What is claimed is:

1. A three dimensional solar cell comprising:

a semiconductor body having a substantially flat bottom surface, and having a plurality of arrayed shaped trenches formed along a top side of the semiconductor body opposite the bottom surface, the semiconductor body forming a pillar between each neighboring shaped trench, such that the semiconductor body has a plurality of arrayed pillars extending toward the top side of the semiconductor body; and

a light collecting material filling the plurality of arrayed shaped trenches along the top side of the semiconductor body and forming a substantially flat light receiving top surface substantially parallel to the bottom surface of the semiconductor body, each of the plurality of arrayed pillars having sidewalls contacting the light collecting transparent material, the light collecting material having an index of refraction that directs incident light more directly downward towards the plurality of arrayed shaped trenches;

wherein each of a set of at least some of the plurality of trenches are structured such that for each of the pillars in the set of pillars, there exists at least one point on the substantially flat light receiving surface that if a light ray is incident on that point, the light ray, if remaining within the corresponding trench, as opposed to entering the semiconductor body, will be redirected upwards at least after a third reflection on neighboring pillars.

2. The solar cell in accordance with Claim 1, wherein each of a set of at least some of the plurality of pillars have at least a portion of a sidewall surface that is facing towards the light receiving surface so as to be at an acute angle with respect to the light receiving top surface.

3. The solar cell in accordance with Claim 1, wherein for a particular horizontal direction, an average thickness at midpoint of the set of pillars is horizontally thinner in that particular horizontal direction than an average thickness ~~of~~ at the midpoint of a corresponding inter-combed set of trenches of the plurality of trenches.

4. The solar cell in accordance with Claim 1, wherein for a particular horizontal direction, an average thickness a midpoint of the set of pillars is horizontally thinner in that particular horizontal direction than half an average thickness ~~of~~ at the midpoint of a corresponding inter-combed set of trenches of the plurality of trenches.

5. The solar cell in accordance with Claim 1, wherein for a particular horizontal direction, an average thickness a midpoint of the set of pillars is horizontally thinner in that

particular horizontal direction than twice an average thickness ~~of~~ at the midpoint of a corresponding inter-combed set of trenches of the plurality of trenches.

6. The solar cell in accordance with Claim 1, wherein an average depth of each of the plurality of trenches in the vertical direction perpendicular to the light receiving top surface is at least half that of the thickness of the semiconductor body between the top side of the semiconductor body and the bottom flat surface.

7. The solar cell in accordance with Claim ~~1~~6, wherein the average depth is less than ten microns.

8. The solar cell in accordance with Claim 1, wherein an average depth of each of the plurality of trenches in the vertical direction perpendicular to the light receiving top surface is at least forty percent that of the thickness of the semiconductor body between the top side of the semiconductor body and the bottom flat surface.

9. The solar cell in accordance with Claim 1, wherein an average depth of each of the plurality of trenches in the vertical direction perpendicular to the light receiving top surface is at least thirty percent that of the thickness of the semiconductor body between the top side of the semiconductor body and the bottom flat surface.

10. The solar cell in accordance with Claim 1, wherein each of a second set of at least some of the plurality of trenches are structured such that for each of the pillars in the second set of pillars, there exists at least one point on the substantially flat light receiving surface that if a light ray is incident on that point, the light ray, if remaining within the corresponding trench, as opposed to entering the semiconductor body, will be redirected upwards at least after a third reflection on neighboring pillars.

11. The solar cell in accordance with Claim 1, wherein each of a second set of at least some of the plurality of trenches are structured such that for each of the pillars in the second set of pillars, there exists at least one point on the substantially flat light receiving surface that if a light ray is incident on that point, the light ray, if remaining within the corresponding trench, as opposed to entering the semiconductor body, will be redirected upwards at least after a second reflection on neighboring pillars, and will have at least a fourth reflection on neighboring pillars.

12. The solar cell in accordance with Claim 1, wherein along a particular horizontal direction, the set of pillars each have at least two photovoltaic junctions.

13. The solar cell in accordance with claim 1, wherein an electrical contact of a first polarity is coupled along the flat bottom surface of the semiconductor body.

14. The solar cell in accordance with Claim 13, where for at least one of the plurality of the plurality of pillars, an electrical contact of a second polarity is positioned within a neighboring trench and coupled to the semiconductor body at a sidewall of the pillar.

15. The solar cell in accordance with Claim 13, wherein an electrical contact of a second polarity is positioned on a flat portion of the top side of the semiconductor body.

