 ADVANCED SOLAR TECHNOLOGY

| Invention Name: | Microsystems Enabled Photovoltaics (MEPV)  
|                | “Solar Glitter” |

![Diagram with various icons connecting to each other, representing different sectors and technologies.]
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EXECUTIVE SUMMARY

Technology

Development

Regulatory Hurdles

Unique Benefits

Landscape

Intellectual Property

Inventive

Other IP Options

Novel

Useful

Market

Size

Competitive Landscape

Clear Competitive Advantage

Growth

Profitability

Ideal -

Commercialisation Summary

The high efficiency and extreme curvature of the device must be emphasised to gain traction in a market with a large population of ostensibly similar devices. Continuous research and development, in addition to global expansion in manufacturing capability, will exert heavy competitive pressures and limit benefits from the rapidly growing market.

Google Summary

A substantial quantity of relevant research and development in this area has been conducted, and numerous laboratory cells that possess similar properties exist. The exact methods of production and array construction are remaining points of difference. A large amount of publically available documents from the original research institute were also found.

Patent Summary

Numerous patents covering individual aspects of this technology and combinations thereof were found. Included in this were granted patents for the original researcher. Again, the specific manufacturing process is the key distinguishing factor.
TECHNOLOGY ANALYSIS

Idea Description

A photovoltaic device comprising an array of microfabricated semiconductor cells, each with its own substrate and contacts at micron scale thickness and submillimeter diameter. Several additional components such as intrinsic solar tracking lensing and self-assembly capability are included. The device can efficiently produce electricity from solar energy while being highly flexible in design and installation, allowing for a wide range of applications previously beyond the reach of large rigid panels.

Features & Benefits

<table>
<thead>
<tr>
<th>Features</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miniaturized components</td>
<td>• Low raw material requirements</td>
</tr>
<tr>
<td></td>
<td>• Installation flexibility</td>
</tr>
<tr>
<td></td>
<td>• Increased functionality</td>
</tr>
<tr>
<td></td>
<td>• Robust structure</td>
</tr>
<tr>
<td>Self-assembly</td>
<td>• Application versatility</td>
</tr>
<tr>
<td>High efficiency</td>
<td>• Inexpensive power production</td>
</tr>
</tbody>
</table>

What may be some innovative aspects of the technology?

Some innovative aspects of this invention could be but are not limited to:

• Low profile PV cells
• Microfabrication of integrated PV system
• Self-assembly of a cell array
• Individual micro-optical focusing
Are there regulatory hurdles?

The specific regulatory requirements will depend on the specific jurisdictions that products and services based on your invention are sold into. For this technology, there may be a moderate amount of regulatory hurdles to overcome in the commercialisation process.

The following links provide information and services available to assist in understanding the specific regulatory requirements in different jurisdictions:

**RESOURCES**

<table>
<thead>
<tr>
<th>Institution</th>
<th>Website</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commission</td>
<td></td>
</tr>
<tr>
<td>and Industry</td>
<td></td>
</tr>
</tbody>
</table>

What is the development status?

The current status of the invention is at the prototype stage.

This is an early stage in product development, and therefore moderate work needs to be done to transfer the technology from this stage into a product that can be sold commercially. The typical developmental steps are:
LANDSCAPE

Semantic Mapping

The semantic map below illustrates the divisional breakdown of this report. To show a simplified landscape setting we have provided the following schematic, however the divisions and subfields shown may have further interconnectedness.¹

PatentScope

Landscape

The following landscape analysis was conducted using patent applications on WIPO PatentScope as an indicator of patenting activity, and thus as a proxy for innovation in the field.

Search query keywords: (bending OR flexible) (photovoltaic cell) yielded 438 patents.

SUMMARY

Patent applications in this area have been steadily increasing over the past decade, but with a significant decline in recent years. This indicates that the technology may have reached maturity, resulting in several competing products for new entrants. Applications originate from a wide range of international companies, showing worldwide interest, but with no single group establishing dominance.
INTELLECTUAL PROPERTY ANALYSIS

- Online Technology Overview – Google Scholar Search
- Patent Searches on Espacenet

Depending on the type of patent, the jurisdictions you pursue, and other advice, your patent application will follow a different (and complex) pathway in order to be granted. However, at this stage of analysis it is important to understand whether your invention may be patentable. This will depend on whether it is **patentable subject matter, useful, inventive** and **novel**. These criteria may change over different regions. For more information on patentability, see **Appendix A**.

