Claims

1. A method of operating a photovoltaic structure comprising:

providing a photovoltaic structure, the photovoltaic structure comprising an array of photovoltaic nanostructures, each photovoltaic nanostructure including:

a conductive nanocable that protrude above a plane of a substrate along its respective axis and

photovoltaic (PV) layers located above the nanocable and the substrate;

for a given light source location, rotating the array of photovoltaic nanostructures within the plane of the substrate;

determining an optimal rotation angle at which a power output from the array becomes a maximum as a function of a rotation angle during the rotation of the array within the plane of the substrate; and

adjusting the rotation angle of the array to the optimal rotation angle by rotating the array within the pane of the substrate for increasing the power output of the array.

2. The method of Claim 1, further comprising adjusting a presentation angle of the array relative to a light source position for further increasing an observable power output of the array.

3. The method of Claim 1, further comprising:

determining an optimal presentation angle between the conductive nanocables and a direction of the given light source location at which the power output from the array becomes a maximum as a function of the presentation angle, wherein the maximum occurs when the presentation angle is not zero; and

adjusting the rotation angle of the array to the optimal presentation angle for further increasing the observable power output of the array.

4. A method of operating a photovoltaic structure comprising:

providing a photovoltaic structure, the photovoltaic structure comprising an array of photovoltaic nanostructures, each photovoltaic nanostructure including:

a conductive nanocable that protrude above a plane of a substrate along its respective axis, and

photovoltaic (PV) layers located above the nanocable and the substrate;

orienting, while incoming light from given light source impinges on the array, the array to change a presentation angle between the axes of the conductive nanocables and the incoming light;

determining an optimal presentation angle at which a power output from the array becomes a maximum as a function of the presentation angle, wherein the optimal presentation angle occurs when the axes of the conductive nanocables are orientated between a parallel direction to the incoming light and a perpendicular direction to the incoming light; and

adjusting the presentation angle of the array to the optimal presentation angle for increasing a power output of the array.

5. The method of Claim 4, further comprising:

determining an optimal rotation angle at which the power output from the array becomes a maximum as a function of a rotation angle during the rotation of the array within the plane of the substrate for the given light source location substrate; and

adjusting the rotation angle of the array to the optimal rotation angle by rotating the array within the pane of the substrate a presentation angle of the array relative to a light source position for further increasing an observable power output of the array.

6. The method of Claim 4, further comprising:

rotating, while the incoming light impinges on the array, the array of photovoltaic nanostructures within the plane of the substrate;

determining an optimal rotation angle at which the power output from the array becomes a maximum as a function of a rotation angle during the rotation of the array within the plane of the substrate; and

adjusting, employing at least one actuator and at least one motor, the rotation angle of the array to the optimal rotation angle by rotating the array within the pane of the substrate for further increasing the power output of the array.

7. The method of any of Claims 1 – 6, wherein the conductive nanocables protrude from the plane of the substrate along a direction that is normal to the plane of the substrate.

8. The method of any of Claims 1 – 6, wherein the conductive nanocables protrude from the plane of the substrate along a direction that is tilted from a surface normal of the plane of the substrate.

9. The method of any of Claims 1 – 3, 5, or 6, wherein the steps of rotating the array and determining the optimal rotation angle are performed periodically, continuously, or at predetermined times during the day.

10. The method of any of Claims 1 – 3, 5, or 6, wherein the time and extent of the rotation of the array is set by an installer, and is automatically applied at an appropriate time.

11. The method of any of Claims 1 – 3, 5, or 6, further comprising employing electronics, at least one actuator, and at least one motor to rotate the array within the plane of the substrate or to change the presentation angle of the array.

12. The method of any one of Claims 1 – 11, wherein each of the photovoltaic layers comprise multiple layers having different grain sizes.

13. The method of any one of Claims 1 – 12, wherein each of the photovoltaic layers comprise a graded layer in which the average grain size varies along the deposited thickness of the graded layer.

14. The method of any one of Claims 1 – 13, wherein the array of photovoltaic nanostructures is arranged in a brush configuration.

15. The method of any one of Claims 1 – 14, wherein each of the photovoltaic layers comprise a material selected from a group consisting of Group V materials, II-VI materials, and III-V materials.

Claims:

1. A method of operating a photovoltaic structure, comprising:

providing a photovoltaic structure, the photovoltaic structure comprising an array of photovoltaic nanostructures, each photovoltaic nanostructure including:

a conductive nanocable that protrudes above a plane of a substrate along its respective axis, and

photovoltaic (PV) layers located above the nanocable and the substrate;

rotating, while incoming light impinges on the array from a given light source, the array of photovoltaic nanostructures within the plane of the substrate around an axis that is perpendicular to the plane of the substrate;

determining an optimal rotation angle at which a power output from the array becomes a maximum as a function of a rotation angle during the rotation of the array within the plane of the substrate around the axis that is perpendicular to the plane of the substrate; and

adjusting the rotation angle of the array to the optimal rotation angle by rotating the array within the pane of the substrate around the axis that is perpendicular to the plane of the substrate for increasing the power output of the array,

wherein the time and extent of the rotation of the array around the axis that is perpendicular to the plane of the substrate is set by an installer, and is automatically applied at an appropriate time.

2. The method as recited in claim 1, further comprising adjusting a presentation angle of the array, as measured between the axes of the conductive nanocables and the incoming light, for further increasing an observable power output of the array.

3. The method of claim 2, wherein the array of photovoltaic nanostructures is characterized by an observable peak power output as the array is rotated around the axis that is perpendicular to the plane of the substrate.

