemented by resonant optical cavities. For example, the resonant optical cavities can be a type of Fabry-Perot cavity. The resonant optical cavity can be configured with a resonant vacuum gap defined between two or more reflective elements (*e.g.*, high reflectance mirrors). The reflective elements of the resonant optical cavity are configured in some embodiments to define an optical axis of the resonant optical cavity substantially coinciding with a gravity field.

In another aspect there is provided an electric power source comprising one or more crystal cavities, each one of the one or more crystal cavities comprising a plurality of lattice impurity atoms and a plurality of light photons trapping lattice vacancies, an electron-hole excitation source configured to excite atoms of the one or more crystal cavities, photo-transducer material/layer(s) at least partially wrapping the one or more crystal cavities for generation of electrical power from photons escaping the crystal cavities. Optionally, the excitation source is an electrical or optical source.

The electric power source comprises in some embodiments a field generator configured to apply electric and/or magnetic field to the one or more crystal cavities for aligning electron spins of atoms thereof in a defined orientation, to thereby set bounce direction of light photons trapped inside the one or more crystal cavities to substantially coincide with direction of a gravity field. In possible applications the electric power source comprises n-type and p-type charge carrier components formed one beside the other in at least one of the crystal cavities to

form a depletion area therebetween, and electrically conducting contacts electrically coupled to the n-type and p-type charge carriers for passage of electric current therebetween due to migration of charge carrier across the depletion region.

In yet another aspect there is provided an electric power source comprising n-type and
5 p-type charge carrier materials formed one beside the other to form a depletion area therebetween in a crystal cavity comprising a plurality of lattice impurity atoms and a plurality of light photons trapping lattice vacancies, an electron-hole excitation source configured to excite atoms of the one or more crystal cavities, and electrically conducting contacts electrically coupled to the n-type and p-type charge carriers for passage of electric current therebetween
10 due to migration of charge carrier across the depletion region.

In yet another aspect there is provided electricity production method comprising optically coupling photo-transducer material/layer(s) to one or more sides of one or more photon trapping and storing structures having vacuum cavities, trapping light photons inside vacuum cavities of the one or more photon trapping and storing structures for generation of
15 electrical power by light photons escaping the vacuum cavities and absorbed in the photo-transducer material/layer(s). The method can comprise mounting the photon trapping and storing structures for back and forth bouncing of light photons trapped therein in a direction substantially parallel to a direction of a gravitation field.

The method comprises in some embodiments arranging two-dimensional flat arrays of
20 the photon trapping and storing structures. The method can comprise stacking the photon trapping and storing structures one on top of the other to facilitate trapping of light photons escaping one of the photon trapping and storing structures by another one of the photon trapping and storing structures in the stack. The method can comprise arranging three-dimensional arrays of the photon trapping and storing structures by stacking a plurality of the
25 two-dimensional flat arrays one on top of the other and/or by mounting side-by-side a plurality of the stacks of the photon trapping and storing structures.

The method comprises in some applications coupling one or more reflective elements to the photon trapping and storing structures, and/or to the stack, to the flat two-dimensional array, to the three-dimensional array, thereby formed, so as to reflect light photons escaping
30 them back thereinto. The method may comprise radiating the photon trapping and storing structures, and/or the stack, the flat two-dimensional array, the three-dimensional array, thereby formed, by one or more light photons beams.

In some application the method comprises measuring a parameter indicative of electrical power produced by the photo-transducer material/layer(s), and activating a photons

source to radiate the photon trapping and storing structures, and/or the stack, the flat two-dimensional array, the three-dimensional array, thereby formed, by one or more light photons beams.

5 In yet another aspect there is provided electricity production method comprising optically coupling one or more crystal cavities, each comprising a plurality of lattice impurity atoms and a plurality of light photons trapping lattice vacancies, to photo-transducer material/layer(s), exciting atoms of the one or more crystal cavities to form electron-hole charge carriers therein, for generation of electrical power by light photons escaping the vacuum cavities and absorbed by the photo-transducer material/layer(s). The exciting of the atoms of
10 the one or more crystal cavities can comprise applying an electrical field to the one or more crystal cavities and/or radiating them by light photons.

The method comprises in possible applications applying electric and/or magnetic field to the one or more crystal cavities for aligning electron spins of atoms thereof in a defined orientation, to thereby set bounce direction of light photons trapped inside the one or more
15 crystal cavities to substantially coincide with direction of a gravity field. The method may include forming n-type and p-type charge carrier components one beside the other in at least one of the crystal cavities, to thereby form a depletion area therebetween, and forming electrically conducting contacts electrically coupled to the n-type and p-type charge carriers for passage of electric current therebetween due to migration of charge carrier across the
20 depletion region.