SUMMARY OF ESPACENET & GOOGLE FINDINGS

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Draft for Client</th>
</tr>
</thead>
<tbody>
<tr>
<td>Useful: Does the invention have a practical utility?</td>
<td>Moderate to Highly. A wide range of applications exists for this technology, from powering mobile goods, to significant energy production.</td>
</tr>
<tr>
<td>Inventive: Is the invention different from what would be obvious to those skilled in the art?</td>
<td>Limited to Moderate. A large body of research and development surrounding flexible photovoltaic cells exists, as well as lensing and thin film techniques.</td>
</tr>
<tr>
<td>Novel: Is the invention different and new from what is known in the prior art?</td>
<td>Moderate. The basic properties of the submission are addressed by literature, but manufacture and design specifics are not. See Google and Espacenet novelty searches.</td>
</tr>
</tbody>
</table>
Online Technology Overview – Google Scholar Search

The following online searches were conducted using Google Scholar, but sometimes we also supplement with general web searching. Images and search terms are hyperlinked for your convenience. We use specific Google operators to widen our search range. For example, the tilde symbol (~) commands Google to search for synonyms or other versions of a selected keyword.

Our methodology for online search is to conduct searches online using keywords from our understanding of the invention through the above analysis. The aim of the search is not a conclusive novelty determination, but rather to ascertain if there is relevant literature. See Appendix B for more information on our Google Scholar Search.

SUMMARY OF GOOGLE SEARCH FINDINGS

A substantial quantity of relevant research and development in this area has been conducted, and numerous laboratory cells that possess similar properties exist. The exact methods of production and array construction are remaining points of difference. A large amount of publically available documents from the original research institute were also found.

TAXONOMY

<table>
<thead>
<tr>
<th>Level</th>
<th>Keywords</th>
<th>Broader</th>
<th>Narrower</th>
<th>Alternate</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>photovoltaic</td>
<td></td>
<td>photovoltaic cell</td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>micro</td>
<td></td>
<td>microfabrication</td>
<td>microsystem</td>
</tr>
<tr>
<td>III</td>
<td>flexible</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>lens</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V</td>
<td></td>
<td></td>
<td>thin film</td>
<td></td>
</tr>
<tr>
<td>VI</td>
<td>array</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Google search query:** (photovoltaic) (micro) (flexible) (lens)

**11500000 results.** [Click here](#) for search query. Several immediately relevant technologies were found, including some published by the submission laboratory.

<table>
<thead>
<tr>
<th>Title</th>
<th>Publication Date</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>a Ultrathin silicon solar microcells for semitransparent, mechanically flexible and microconcentrator module designs</td>
<td>2008</td>
<td>A highly relevant article discussing the manufacture of ultra-thin flexible PV cells with micro-lens tracking.</td>
</tr>
<tr>
<td>c EVG</td>
<td>Thin PV Wafers</td>
<td>March 2010</td>
</tr>
</tbody>
</table>

a. [Click here](#) for full reference.
b. Click here for full reference.

The use of flat-plane solar concentrators is an effective approach toward collecting sunlight economically and without sun trackers. The optical concentrators are, however, usually made of rigid glass or plastics having limited flexibility, potentially restricting their applicability. In this communication, we describe flexible waveguiding photovoltaics (FWPVs) that exhibit high optical efficiencies and great mechanical flexibility. We constructed these FWPVs by integrating poly-Si solar cells, a soft polydimethylsiloxane (PDMS) waveguide, and a TiO₂-doped backside reflector. Optical microstructures that increase the light harvesting ability of the FWPVs can be fabricated readily, through soft lithography, on the top surface of the PDMS waveguide. Our optimized structure displayed an optical efficiency of greater than 42% and a certified power conversion efficiency (PCE) of 5.57%, with a projected PCE as high as approximately 18%. This approach might open new avenues for the harvesting of solar energy at low cost with efficient, mechanically flexible photovoltaics.

c. Click here for full reference.

Reducing the thickness of solar cells offers multiple advantages. The substrate cost for crystalline silicon is still a significant part of the total module costs—reducing the thickness allows reducing the cost. The PV roadmap predicts a crystalline silicon wafer thickness of 100 μm by 2020. Reducing the wafer thickness increases the risk of wafer breakage during processing, which would require shutting down the processing line to clean out the broken wafers. Temporary bonding and debonding enables breakage-free PV cell production by bonding the thin substrate on a carrier wafer. The carrier wafer provides mechanical stability during the entire manufacturing process. At the end, the thin substrate is debonded and mounted into the PV module.