16. The solar cell in accordance with Claim 1, wherein an electrical contact of a first polarity is coupled along a front side of the semiconductor body.

17. The solar cell in accordance with Claim 1, wherein an electrical contact of a second polarity is coupled along a back side of the semiconductor body.

18. A three dimensional solar cell comprising:

a semiconductor body having a substantially flat bottom surface, and having a plurality of arrayed shaped trenches formed along a top side of the semiconductor body opposite the bottom surface, the semiconductor body forming a pillar between each neighboring shaped trench, such that the semiconductor body has a plurality of arrayed pillars extending toward the top side of the semiconductor body; and

a light collecting material filling the plurality of arrayed shaped trenches along the top side of the semiconductor body and forming a substantially flat light receiving top surface substantially parallel to the bottom surface of the semiconductor body, each of the plurality of arrayed pillars having sidewalls contacting the light collecting transparent material, the light collecting material having an index of refraction that directs incident light more directly downward towards the plurality of arrayed shaped trenches;

wherein each of a set of at least some of the plurality of pillars have at least a portion of a sidewall surface that is facing towards the light receiving surface so as to be at an acute angle with respect to the light receiving top surface.

19. The solar cell in accordance with Claim 18, wherein for at least one of the plurality of pillars, the sidewall surface comprises a top portion that has an acute angle with respect to the light receiving top surface.

20. The solar cell in accordance with Claim 18, wherein for at least one of the plurality of pillars, the sidewall surface is entirely at an acute angle with respect to the light receiving top surface.

CLAIMS

What is claimed is:

1. A three dimensional solar cell comprising:

a semiconductor body having a substantially flat bottom surface, and having a plurality of arrayed shaped trenches formed along a top side of the semiconductor body opposite the bottom surface, the semiconductor body forming a pillar between each neighboring shaped trench, such that the semiconductor body has a plurality of arrayed pillars extending toward the top side of the semiconductor body; and

a light collecting material filling the plurality of arrayed shaped trenches along the top side of the semiconductor body and forming a substantially flat light receiving top surface substantially parallel to the bottom surface of the semiconductor body, each of the plurality of arrayed pillars having sidewalls contacting the light collecting transparent material;

wherein each of a set of at least some of the plurality of trenches are structured such that for each of the pillars in the set of pillars, there exists at least one point on the substantially flat light receiving surface that if a light ray is incident on that point, the light ray, if remaining within the corresponding trench, as opposed to entering the semiconductor body, will be redirected upwards at least after a third reflection on neighboring pillars.

2. The solar cell in accordance with Claim 1, wherein each of a set of at least some of the plurality of pillars have at least a portion of a sidewall surface that is facing towards the light receiving surface so as to be at an acute angle with respect to the light receiving top surface.

3. The solar cell in accordance with Claim 1, wherein for a particular horizontal direction, an average thickness a midpoint of the set of pillars is horizontally thinner in that particular horizontal direction than an average thickness of at the midpoint of a corresponding inter-combed set of trenches of the plurality of trenches.

4. The solar cell in accordance with Claim 1, wherein for a particular horizontal direction, an average thickness a midpoint of the set of pillars is horizontally thinner in that particular horizontal direction than half an average

thickness of at the midpoint of a corresponding inter-combed set of trenches of the plurality of trenches.

5. The solar cell in accordance with Claim 1, wherein for a particular horizontal direction, an average thickness a midpoint of the set of pillars is horizontally thinner in that particular horizontal direction than twice an average thickness of at the midpoint of a corresponding inter-combed set of trenches of the plurality of trenches.

6. The solar cell in accordance with Claim 1, wherein an average depth of each of the plurality of trenches in the vertical direction perpendicular to the light receiving top surface is at least half that of the thickness of the semiconductor body between the top side of the semiconductor body and the bottom flat surface.

7. The solar cell in accordance with Claim 1, wherein the average depth is less than ten microns.

8. The solar cell in accordance with Claim 1, wherein an average depth of each of the plurality of trenches in the vertical direction perpendicular to the light receiving top surface is at least forty percent that of the thickness of the semiconductor body between the top side of the semiconductor body and the bottom flat surface.

9. The solar cell in accordance with Claim 1, wherein an average depth of each of the plurality of trenches in the vertical direction perpendicular to the light receiving top surface is at least thirty percent that of the thickness of the semiconductor body between the top side of the semiconductor body and the bottom flat surface.