In yet another aspect there is provided electricity production method comprising forming n-type and p-type charge carrier materials one beside the other to form a depletion area therebetween in a crystal cavity comprising a plurality of lattice impurity atoms and a plurality of light photons trapping lattice vacancies, coupling electrically conducting contacts to the n-
25 type and p-type charge carriers for passage of electric current therebetween due to migration of charge carriers across the depletion region, and exciting atoms of the one or more crystal cavities to form electron-hole charge carriers therein by an external excitation source.

Technical/scientific terms used herein are intended to have the meaning commonly understood by those of ordinary skill in the art of this disclosure.

30 BRIEF DESCRIPTION OF THE DRAWINGS

In order to understand the invention and to see how it may be carried out in practice, embodiments will now be described, by way of non-limiting example only, with reference to

the accompanying drawings. Features shown in the drawings are meant to be illustrative of only some embodiments of the invention, unless otherwise implicitly indicated. In the drawings like reference numerals are used to indicate corresponding parts, and in which:

Figs. 1A and 1B schematically illustrate an opto-electric power source according to some possible embodiments, wherein **Fig. 1A** shows a sectional view of the opto-electric power source, and **Fig. 1B** shows orientation of the opto-electric power source being collinear with the gamma acceleration vector of the gravitational field source (M);

Figs. 2A and 2B schematically illustrate arrays/matrices of opto-electric power source structures according to some possible embodiments, wherein **Fig. 2A** shows two-dimensional arrays of opto-electric power sources, and **Fig. 2B** shows a sectional perspective view of a stack of the two-dimensional arrays of photon trapping and storing structures surrounded by photo-transducer material/layer(s);

Figs. 3A to 3C schematically illustrate opto-electric power sources of some embodiments, wherein **Fig. 3A and 3B** show sectional views of opto-electric power sources and **Fig. 3C** shows a bottom side of an array of a plurality of such opto-electric power sources electrically connected to construct portable stable/reliable electric power source;

Figs. 4A and 4B schematically illustrate an opto-electric power source utilizing photonic crystals as photon trapping and storing structures;

Fig. 5A and 5B schematically illustrates possible mounting of an opto-electric power source according to some possible embodiments, wherein **Fig. 5A** exemplifies a plumb line suspension approach and **Fig. 5B** demonstrates a surface levelling approach; and

Fig. 6 schematically illustrates principles of embodiments disclosed herein.

DETAILED DESCRIPTION OF EMBODIMENTS

One or more specific and/or alternative embodiments of the present disclosure will be described below with reference to the drawings, which are to be considered in all aspects as illustrative only and not restrictive in any manner. It shall be apparent to one skilled in the art that these embodiments may be practiced without such specific details. In an effort to provide a concise description of these embodiments, not all features or details of an actual implementation are described at length in the specification. Elements illustrated in the drawings are not necessarily to scale, or in correct proportional relationships, which are not critical. Emphasis instead being placed upon clearly illustrating the principles of the invention such that persons skilled in the art will be able to make and use the opto-electric power source structures

disclosed herein. This invention may be provided in other specific forms and embodiments without departing from the essential characteristics described herein.

The present application discloses opto-electric power source structures configured to generate electrical power from light photons trapped and stored in specially designed photons retaining assemblies by photo-transducer material/layer(s) at least partially surrounding the photons retaining assemblies. In opto-electric power source structures disclosed herein the photons retaining assemblies are configured as vertical-bounce photon structures that cause vertical motion of the photons therein with respects to the earth/planet surface, such that the axis of motion of the bouncing photons trapped therein substantially coincides with the direction of the earth/planet gravity field. For example, in embodiments utilizing optical resonant cavities, the optical axes of the mirrors/reflective elements of the cavities are configured to coincide with the direction of the gravity field of the earth/planet, for the photons to bounce back and forth therebetween along the direction of the gravity field of the earth/planet.

This configuration of the photons retaining assemblies thus causes the trapped bouncing light photons to interact with the gravitational field of the earth, for thereby amplifying the power and/or number of the photons trapped therein. In this way, as the energy of the photons increases, some of these light photons bounce out and escape the photon retaining assemblies and are absorbed by the photo-transducer material/layer(s) wrapping one or more sides of the photon retaining assemblies, thereby generating electrical energy from the escaping light photons.