Besides the economical advantage ultra thin solar cells enable a higher cell efficiency. Theoretical calculations taking into account auger- and radiative recombination showed an optimal cell thickness of 40 μm (Kerr et al., 20th IEEE PVSC, 2002). Thin PV cells can be either mounted on a rigid or a flexible substrate. Integration into a flexible substrate reduces the weight and opens the field of use for silicon solar cells. For multi-junction solar cells based on compound semiconductor materials temporary bonding and debonding is used for layer transfer from the growth substrate to the final substrate.
**SEARCH 2**

**Google search query:** ("photovoltaic cell") (microfabrication OR "micro-fabrication") (flexible) ("thin film")

<table>
<thead>
<tr>
<th>Title</th>
<th>Publication Date</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. <strong>Microsystems enabled photovoltaics (MEPV)</strong></td>
<td>2012</td>
<td>A detailed publication from the original submission.</td>
</tr>
</tbody>
</table>

a. [Click here](#) for full reference.

Sandia’s MEPV team has developed microscale photovoltaic (PV) cells using microsystems tools and manufacturing techniques familiar to the semiconductor industry. With dimensions as small as 100-μm wide and 1-μm thick, these miniaturized PV cells convert photons from the sun or any other light source into electricity. As with microelectronic components, the small size of the PV cells enables the packaging and integration of the energy system into a variety of formats that conform to the shapes and contours of the powered device and blend into the device’s look, feel, and functionality.
Google search query: ("photovoltaic cell") (micro) (flexible) (lens) ("thin film") (array)

205000 results. Click here for search query. Several patents related to lensing and thin film PV arrays found.

<table>
<thead>
<tr>
<th>Title</th>
<th>Publication Date</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>b THIN FILM PHOTOVOLTAIC DEVICES WITH MICROLENS ARRAYS - UNIVERSITY OF FLORIDA RESEARCH FOUNDATION, INC.</td>
<td>04/18/2013</td>
<td>A related patent discussing the use of various lensing structures for thin film PV arrays.</td>
</tr>
</tbody>
</table>

a. Click here for full reference.

Abstract:
The integrated system for the conversion of solar energy into eco-compatible energy, comprises panels destined to the reception of solar rays, and is characterized by the presence in the panels of: A plastic film bearing micro-etchings that form an array of multi-focal holographic micro-lenses (m1. m2) of infinitesimal size, capable of being positioned on the panel in a random manner, or A pair of plastic films superposed on each other, bearing on their inner and outer surfaces micro-undulator forms capable of creating a series of micro-lenses (c1. c2) of an o-
spherical shape and infinitesimal size, having different refractive indices and capable of being positioned on the panel in a random manner.

b. Click here for full reference.

Textured transparent layers are formed on the incident light receiving surface of thin film solar cells to increase their efficiency by altering the incident light path and capturing a portion of the light reflected at the MLA. The textured transparent layer is an array of lenses of micrometer proportions such as hemispheres, hemi-ellipsoids, partial-spheres, partial-ellipsoids, cones, pyramids, prisms, half cylinders, or combinations thereof. A method of forming the textured transparent layer to the light incident surface of the solar cell is by forming an array of lenses from a photcurable resin and its subsequent curing. The photcurable resin can be applied by inkjet printing or can be applied by roll to roll imprinting or stamping with a mold.
Google Scholar search query: ("photovoltaic cell") (micro) (flexible) ("thin film")

3890 results. Click here for search query. Several results returned related to the device, Some closely related.

<table>
<thead>
<tr>
<th>Title</th>
<th>Publication Date</th>
<th>Comment</th>
</tr>
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</table>

a. Click here for full reference.