10. The solar cell in accordance with Claim 1, wherein each of a second set of at least some of the plurality of trenches are structured such that for each of the pillars in the second set of pillars, there exists at least one point on the substantially flat light receiving surface that if a light ray is incident on that point, the light ray, if remaining within the corresponding trench, as opposed to entering the semiconductor body, will be redirected upwards at least after a third reflection on neighboring pillars.

11. The solar cell in accordance with Claim 1, wherein each of a second set of at least some of the plurality of trenches are structured such that for each of the pillars in the second set of pillars, there exists at least one point on the substantially flat light

receiving surface that if a light ray is incident on that point, the light ray, if remaining within the corresponding trench, as opposed to entering the semiconductor body, will be redirected upwards at least after a second reflection on neighboring pillars, and will have at least a fourth reflection on neighboring pillars.

12. The solar cell in accordance with Claim 1, wherein along a particular horizontal direction, the set of pillars each have at least two photovoltaic junctions.

13. The solar cell in accordance with claim 1, wherein an electrical contact of a first polarity is coupled along the flat bottom surface of the semiconductor body.

14. The solar cell in accordance with Claim 13, where for at least one of the plurality of the plurality of pillars, an electrical contact of a second polarity is positioned within a neighboring trench and coupled to the semiconductor body at a sidewall of the pillar.

15. The solar cell in accordance with Claim 13, wherein an electrical contact of a second polarity is positioned on a flat portion of the top side of the semiconductor body.

16. The solar cell in accordance with Claim 1, wherein an electrical contact of a first polarity is coupled along a front side of the semiconductor body.

17. The solar cell in accordance with Claim 1, wherein an electrical contact of a second polarity is coupled along a back side of the semiconductor body.

18. A three dimensional solar cell comprising:

a semiconductor body having a substantially flat bottom surface, and having a plurality of arrayed shaped trenches formed along a top side of the semiconductor body opposite the bottom surface, the semiconductor body forming a pillar between each neighboring shaped trench, such that the semiconductor body has a plurality of arrayed pillars extending toward the top side of the semiconductor body; and

a light collecting material filling the plurality of arrayed shaped trenches along the top side of the semiconductor body and forming a substantially flat light receiving top surface substantially parallel to the bottom surface of the semiconductor body, each of the plurality of arrayed pillars having sidewalls contacting the light collecting transparent material;

wherein each of a set of at least some of the plurality of pillars have at least a portion of a sidewall surface that is facing towards the light receiving surface so as to be at an acute angle with respect to the light receiving top surface.

19. The solar cell in accordance with Claim 18, wherein for at least one of the plurality of pillars, the sidewall surface comprises a top portion that has an acute angle with respect to the light receiving top surface.

20. The solar cell in accordance with Claim 18, wherein for at least one of the plurality of pillars, the sidewall surface is entirely at an acute angle with respect to the light receiving top surface.

CLAIMS

What is claimed is:

1. A three dimensional solar cell comprising:

a semiconductor body having a substantially flat bottom surface, and having a plurality of arrayed shaped trenches formed along a top side of the semiconductor body opposite the bottom surface, the semiconductor body forming a pillar between each neighboring shaped trench, such that the semiconductor body has a plurality of arrayed pillars extending toward the top side of the semiconductor body; and

a light collecting material filling the plurality of arrayed shaped trenches along the top side of the semiconductor body and forming a substantially flat light receiving top surface substantially parallel to the bottom surface of the semiconductor body, each of the plurality of arrayed pillars having sidewalls contacting the light collecting transparent material, the light collecting material having an index of refraction that directs incident light more directly downward towards the plurality of arrayed shaped trenches;

wherein each of a set of at least some of the plurality of trenches are structured such that for each of the pillars in the set of pillars, there exists at least one point on the substantially flat light receiving surface that if a light ray is incident on that point, the light ray, if remaining within the corresponding trench, as opposed to entering the semiconductor body, will be redirected upwards at least after a third reflection on neighboring pillars.

2. The solar cell in accordance with Claim 1, wherein each of a set of at least some of the plurality of pillars have at least a portion of a sidewall surface that is facing towards the light receiving surface so as to be at an acute angle with respect to the light receiving top surface.

3. The solar cell in accordance with Claim 1, wherein for a particular horizontal direction, an average thickness at the midpoint of the set of pillars is horizontally thinner in that particular horizontal direction than an average thickness at the midpoint of a corresponding inter-combed set of trenches of the plurality of trenches.