For an overview of several example features, process stages, and principles of the present disclosure, the examples of optical resonant cavities and photonic crystals are illustrated schematically and diagrammatically in the figures for implementing the photon trapping and storing assemblies. These optical resonant cavities and photonic crystals are however shown as one example implementation that demonstrates a number of features, processes, and principles used to construct the opto-electric power source structures, but they can be implemented using other photon trapping and storing structures as well and/or made in different variations. Therefore, this description will proceed with reference to the shown examples, but with the understanding that the invention recited in the claims below can also be implemented in myriad other ways, once the principles are understood from the descriptions, explanations, and drawings herein. All such variations, as well as any other modifications apparent to one of ordinary skill in the art and useful in opto-electric power generation

applications may be suitably employed, and are intended to fall within the scope of this disclosure.

Figs. 1A and 1B schematically illustrate an opto-electric power source **10** according to some possible embodiments. The opto-electric power source **10** comprises an optical resonant cavity **15** (e.g., Fabry-Perot cavities with a very high quality factor (Q)) at least partially wrapped by photo-transducer material/layer(s) (e.g., photovoltaic material/cells) **17**. The optical resonant cavity **15** comprises two or more reflectors **15a, 15b** mounted one in front of the other for light photons **11** entering the cavity **15c** to be thereby reflected and bounce between one reflector to the other. In this specific example two concaved mirrors **15a, 15b** are positioned one in front of the other, such that the light photons **11** beam reflected therein converge to focus towards the optical axis **15x** of the optical resonant cavity **15**.

In some embodiments an opening **10u** is formed in at least one of the sides of the photo-transducer material/layer(s) **17** for feeding photon beams **12r** into the cavity **15c** from time to time to initialize its operation or to replenish it with new light photons. The photon beams **12r** entering the optical resonant cavity **15** can be generated by any suitable photon source **12**, such as, for example, a celestial source (e.g., the sun), synchrotron radiation, electric (e.g., laser) light source, radioluminescence compositions, etc. As light photons **11** trapped inside the optical resonant cavity **15** bounce back and forth between the reflectors **15a, 15b** they undergo a gradual amplification process until they are significantly amplified.

As the energy and/or the number of the light photons **11** trapped inside the optical resonant cavity **15** gradually increases due to the interaction between the light photons trapped inside the optical cavity with the gravitational field of the gravitation source **M** (e.g., of the earth), some of these light photons stop matching with wave pattern modes of the optical resonant cavity **15** and thus deflect of the optical resonant cavity **15**, and thus expelled out of the cavity **15c** (shown by dash-dotted arrowed lines). The energetic light photons **11** reflected out of the cavity **15c** are absorbed by the photo-transducer material/layer(s) **17** and converted thereby into electric voltage V_{elec} , that can be consumed via the electric power terminals **18** of the photo-transducer material/layer(s) **17**.

Optionally, but in some embodiments preferably, the optical resonant cavity **15** is a vertical-bounce optical resonant cavity configured such that its optical axis **15x** substantially coincides with the direction of the gravity acceleration vector $\vec{g}$ of the earth/planet. This way, as the trapped light photons **11** converge inside the cavity **15c** and focus to bounce along the optical axis **15x** of the vertical-bounce optical resonant cavity **15**, they interact with the gravity

field Υ of the earth/planet **19**, which thereby amplifies the power and/or the number of the bouncing photons trapped inside the cavity **15c**.

As the direction of bouncing motion of the trapped light photons **11** inside the vertical-bounce optical resonant cavity **15** is collinear with the direction of the acceleration vector $\vec{g}$ *i.e.*, along the z axis (shown in **Fig. 1B**) of the source (*i.e.*, the earth/planet **19**) of the gravitational field Υ , the trajectory path of the trapped light photons **11** inside the cavity **15c** is sometimes in a direction identical to the direction of the earth/planet acceleration vector $\vec{g}$, and sometimes in a direction opposite to the direction of the earth/planet acceleration vector $\vec{g}$, as exemplified by small arrowed lines in **Fig. 1A**.

In some embodiments the vertical-bounce optical resonant cavity **15** is configured to amplify the number of trapped light photons **11** bouncing inside its cavity **15c** with a photon doubling time constant of the order of 4 hours, *i.e.*, $\tau \approx 4$. The following relation represents the quantity N of photons obtained inside the cavity **15c** after a time interval T : $N \approx 2^{T/\tau}$.

Fig. 2A shows two-dimensional arrays **20** of photons retaining assemblies (*e.g.*, optical resonant cavity **15** of **Figs. 1A** and **1B**) manufactured in form of planar sheets. Each two-dimensional array **20** of the photons retaining assemblies can be made up of one or more dozens of plate-shaped photons retaining assemblies (*e.g.*, microcavity) **15**, which can be wrapped by photo-transducer material/layer(s) (*e.g.*, photovoltaic material/cells) **17**. In this non-limiting example, each two-dimensional array **20** comprises 100 (hundred) photons retaining assemblies **15** arranged to form a 10×10 square array structure, but other geometrical arrangements can be contemplated, using different number of photons retaining assemblies **15**, per specific application specifications and requirements.