**Thin-film solar cell fabricated on a flexible metallic substrate**

**US 7053294 B2**

**ABSTRACT**

A thin-film solar cell (10) is provided. The thin-film solar cell (10) comprises a flexible metallic substrate (12) having a first surface and a second surface. A back metal contact layer (16) is deposited on the first surface of the flexible metallic substrate (12). A semiconductor absorber layer (14) is deposited on the back metal contact. A photoactive film deposited on the semiconductor absorber layer (14) forms a heterojunction structure and a grid contact (24) deposited on the heterojunction structure. The flexible metal substrate (12) can be constructed of either aluminium or stainless steel. Furthermore, a method of constructing a solar cell is provided. The method comprises providing an aluminum substrate (12), depositing a semiconductor absorber layer (14) on the aluminum substrate (12), and insulating the aluminum substrate (12) from the semiconductor absorber layer (14) to inhibit reaction between the aluminum substrate (12) and the semiconductor absorber layer (14).
b. Click here for full reference.

**ABSTRACT**

The flexible photovoltaic cell includes thin front and rear junction regions electrically in series, each formed of ceramic metallic glass semi-conductor alloys of silicon of approximately zero thermal expansion/contraction coefficient laminated with an intervening semi-conducting layer less than 60 Angstroms thick or an insulating layer less than 20 Angstroms thick. The respective spectral sensitivities of the front and rear junction regions are tailored to different frequency ranges. In front are six layers described in sequence rear to front. The lowermost (sixth) is a green/blue semi-insulating cobalt and tin passivating and filter layer less than 10 Angstroms thick. The fifth is a semi-conductive, degradation-protective “window” and one-way mirror for returning back-reflected light. The fourth is an insulating tunneling layer less than 15 Angstroms thick for coupling a front collection grid to the “window”. Covering the fourth is a triple-layer, anti-reflection coating (ARC) whose middle layer bonds the outer ARC layers and secondarily protects the cell from atmospheric degradation. An internally reflective rear ARC layer cooperates with the “window” for returning back-reflected light. The frontmost ARC layer is mainly comprised of $\text{Al}_2\text{O}_3$ and SiO$_2$ in the range of 200 to 650 Angstroms thickness. The cell backside is shown having undulations for randomizing reflected light rays. The six front layers effectively adapt the cell for receptivity to solar radiation from about 4,000 to about 12,000 Angstroms, excluding radiation outside thereof, thus accepting 69 percent of solar energy vertically reaching the earth’s surface.

**SEARCH 5**

Google Scholar search query: ("photovoltaic cell") (micro) (flexible) (lens) ("thin film") (array)

602 results. Click here for search query. Results returned related to thin film photovoltaics with concentrator layers.

<table>
<thead>
<tr>
<th>Title</th>
<th>Publication Date</th>
<th>Comment</th>
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</table>

In various embodiments described herein, a device comprising a light guiding layer optically coupled to a photocell is described. A plurality of surface features are formed on one the surface of the light guiding layer. The surface features can comprise facets that are angled with respect to each other. Light incident on the surface of the light guide is redirected by the surface features and guided through the light guide by multiple total internal reflections. The guided light is directed towards a photocell.

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Google Scholar search query: ("photovoltaic cell") (microsystem) (lens) ("thin film") (array)

93 results. Click here for search query. No immediately relevant results returned.
Patent Searches on Espacenet

NOVELTY SEARCH

This is not a full Patentability search. The preliminary searches in Espacenet are an attempt to find relevant literature in available public databases based on our understanding of the invention through your submission and the above technology analysis. For more on the specifics of our Espacenet searches refer to Appendix C.

The results below are hyperlinked so you can replicate the searches with one click, then easily modify, expand, and explore them. The tables include hyperlinks to the patent applications from these searches which may be relevant, or of interest, to the current invention.

SUMMARY OF ESPACENET SEARCHES

Numerous patents covering individual aspects of this technology and combinations thereof were found. Included in this were granted patents for the original researcher. Again, the specific manufacturing process is the key distinguishing factor.

TAXONOMY

<table>
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<tr>
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<tr>
<td>III</td>
<td>flexible</td>
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<td></td>
<td></td>
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<tr>
<td>IV</td>
<td></td>
<td></td>
<td>concentrator</td>
<td></td>
</tr>
<tr>
<td>V</td>
<td></td>
<td></td>
<td>thin film</td>
<td></td>
</tr>
<tr>
<td>VI</td>
<td>array</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VII</td>
<td>solar</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>
Espacenet search query: (photovoltaic) (flexible) ("thin film") (array)

8 results. Click here for search query. A few relevant results returned concerning flexible thin-film PV arrays.