4. The method of claim 3, wherein the step of rotating the array around the axis that is perpendicular to the plane of the substrate or the step of adjusting a presentation angle of the array, as measured between the axes of the conductive nanocables and the incoming light, is performed periodically, continuously, or at predetermined times during the day.

5. The method of claim 3, wherein the step of rotating the array around the axis that is perpendicular to the plane of the substrate or the step of adjusting a presentation angle, as measured between the axes of the conductive nanocables and the incoming light, of the array is performed automatically.

6. The method of claim 1, wherein each conductive nanocable comprises an interface between at least two refractive layers configured to refract or reflect light.

7. The method of claim 6, wherein rotating the array around the axis that is perpendicular to the plane of the substrate or adjusting a presentation angle of the array, as measured between the axes of the conductive nanocables and the incoming light, changes the apparent optical thickness of the array to incident light.

8. The method of claim 7, wherein changing the apparent optical thickness of the array to incident light amplifies the number of times the incident light bounces within the nanostructures of the array.

9. The method of claim 3, wherein an average grain size of at least one of the PV layers is less than about 100 nm.

10. The method of claim 3, wherein an average grain size of each of the PV layers is less than about 100 nm.

11. The method of claim 3, wherein the nanocables are elongated.

12. The method of claim 11, wherein the nanocables have substantially uniform peripheries and longitudinal lengths.

13. The method of claim 3, wherein the array of nanostructures is characterized by a capability to produce more than one electron per photon engaging the array of photovoltaic nanostructures.

14. A method of operating a photovoltaic structure, comprising:

providing a photovoltaic structure, the photovoltaic structure comprising an array of photovoltaic nanostructures, each photovoltaic nanostructure including:

a conductive nanocable that protrudes above a plane of a substrate along its respective axis, and

photovoltaic (PV) layers located above the nanocable and the substrate;

rotating, while incoming light impinges on the array from a given light source, the array of photovoltaic nanostructures within the plane of the substrate around an axis that is perpendicular to the plane of the substrate;

determining an optimal rotation angle at which a power output from the array becomes a maximum as a function of a rotation angle during the rotation of the array within the plane of the substrate around the axis that is perpendicular to the plane of the substrate; and

adjusting the rotation angle of the array to the optimal rotation angle by rotating the array within the pane of the substrate around the axis that is perpendicular to the plane of the substrate for increasing the power output of the array;

orienting the array to change a presentation angle between the axes of the conductive nanocables and the incoming light;

determining an optimal presentation angle at which a power output from the array becomes a maximum as a function of the presentation angle, wherein the optimal presentation angle occurs when the conductive nanocables are orientated between a parallel direction to the incoming light and a perpendicular direction to the incoming light; and

adjusting the presentation angle of the array to the optimal presentation angle for further increasing a power output of the array.

15. The method of claim 1, wherein the conductive nanocables protrude from the plane of the substrate along a direction that is normal to the plane of the substrate.

16. The method of claim 1, wherein the conductive nanocables protrude from the plane of the substrate along a direction that is tilted from a surface normal of the plane of the substrate.

17. The method of claim 1, wherein the steps of rotating the array around the axis that is perpendicular to the plane of the substrate and determining the optimal rotation angle are performed periodically, continuously, or at predetermined times during the day.

18. A method of operating a photovoltaic structure, comprising:

providing a photovoltaic structure, the photovoltaic structure comprising an array of photovoltaic nanostructures, each photovoltaic nanostructure including:

a conductive nanocable that protrudes above a plane of a substrate along its respective axis, and

photovoltaic (PV) layers located above the nanocable and the substrate;

rotating, while incoming light impinges on the array from a given light source, the array of photovoltaic nanostructures within the plane of the substrate around an axis that is perpendicular to the plane of the substrate;

determining an optimal rotation angle at which a power output from the array becomes a maximum as a function of a rotation angle during the rotation of the array within the plane of the substrate around the axis that is perpendicular to the plane of the substrate; and

adjusting the rotation angle of the array to the optimal rotation angle by rotating the array within the pane of the substrate around the axis that is perpendicular to the plane of the substrate for increasing the power output of the array,

employing electronics, at least one actuator, and at least one motor to rotate the array within the plane of the substrate around the axis that is perpendicular to the plane of the substrate, or to change [[the]] a presentation angle of the array that is measured between the axes of the conductive nanocables and the incoming light.

19. A method of operating a photovoltaic structure comprising:

providing a photovoltaic structure, the photovoltaic structure comprising an array of photovoltaic nanostructures, each photovoltaic nanostructure including:

a conductive nanocable that protrude above a plane of a substrate along its respective axis, and

photovoltaic (PV) layers located above the nanocable and the substrate;

orienting, while incoming light from given light source impinges on the array, the array to change a presentation angle between the axes of the conductive nanocables and the incoming light;

determining an optimal presentation angle at which a power output from the array becomes a maximum as a function of the presentation angle, wherein the optimal presentation

angle occurs when the axes of the conductive nanocables are orientated between a parallel direction to the incoming light and a perpendicular direction to the incoming light; [[and]]

adjusting the presentation angle of the array to the optimal presentation angle for increasing a power output of the array;

rotating, while the incoming light impinges on the array, the array of photovoltaic nanostructures within the plane of the substrate around the axis that is perpendicular to the plane of the substrate;

determining an optimal rotation angle at which the power output from the array becomes a maximum as a function of a rotation angle during the rotation of the array within the plane of the substrate; and

adjusting, employing at least one actuator and at least one motor, the rotation angle of the array to the optimal rotation angle by rotating the array within the plane of the substrate for further increasing the power output of the array.