Fig. 2B shows a sectional view of a three-dimensional array **25** of stacks **21** of photons retaining assemblies (*e.g.*, microcavities **15**). In this non-limiting example the three-dimensional array **25** of photons retaining assemblies **15** is constructed as a layered structure of a plurality of the two-dimensional arrays **20** of the photons retaining assemblies **15**, stacked one on top of the other, to thereby form a plurality of stacks/columns **21**, wherein the photons retaining assemblies **15** of each stack/column **21** are substantially aligned about a common optical axis **15x** of its photons retaining assemblies **15**.

The three-dimensional array **25** of photons retaining assemblies **15** can be manufactured on a support/substrate element (*e.g.*, PCB) **20s**. As seen, in possible embodiments, the bottom, and possibly also the top, photons retaining assembly (*e.g.*, microcavity **15**) of each stack/column **21** of photons retaining assemblies **15** is optically coupled to one or more light

photons (e.g., laser diode) sources **12** configured to introduce light photons (**11**) into the stacks/columns **21** of the photons retaining assemblies **15**. Optionally, a single light photon source **12** is used to introduce light photons (**11**) into a plurality of adjacently located stacks/columns **21** of the photons retaining assemblies **15**, or to the entire three-dimensional array **25**. In possible embodiments each stack/column **21** of the photons retaining assemblies **15** is optically coupled to a respective one of the light photon source **12**, as exemplified in **Fig. 3B**.

In this non-limiting example, the light photons source(s) **12** is attached to, or integrally embedded in, the substrate **20s**. The light photons source(s) **12** is configured in some embodiments to initiate and/or refresh operation of the photons retaining assemblies **15** of its respective stack/column **21** of the photons retaining assemblies **15**, by periodically or intermittently supplying new light photons thereto. In possible embodiments each three-dimensional array **25** of stacked two-dimensional arrays **21** of the photons retaining assemblies **15** comprises several hundred (or about a thousand) of photons retaining assemblies **15**.

The substrate **20s** comprises in some embodiments control circuitry **12c** configured to periodically or intermittently activate the one or more light photon sources **12**. In some embodiments the control circuitry **12c** is configured to receive an electric power measure (e.g., V_{elec} and/or a corresponding electric current) **7p** indicative of the electric power generated by the photo-transducer material/layer(s) **17,24** and activate the one or more light photon sources **12** whenever the electric power measure **7p** is smaller than a predefined threshold value.

In this non-limited example, the three-dimensional array **25** of photons retaining assemblies **15** is at least partially wrapped by photo-transducer material/layer(s) (e.g., photovoltaic panels/cells) **24**, in addition to, or instead of, the photo-transducer material/layer(s) **17**, configured to convert energetic light photons escaping out of the photons retaining assemblies **15** into electrons stream. The electrical power/voltage (V_{elect}) produced by the photo-transducer material/layer(s) **17,24** can be supplied for consumption via their electric power terminals **18c**. In possible embodiments, the electric power produced by the photo-transducer material/layer(s) **24** and/or **17** is stored in a high value capacitive element (not shown) for electricity supply at needs.

Figs. 3A and 3B show a sectional view of a stack **25'** of two-dimensional arrays **20** of photon retaining assemblies (**15**) according to some embodiments (e.g., see **Fig. 2A**), wrapped at least partially by photo-transducer material/layer(s) **17**. As seen, the two-dimensional arrays **20** of photon retaining assemblies (**15**) are stacked one on top of the other on top of a substrate (e.g., PCB) **20s**, which in some embodiments comprises one or more light photon sources **12**.

Optionally, but in some embodiments preferably, the three-dimensional stack array **25'** of two-dimensional arrays **20** photon retaining assemblies (**15**) is sandwiched between two or more reflectors (*e.g.*, mirrors) **21a, 21b**. The reflectors **21a, 21b** are configured to direct light photons escaping the three-dimensional stack of arrays **20** of the photon retaining assemblies **15** at the top and bottom extremities of the stack back into the three-dimensional stack array **25'** of the photon retaining assemblies **15**. The one or more light photon sources **12** can be configured to introduce light photons into photon retaining assemblies (**15**) via one or more apertures (not shown) formed in the reflector **21b**. Alternatively, the reflector **21b** is implemented by a type of one way mirror allowing the light photons from the one or more light photon sources **12** to pass into the arrays **20** of the photon retaining assemblies **15** and preventing the bouncing photons from escaping the three-dimensional stack array **25'**.