<table>
<thead>
<tr>
<th>Title</th>
<th>Publication Number</th>
<th>Publication Date</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>a Device for spraying electrode and synchronously depositing thin film in manufacturing of flexible thin film photovoltaic cell</td>
<td>CN202465863 (U)</td>
<td>2012-10-03</td>
<td>A related method of forming a thin-film PV array.</td>
</tr>
<tr>
<td>b Method of forming an electronic device</td>
<td>GB2376344 (A)</td>
<td>2002-12-11</td>
<td>A relevant patent describing the formation of a thin film photovoltaic cell on a flexible substrate with lensing.</td>
</tr>
</tbody>
</table>

a. Click here for full reference.

The utility model provides a device for spraying an electrode and synchronously depositing a thin film in manufacturing of a flexible thin film photovoltaic cell and relates to the device for spraying the electrode and synchronously depositing the thin film in a PECVD (Plasma Enhanced Chemical Vapor Deposition) preparation process. The device comprises vacuum equipment which is internally provided with a spraying electrode and a base electrode; the electrode is connected with an outer radio frequency power supply; the electrode is attached with a battery substrate; the spraying electrode is internally provided with a gas channel; and the spraying electrode and the attached battery substrate are provided with small holes. Two groups of the small holes correspond one by one and are arrayed in a matrix or concentric circle array. Gas passed through two groups of the small holes to vertically spray to the battery substrate on the base electrode, and meanwhile, the battery substrate on the spraying electrode obtains the sprayed gas so as to realize thin film depositing. Therefore, the surface of the battery substrate on the electrode is deposited with the thin film and the thin film photovoltaic cell is prepared by the electrode. The capacity of the equipment can be multiplied, and the washing working amount of the electrode also can be extremely reduced.

b. Click here for full reference.

A method of forming a solar cell or photovoltaic using the technique of drop on demand printing to deposit a plurality of droplets of deposition material that when suitably dried or solidified form the elements of the device. Printing materials include polymers, metalloorganics, buckminsterfullerenes doped conducting polymers, polythiophenes, phthalocyanines and mixtures thereof. The solar cell may be a thin film or thick film device, and possess a single or multiple heterojunction. The solar cell is formed on a flexible or rigid substrate 402, and an array of microcavities 412 formed from an anode are deposited to maximise the light collection efficiency.
SEARCH 2

Espacenet search query: ("photovoltaic cell") (micro) ("thin film")

4 results. Click here for search query. Results related to thin film PV cell manufacture found.

<table>
<thead>
<tr>
<th>Title</th>
<th>Publication Number</th>
<th>Publication Date</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thin-film photovoltaic cell</td>
<td>CN102088039 (A)</td>
<td>2011-06-08</td>
<td>A related patent describing fabrication of a thin film PV cell.</td>
</tr>
</tbody>
</table>

a. Click here for full reference.

A thin-film photovoltaic cell is provided. The thin-film photovoltaic cell comprises a transparent substrate, a conformal transparent conductive oxide layer situated on the transparent substrate, a conformal semiconductor layer situated on the conformal transparent conductive oxide layer, and a conformal metal layer situated on the conformal semiconductor layer. Micro-protrusions are disposed on the surface of the transparent substrate or the transparent conductive oxide layer. The height, width, and interval of the micro-protrusion are larger than ten times of incident light’s wavelength and smaller than the width of the photovoltaic cell. Micro-protrusions, in micro-meter scale, are produced on a surface of the photovoltaic cell to produce scattering effect and multiple reflecting effect of incident light.
Espacenet search query: (photovoltaic) (concentrator) ("thin film") (solar)

6 results. Click here for search query. Several results disclosing thin film and lensing found.

<table>
<thead>
<tr>
<th>Title</th>
<th>Publication Number</th>
<th>Publication Date</th>
<th>Comment</th>
</tr>
</thead>
</table>

a. Click here for full reference.

A low cost concentrating photovoltaic system includes a condenser system having refractive or reflective optics and a photovoltaic module having one or more thin film solar cells. The thin film solar cells may be a-Si, CdTe, Cu(InGa)Se₂, organic solar cell or dye sensitized solar cells. The condenser system may be a flat, cylindrical or hemispherical Fresnel lens, a parabolic reflector, a compound parabolic concentrator, a reflective V-trough, or a combination thereof. The condenser system has a concentration ratio of about 10 to 100 or higher. No tracking system is needed in many examples, or a simple one-axis tracking may be used. In one example, the condenser system uses a hemispherical Fresnel lens which focuses sunlight onto a hemispherical focal surface, and one thin film solar cell (mounted on a tracking unit) or multiple cells (without tracking) are disposed on the hemispherical focal surface of the Fresnel lens.

b. Click here for full reference.