4. The solar cell in accordance with Claim 1, wherein for a particular horizontal direction, an average thickness a midpoint of the set of pillars is horizontally thinner in that particular horizontal direction than half an average thickness at the midpoint of a corresponding inter-combed set of trenches of the plurality of trenches.

5. The solar cell in accordance with Claim 1, wherein for a particular horizontal direction, an average thickness a midpoint of the set of pillars is horizontally thinner in that

particular horizontal direction than twice an average thickness at the midpoint of a corresponding inter-combed set of trenches of the plurality of trenches.

6. The solar cell in accordance with Claim 1, wherein an average depth of each of the plurality of trenches in the vertical direction perpendicular to the light receiving top surface is at least half that of the thickness of the semiconductor body between the top side of the semiconductor body and the bottom flat surface.

7. The solar cell in accordance with Claim 6, wherein the average depth is less than ten microns.

8. The solar cell in accordance with Claim 1, wherein an average depth of each of the plurality of trenches in the vertical direction perpendicular to the light receiving top surface is at least forty percent that of the thickness of the semiconductor body between the top side of the semiconductor body and the bottom flat surface.

9. The solar cell in accordance with Claim 1, wherein an average depth of each of the plurality of trenches in the vertical direction perpendicular to the light receiving top surface is at least thirty percent that of the thickness of the semiconductor body between the top side of the semiconductor body and the bottom flat surface.

10. The solar cell in accordance with Claim 1, wherein each of a second set of at least some of the plurality of trenches are structured such that for each of the pillars in the second set of pillars, there exists at least one point on the substantially flat light receiving surface that if a light ray is incident on that point, the light ray, if remaining within the corresponding trench, as opposed to entering the semiconductor body, will be redirected upwards at least after a third reflection on neighboring pillars.

11. The solar cell in accordance with Claim 1, wherein each of a second set of at least some of the plurality of trenches are structured such that for each of the pillars in the second set of pillars, there exists at least one point on the substantially flat light receiving surface that if a light ray is incident on that point, the light ray, if remaining within the corresponding trench, as opposed to entering the semiconductor body, will be redirected upwards at least after a second reflection on neighboring pillars, and will have at least a fourth reflection on neighboring pillars.

12. The solar cell in accordance with Claim 1, wherein along a particular horizontal direction, the set of pillars each have at least two photovoltaic junctions.

13. The solar cell in accordance with claim 1, wherein an electrical contact of a first polarity is coupled along the flat bottom surface of the semiconductor body.

14. The solar cell in accordance with Claim 13, where for at least one of the plurality of the plurality of pillars, an electrical contact of a second polarity is positioned within a neighboring trench and coupled to the semiconductor body at a sidewall of the pillar.

15. The solar cell in accordance with Claim 13, wherein an electrical contact of a second polarity is positioned on a flat portion of the top side of the semiconductor body.

16. The solar cell in accordance with Claim 1, wherein an electrical contact of a first polarity is coupled along a front side of the semiconductor body.

17. The solar cell in accordance with Claim 1, wherein an electrical contact of a second polarity is coupled along a back side of the semiconductor body.

18. A three dimensional solar cell comprising:

a semiconductor body having a substantially flat bottom surface, and having a plurality of arrayed shaped trenches formed along a top side of the semiconductor body opposite the bottom surface, the semiconductor body forming a pillar between each neighboring shaped trench, such that the semiconductor body has a plurality of arrayed pillars extending toward the top side of the semiconductor body; and

a light collecting material filling the plurality of arrayed shaped trenches along the top side of the semiconductor body and forming a substantially flat light receiving top surface substantially parallel to the bottom surface of the semiconductor body, each of the plurality of arrayed pillars having sidewalls contacting the light collecting transparent material, the light collecting material having an index of refraction that directs incident light more directly downward towards the plurality of arrayed shaped trenches;

wherein each of a set of at least some of the plurality of pillars have at least a portion of a sidewall surface that is facing towards the light receiving surface so as to be at an acute angle with respect to the light receiving top surface.

19. The solar cell in accordance with Claim 18, wherein for at least one of the plurality of pillars, the sidewall surface comprises a top portion that has an acute angle with respect to the light receiving top surface.

20. The solar cell in accordance with Claim 18, wherein for at least one of the plurality of pillars, the sidewall surface is entirely at an acute angle with respect to the light receiving top surface.