As seen in **Fig. 3B**, the three-dimensional stack array **25'** of the photon retaining assemblies **15** can be configured such that optical axes **15x** of the photon retaining assemblies **15** in each stack/column **21** are substantially aligned, or parallel, to the same optical axis **15x**. Optionally, but in some embodiments preferably, the optical axes **15x** of the stack-columns **21** of photon retaining assemblies **15** substantially coincide with the direction of gravity **g**, as exemplified in **Fig. 3A**.

Fig. 3C demonstrates a portable electric power source (*e.g.*, battery) **30** made of a plurality of opto-electric power sources **25** of **Fig. 2B** (or **25'** of **Fig. 3A**, or **25''** of **Fig. 3B**). In this non-limiting example, the portable electric power source **30** is arranged in form of a block of the opto-electric power sources **25** (or **25'** or **25''**) attached one to the other, and electrically connected by their electric power terminals **18** at a bottom side of the portable electric power source **30**.

The resonant optical cavities **15** of embodiments disclosed herein can be implemented in a myriad of different configurations *e.g.*, utilizing any of the configurations described hereinabove and hereinbelow. Generally, there are two basic types of optical cavities: (1) standing wave (or linear) cavities, where light photons bounce back and forth between two end reflectors/mirrors; and (2) ring cavities (ring resonators), where the light photons circulate in round trips *e.g.*, in two different angular directions.

Standing-wave resonant optical cavities are the most common type of optical cavities. They are used in a wide variety of applications, including lasers, interferometers, and optical delay lines. Standing-wave cavities are typically made up of two highly reflecting mirrors that are placed facing each other. The mirrors are separated by a distance that is equal to half of the

wavelength of light photons to be trapped therein. This ensures that the light waves will reflect back and forth between the mirrors in a standing-wave mode pattern.

Ring resonant optical cavities are less common than standing-wave resonant cavities, but they have some unique properties that make them useful for certain applications. Ring resonant cavities are typically made up of a single mirror that is surrounded by a ring of material that has a high refractive index. The light waves received in the ring resonant optical cavity are trapped thereinside and circulate around the ring many times before they are emitted out of the cavity. This configuration allows for very high-quality light beams to be produced.

For example, a distributed Bragg reflector (DBR) Cavity consists of two distributed Bragg reflectors acting as highly reflective mirrors. The DBRs are made up of alternating layers of materials with different refractive indices. By carefully designing the layer thickness and refractive index contrast, a high reflectivity over a specific wavelength range can be achieved.

By way of comparison to Fabry-Perot:

- Fabry-Perot configured as vertical-bounce optical cavity of embodiments hereof.
 - Advantages: simple, inexpensive, and easy to fabricate.
 - Disadvantages: low coherence, low power output.
- Distributed optical cavity configured as vertical-bounce cavity of embodiments hereof.
 - Advantages: high coherence, high power output, good beam quality.
 - Disadvantages: complex, expensive, and difficult to fabricate.

Confocal cavities are another type of standing-wave resonant optical cavity that has two spherical mirrors that are placed facing each other. The mirrors are separated by a distance that is equal to the focal length of the mirrors.

Other possible optical resonators implementations are discussed hereinbelow.

Photonic crystal cavity: photonic crystal cavities are crystal lattice structures with a periodically varying refractive index. A photonic crystal cavity is created within the photonic crystal structure, usually by introducing a defect (*e.g.*, impurity) or a localized variation in the periodic structure of the crystal. The defect acts as an optical cavity, confining light within a specific wavelength range, exhibiting a nanocavity on the order of tens to hundreds of nanometers in size.

Another type of resonant optical cavity usable in embodiments hereof, is the Plasmonic Nanoresonator, which may be implemented by the following configurations.

- Microdisk Cavity: a microdisk cavity is a circular or ring-shaped resonator typically made from semiconductor materials. Light is confined within the circumference of the

disk by total internal reflection. The size of the disk determines the resonant wavelength, and by controlling the dimensions of the ring, specific wavelengths can be selected.