This project encompassed design and fabrication of a single pixel for a solar concentrator photovoltaic monolithic micromirror. Photovoltaic concentrators offer a competitive electricity cost. Such concentrating microarrays may enable photovoltaic cells with 40-50% efficiency using III-V compound heterostructures.

The main components of the design include a thin film solar cell, an array of soft polymer microlenses to optimally concentrate solar radiation, and a heat sink to manage the heat dissipated. Microlens arrays were fabricated in polydimethylsiloxane (PDMS) using soft lithography techniques and the optical properties (transmittance, lens magnification, aberrations, etc.) were characterized. The results indicate that such microarrays can be used for a monolithic concentrating photovoltaic array.
**Espacenet search query**: ("photovoltaic solar concentrator")

4 results. [Click here](#) for search query. Submission results returned.

<table>
<thead>
<tr>
<th>Title</th>
<th>Publication Number</th>
<th>Publication Date</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>a Photovoltaic solar concentrator</td>
<td>US8329503 (B1)</td>
<td>2012-12-11</td>
<td>A patent granted to the original researcher of the submission.</td>
</tr>
</tbody>
</table>

a. [Click here](#) for full reference.

A photovoltaic solar concentrator is disclosed with one or more transverse-junction solar cells (also termed point contact solar cells) and a lens located above each solar cell to concentrate sunlight onto the solar cell to generate electricity. Piezoelectric actuators tilt or translate each lens to track the sun using a feedback-control circuit which senses the electricity generated by one or more of the solar cells. The piezoelectric actuators can be coupled through a displacement multiplier linkage to provide an increased range of movement of each lens. Each lens in the solar concentrator can be supported on a frame (also termed a tilt plate) having three legs, with the movement of the legs being controlled by the piezoelectric actuators.
**Other Intellectual Property Rights**

Listed below are other ways you may be able to protect your intellectual property. We recommend you seek an attorney or intellectual property rights specialist to further address the IP protection. See [Appendix D](#) for more information.

<table>
<thead>
<tr>
<th>TYPE</th>
<th>COMMENTS</th>
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<tbody>
<tr>
<td>Circuit Layout Rights</td>
<td>May apply to designed or self-assembled circuits</td>
</tr>
</tbody>
</table>

For a more comprehensive list of types of intellectual property, refer to Wikipedia’s “[List of intellectual property-related topics](#)”.
MARKET ANALYSIS

OPPORTUNITY ASSESSMENT

The following shows potential commercial applications of the invention, assuming it were successfully commercialised.

SUMMARY OF MARKET ANALYSIS

The total market for solar photovoltaics is growing rapidly, but this is being easily matched by an increase in supply capacity, and development of new technologies to deliver unique benefits as prices fall across the board. The industry exists within an atmosphere of intense competition, driving down profitability and requiring constant introduction of new capabilities and segments to maintain an edge. Focus on the niche field of micro-solar cells for embedded and other atypical applications may present a unique opportunity for strong and profitable commercialization in this industry. This technology may have to prove its advantages over other "flexible" type solar cells.
Different products and services can have different purchasers and users depending on where they exist in the value chain. The following table is an assessment of the industry for the primary opportunity.