- Photonic Wire Cavity: A photonic wire cavity consists of a narrow waveguide or wire structure that is designed to confine light within a small cross-sectional area. This confinement leads to an increased interaction between the light and the surrounding materials, enabling strong light-matter interactions.
- Whispering gallery mode (WGM) cavity: a WGM cavity is typically a spherical or cylindrical structure where light waves are confined due to total internal reflection. The light follows a path around the curved surface, circulating within the cavity. WGM cavities can exhibit high-Q (quality factor) resonances and are used in applications such as microresonators and biosensors.
- Microcavity: a microcavity is a small-scale optical cavity that can confine light in a very small volume. It typically consists of two highly reflecting mirrors, and light is trapped and circulates within the microcavity. Microcavities have applications in quantum optics, cavity quantum electrodynamics, and optical sensing.
- Nanofibre-based optical cavities are particularly useful for quantum optics applications, such as the development of integrated single-photon sources, and for studying fundamental light-matter interactions in cavity quantum electrodynamics (CQED).

Fig. 4A depicts non-optical resonant cavities **50** usable in embodiments hereof, wherein impurity atoms **38v** implanted in a crystal lattice **38**, such as diamond, and lattice vacancies **38c** (**V**), are used to implement photons retaining assemblies known as crystal cavity, having properties similar to those of optical resonant cavities. The non-optical resonant cavities **50** uses properties of the NV (Nitrogen-vacancy) colored center of the diamond, but with a particular atom **38v** (**A**, *e.g.*, alkaline atoms embedded in a high-pressure high-temperature (HPHT) synthesis crystallization process), instead of the Nitrogen atom (N), and a formed vacancy (**V**) **38c** (*e.g.*, by irradiating the crystal with high-energy particles, such as electrons, protons, neutrons, or ions, which may be followed by annealing) Accordingly, the **AV** center is made up of an impurity atom **38v** and a vacancy **38c**, forming a point defect in the crystal (*e.g.*, diamond) lattice **38**, which behaves like an artificial atom trapped in the diamond crystal matrix *i.e.*, such artificial atoms have the property of emitting and absorbing the same light photons in very short time intervals.

By polarizing the spin direction of electrons of the impurity atoms (**A**) **38v** *e.g.*, by an externally applied magnetic or electrical field/effect, an emission-absorption of light photons

can be achieved in a preferred direction collinear/coinciding with the direction of Earth's acceleration vector $\vec{g}$. **Fig. 4A** exemplifies application of an external magnetic field **B** by an electromagnet **44** to affect a desired spin polarisation direction in the atoms of the non-optical resonant cavities **50**, in order to cause the light photons trapped in the crystal lattice **38** to bounce in a direction coinciding with the direction of the gravity acceleration **g**.

Fig. 4B schematically illustrates use of N-type **32** and P-type **33** doped crystal cavity structures (**50**) according to possible embodiments, for production electricity due to light photons, bouncing thereinside according to some embodiments in a direction substantially coinciding with the direction of the gravity acceleration **g** of the planet/earth. As seen, in this electrical power source **37** the N-type **32** and P-type **33** doped crystal cavity structures are attached one to the other, thereby forming a depletion region **31** configured to permit migration of electrons **35** and holes **36** charge carriers from one side thereof to the other. The depletion region **31** can be substantially perpendicular to the direction of the gravity acceleration **g**. The electrodes, **30a** electrically connected to the N-type **32** crystal cavity structure, and **30b** electrically connected to the P-type **33** doped crystal cavity structure, are coupled to the electric power terminals **39** for supply of the electric voltage V_{elec} evolving due to the migration of the charge carriers **35,36**.

In some embodiments the electrical power source **37** is coupled to an electron-hole atom excitation source **51** configured to periodically or intermittently apply excitations **51e** thereto for formation of electron-hole charge carriers in the N-type **32** and/or P-type **33** crystal cavity structures. For example, the excitation source **51** can be configured to apply an electric field over at least some portion of the electrical power source **37**, and/or radiate at least some portion of the electrical power source **37** with one or more light beams.

The excess light photons produced by the amplification of the energy and/or number of light photons emitted and absorbed by the atoms **38v** and vacancies **38c** pairs (due to the interaction between photons and the gravitational field), can:

a) Release electrons **35** from the impurity atoms (A) **38v** using the surplus of light photons created due to the interaction between the trapped light photons and the gravitation field of the earth/planet and use of the electron recombination properties of the semiconductor materials **32,33** of the AV (e.g., Diamond) crystal **50** to generate electricity directly by migration of the charge carriers **35,36** (supplied via the electric power terminals **39**) across the depletion region **31**.

b) Use excess light photons to generate electricity using photo-transducer material/layer(s) (e.g., photovoltaic cells/panels) 17 at least partially wrapping the semiconductor structure crystal cavity 37.

c) Use both (a) and (b) methods together to generate electricity.

5 **Fig. 5A** exemplifies alignment of an opto-electric power source 54 according to any of the embodiments disclosed herein with respect to the ground surface 19. In this non-limiting example the opto-electric power source 54 has a substantially flat base configured for placement on a levelled flat surface such that the optical axes 15x of the photons retaining assemblies thereof are substantially perpendicular to the ground surface 19. It is noted that
10 deviations of few degrees of the bouncing direction of the light photons from the direction of the gravitation's acceleration may be tolerable for operation of the opto-electric power source 54 according to embodiments hereof. Thus, it is sufficient to place the opto-electric power source 54 substantially straight on a flat levelled surface 19 for the bounce direction of the light photons to coincide, or nearly coincide, with the direction of the gravity field, to guarantee
15 proper operation. **Fig. 5B** exemplifies suspension of the opto-electric power source 54 by a plumb line 52 for aligning the optical axes 15x of the photons retaining assemblies with the direction of the gravity acceleration **g** of the planet/earth, to thereby guarantee that the bouncing direction of the light photons trapped inside its photons retaining assemblies coincides, or nearly coincides, with the direction of the gravity field.

20 Relative terms such as "lower," "upper," "horizontal," "vertical," "above," "below," "up," "down," "top" and "bottom", as well as derivatives thereof (e.g., "horizontally," "downwardly," "upwardly," etc.), and similar adjectives in relation to orientation of the described elements/components refer to the manner in which the illustrations are positioned on the paper, not as any limitation to the orientations in which these elements/components can be
25 used in actual applications.

It should be understood that throughout this disclosure, where a process or method is shown or described, the steps/acts of the method may be performed in any order and/or simultaneously, and/or with other steps/acts not illustrated/described herein, unless it is clear from the context that one step depends on another being performed first. In possible
30 embodiments not all of the illustrated/described steps/acts are required to carry out the method.

As described hereinabove and shown in the associated figures, the present disclosure provides opto-electric power sources utilizing specially designed photon trapping and storing structures at least partially wrapped by photo-transducer material/layer(s) for generation of electrical power from photons released from the photon trapping and storing structures, and

related methods. While particular embodiments of the invention have been described, it will be understood, however, that the invention is not limited thereto, since modifications may be made by those skilled in the art, particularly in light of the foregoing teachings. As will be appreciated by the skilled person, the invention can be carried out in a great variety of ways, employing
5 more than one technique from those described above, all without exceeding the scope of the claims.

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CLAIMS:

1. An opto-electric power source comprising:
one or more photon trapping and storing structures configured for back and forth
bouncing light photons trapped inside a vacuum cavity thereof in a direction that substantially
5 coincides with a direction of a gravity field; and
photo-transducer material/layer(s) at least partially wrapping said one or more photon
trapping and storing structures for generation of electrical power from photons escaping said
photon trapping and storing structures.
2. The opto-electric power source of claim 1 comprising a plurality of the photon trapping
10 and storing structures arrange in a flat two-dimensional array.
3. The opto-electric power source of claim 1 or 2 comprising one or more stacks of the
photon trapping and storing structures, or of the flat two-dimensional arrays, optically coupled
and stacked one on top of the other for light photons escaping one of said plurality of the photon
trapping and storing structures to be absorbed in another one of said plurality of the photon
15 trapping and storing structures in said stack.
4. The opto-electric power source of claim 2 or 3 wherein the photo-transducer
material/layer(s) at least partially wraps the flat two-dimensional array or the one or more
stacks of the photon trapping and storing structures.
5. The opto-electric power source of any one of claims 2 to 4 comprising top and bottom
20 reflective elements optically coupled to top and bottom extremities of the one or more stacks
of the photon trapping and storing structures respectively, for reflecting light photons escaping
said stacks of photon trapping and storing structures back into said stacks.
6. The opto-electric power source of any one of claims 2 to 5 comprising one or more light
photon sources optically coupled to the stacks of the photon trapping and storing structures for
25 introducing beams of light photons thereinto.
7. The opto-electric power source of claim 6 comprising control circuitry configured
receive a measure of electric power produced by the photo-transducer material/layer(s), and
activate the one or more light photon sources whenever said measure of electric power is below
a determined value for introducing light photons thereinto.
- 30 8. The opto-electric power source of any one of the preceding claims wherein the photon
trapping and storing structures are implemented by resonant optical cavities.
9. The opto-electric power source of claim 8 wherein the resonant optical cavities are a
type of Fabry-Perot cavity.