<table>
<thead>
<tr>
<th>Sector</th>
<th>NAICS 31-33 Manufacturing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sub-sector</td>
<td>NAICS 334 Computer &amp; electronic product manufacturing</td>
</tr>
<tr>
<td>Industry Group</td>
<td>NAICS 3344 Semiconductor and Other Electronic Component Manufacturing</td>
</tr>
<tr>
<td>Industry</td>
<td>NAICS 33441 Semiconductor &amp; other electronic component manufacturing</td>
</tr>
<tr>
<td>National Specific Industry</td>
<td>NAICS 334413 Semiconductor and Related Device Manufacturing</td>
</tr>
<tr>
<td></td>
<td>This U.S. industry comprises establishments primarily engaged in manufacturing semiconductors and related solid state devices. Examples of products made by these establishments are integrated circuits, memory chips, microprocessors, diodes, transistors, solar cells and other optoelectronic devices.</td>
</tr>
<tr>
<td>Industry Segment</td>
<td>Photovoltaic devices, solid-state, manufacturing</td>
</tr>
<tr>
<td>Products and/or Services</td>
<td>Flexible, highly versatile arrays of microfabricated solar cells.</td>
</tr>
<tr>
<td>Market Need</td>
<td>Increasing demand for cheap, robust and self-contained energy generation for varied applications.</td>
</tr>
<tr>
<td>Purchaser</td>
<td>Semiconductor, solar cell manufacturers</td>
</tr>
<tr>
<td>Consumer</td>
<td>Power companies, secondary electronics manufacturer, business and consumers</td>
</tr>
<tr>
<td>Distribution Channels</td>
<td>Tier 1</td>
</tr>
<tr>
<td>Estimated Unit Price</td>
<td>$10-$10000</td>
</tr>
<tr>
<td>Estimated Frequency of Purchase by End Consumer</td>
<td>2-5 years</td>
</tr>
<tr>
<td>Comments</td>
<td>The large range of available end consumers of this technology, and the ever growing need for inexpensive energy will help to insulate the revenues from negative influences.</td>
</tr>
</tbody>
</table>
A large number of small firms exist in this industry, suggesting star-up optimism, but the vast majority of revenue flows to the relatively small number of very large established companies. The total number of companies has remained relatively stable, while average employee numbers are down, indicating a downsizing trend among even these firms. This may be due to the fact that operating profits are highly responsive to diminishing revenue, requiring cost elimination.
COMPANY FINANCIALS FOR SEMICONDUCTOR AND RELATED DEVICE MANUFACTURING

The average current ratio for companies in this industry is high, indicating a low liquidity risk. A average operating profit of 8% indicates a healthy outlook. All other indicators show stability.

Average US Public Company in 2010

<table>
<thead>
<tr>
<th>Income Statement (amounts in USD Thousands)</th>
<th>Company Balance Sheet (amounts in USD Thousands)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Revenue</strong></td>
<td><strong>Assets</strong></td>
</tr>
<tr>
<td>Sales</td>
<td>Cash</td>
</tr>
<tr>
<td>16,938,000</td>
<td>2,777,053</td>
</tr>
<tr>
<td><strong>Cost of Sales</strong></td>
<td>Net Accounts Receivable</td>
</tr>
<tr>
<td>Cost of Goods Sold</td>
<td>3,791,910</td>
</tr>
<tr>
<td>10,238,600</td>
<td>Inventories</td>
</tr>
<tr>
<td><strong>Gross Margin</strong></td>
<td>1,539,054</td>
</tr>
<tr>
<td>Gross Margin</td>
<td>Short-Term Investments</td>
</tr>
<tr>
<td>6,699,400</td>
<td>81,404</td>
</tr>
<tr>
<td><strong>Expenses</strong></td>
<td>Other Current Assets</td>
</tr>
<tr>
<td>Advertising</td>
<td>1,731,385</td>
</tr>
<tr>
<td>206,254</td>
<td>Long-Term Investments</td>
</tr>
<tr>
<td>Salaries &amp; Wages</td>
<td>6,196,158</td>
</tr>
<tr>
<td>1,792,752</td>
<td>Plant, Property &amp; Equipment</td>
</tr>
<tr>
<td>Employee Benefit Program</td>
<td>3,290,681</td>
</tr>
<tr>
<td>285.321</td>
<td>Other Assets</td>
</tr>
<tr>
<td>Pension &amp; Annuity Plans</td>
<td>1,334,511</td>
</tr>
<tr>
<td>73.900</td>
<td>Net Intangible Assets</td>
</tr>
<tr>
<td>Compensation of Officers</td>
<td>2,809,472</td>
</tr>
<tr>
<td>172.327</td>
<td></td>
</tr>
<tr>
<td>Bad Debt</td>
<td>Total Assets</td>
</tr>
<tr>
<td>54.625</td>
<td>23,551,630</td>
</tr>
<tr>
<td>Rent Paid</td>
<td></td>
</tr>
<tr>
<td>169,397</td>
<td></td>
</tr>
<tr>
<td>Repairs</td>
<td>Liabilities</td>
</tr>
<tr>
<td>74,849</td>
<td>Accounts Payable</td>
</tr>
<tr>
<td>Depreciation Depletion Amort.</td>
<td>3,240,578</td>
</tr>
<tr>
<td>915,279</td>
<td>Short-Term Obligations</td>
</tr>
<tr>
<td>Interest Paid</td>
<td>488,949</td>
</tr>
<tr>
<td>337,083</td>
<td>Other Current Liabilities</td>
</tr>
<tr>
<td>Miscellaneous Expenses</td>
<td>1,646,357</td>
</tr>
<tr>
<td>1,320,097</td>
<td></td>
</tr>
<tr>
<td><strong>Total Expenses</strong></td>
<td>Total Current Liabilities</td>
</tr>
<tr>
<td>5,401,884</td>
<td>5,375,884</td>
</tr>
<tr>
<td><strong>EBITDA</strong></td>
<td>Long-Term Debt</td>
</tr>
<tr>
<td>2,549,878</td>
<td>5,391,874</td>
</tr>
<tr>
<td><strong>Net Income</strong></td>
<td>Total Liabilities</td>
</tr>
<tr>
<td><strong>Operating Profit</strong></td>
<td>10,767,760</td>
</tr>
<tr>
<td>1,297,516</td>
<td></td>
</tr>
<tr>
<td><strong>Total Liabilities &amp; Net Worth</strong></td>
<td>Total Net Worth &amp; Owner Equity</td>
</tr>
<tr>
<td><strong>Total Liabilities &amp; Net Worth</strong></td>
<td>12,783,870</td>
</tr>
<tr>
<td>23,551,630</td>
<td></td>
</tr>
</tbody>
</table>