10. The opto-electric power source of claim 8 or 9 wherein the resonant optical cavity is configured with a resonant vacuum gap defined between two or more reflective elements.
11. The opto-electric power source of claim 10 wherein the reflective elements of the resonant optical cavity are configured to define an optical axis of the resonant optical cavity
5 substantially coinciding with a gravity field.
12. An electric power source comprising one or more crystal cavities, each comprising a plurality of lattice impurity atoms and a plurality of light photons trapping lattice vacancies; an electron-hole excitation source configured to excite atoms of said one or more crystal cavities, photo-transducer material/layer(s) at least partially wrapping said one or more crystal cavities
10 for generation of electrical power from photons escaping said crystal cavities; and a field generator configured to apply electric and/or magnetic field to the one or more crystal cavities for aligning electron spins of atoms thereof in a defined orientation, to thereby set bounce direction of light photons trapped inside said one or more crystal cavities to substantially coincide with direction of a gravity field.
13. The electric power source of claim 12 wherein the excitation source is an electrical or optical source.
14. The electric power source of claim 12 or 13 comprising n-type and p-type charge carrier components formed one beside the other in at least one of the crystal cavities to form a depletion area therebetween, and electrically conducting contacts electrically coupled to said n-type and
20 p-type charge carriers for passage of electric current therebetween due to migration of charge carrier across said depletion region.
15. Electricity production method comprising optically coupling photo-transducer material/layer(s) to one or more sides of one or more photon trapping and storing structures having vacuum cavities; mounting the photon trapping and storing structures for back and forth
25 bouncing of light photons trapped thereinside in a direction substantially parallel to a direction of a gravitation field; and trapping light photons inside vacuum cavities of said one or more photon trapping and storing structures for generation of electrical power by light photons escaping said vacuum cavities and absorbed in said photo-transducer material/layer(s).
16. The method of claim 15 comprising arranging two-dimensional flat arrays of the photon trapping and storing structures.
30
17. The method of claim 15 to 16 comprising stacking the photon trapping and storing structures one on top of the other to facilitate trapping of light photons escaping one of the said photon trapping and storing structures by another one of the photon trapping and storing structures in the stack.

18. The method of claim 16 or 17 comprising arranging three-dimensional arrays of the photon trapping and storing structures by stacking a plurality of the two-dimensional flat arrays one on top of the other and/or by mounting side-by-side a plurality of the stacks of the photon trapping and storing structures.

5 19. The method of any one of claims 15 to 18 comprising coupling one or more reflective elements to the photon trapping and storing structures, and/or to the stack, and/or the flat two-dimensional array, and/or the three-dimensional array, thereby formed, so as to reflect light photons escaping them back thereinto.

20. The method of any one of claims 15 to 19 comprising radiating the photon trapping and
10 storing structures, and/or the stack, and/or the flat two-dimensional array, and/or the three-dimensional array, thereby formed, by one or more light photons beams.

21. The method of any one of claims 15 to 20 comprising measuring a parameter indicative of electrical power produced by the photo-transducer material/layer(s), and activating a photons source to radiate the photon trapping and storing structures, and/or the stack, and/or
15 the flat two-dimensional array, and/or the three-dimensional array, thereby formed, by one or more light photons beams.

22. Electricity production method comprising optically coupling one or more crystal cavities, each comprising a plurality of lattice impurity atoms and a plurality of light photons trapping lattice vacancies, to photo-transducer material/layer(s); applying electric and/or
20 magnetic field to the one or more crystal cavities for aligning electron spins of atoms thereof in a defined orientation, to thereby set bounce direction of light photons trapped inside said one or more crystal cavities to substantially coincide with direction of a gravity field; and exciting atoms of said one or more crystal cavities to form electron-hole charge carriers therein, for generation of electrical power by light photons escaping said vacuum cavities and absorbed by
25 said photo-transducer material/layer(s).

23. The method of claim 22 wherein the exciting of the atoms of the one or more crystal cavities comprises applying an electrical field to the one or more crystal cavities and/or radiating them by light photons.

24. The method of claim 22 or 23 comprising forming n-type and p-type charge carrier
30 components one beside the other in at least one of the crystal cavities, to thereby form a depletion area therebetween, and forming electrically conducting contacts electrically coupled to said n-type and p-type charge carriers for passage of electric current therebetween due to migration of charge carrier across said depletion region.

25. Electricity production method comprising forming n-type and p-type charge carrier materials one beside the other to form a depletion area therebetween in a crystal cavity comprising a plurality of lattice impurity atoms and a plurality of light photons trapping lattice vacancies, coupling electrically conducting contacts to said n-type and p-type charge carriers
- 5 for passage of electric current therebetween due to migration of charge carrier across said depletion region, and exciting atoms of said one or more crystal cavities to form electron-hole charge carriers therein by an external excitation source.