Source: IRS, see [www.sec.gov/edgar.shtml](http://www.sec.gov/edgar.shtml)
NEW INVESTMENTS

The Industrial and Energy industry was in the top 3 industries that received venture capital funding in 2011, however recently has seen a drop in number of deals and total funding. This industry is largely influenced by Clean Energy technology which saw the lowest number of deals and funding more recently. Energy efficiency and renewables maintain strong deal and dollar activity in 2012. Historically, total and first round financing peaked in 2008, followed by a sharp decline. It appears that prior to 2008, total investment was nearly parallel to first round investing, indicating that most companies were funded in the earlier stage, and little thereafter. Since 2008, funding has appeared to be more conservative, with first round financing bottoming out and total financing appearing at a later stage.

US Venture Capital Investment & Average Investment Deal

Source data: National Venture Capital Association [www.nvca.org](http://www.nvca.org)
INDUSTRY REPORTS

The market of photovoltaic cell based electricity production across all applications is growing fast, and expanding across the global market. A worldwide manufacturing response to this market growth and its predicted continuation is resulting in dramatically increased competition in domestic markets. The expansion of various subsectors, in particular thin-film cell production, are dramatically increasing their market share as their benefits become clear. This development means increased unpredictability for manufacturers of current technologies.


Solar Panel Manufacturing in the US

The Solar Panel Manufacturing industry experienced significant volatility during the past five years. Generous government tax credits for energy efficiency initially stimulated downstream demand from consumers, businesses, manufacturers and solar power producers, while government assistance helped industry operators expand production capacity. However, in the five years to 2018, intensifying international competition and waning demand will cripple revenue. Operators in this industry manufacture solar panels and solar cells and supplies these products to solar panel installers and downstream residential, commercial and utility customers. This industry however, does not include American companies that manufacture solar panels abroad.

This report covers the scope, size, disposition and growth of the industry including the key sensitivities and success factors. Also included are five year industry forecasts, growth rates and an analysis of the industry key players and their market shares.

FRAUNHOFER INSTITUTE FOR SOLAR ENERGY SYSTEMS ISE Photovoltaics Report
Fraunhofer ISE 2013. Click here.
If 2013 was about raising the issue, 2014 will be about defining solutions. Increasingly, solar is not bound by its cost, but rather by its role in the electricity sector. And as solar continues along its path toward the mainstream, its integration with the broader electricity market from a technical, market and regulatory perspective will become one of the most important issues in the industry.

Key Figures
- The U.S. installed 4,751 MW of solar PV in 2013, up 41% over 2012 and nearly fifteen times the amount installed in 2008.
- There is now a total of 12.1 GW of PV and 918 MW of CSP operating in the U.S.
- There were 140,000 individual solar installations in the U.S. in 2013, and a total of over 445,000 systems operating today.
- Q4 2013 was by far the largest quarter ever for PV installations in the U.S., with 2,106 MW energized, up 60% over the second-largest quarter (Q4 2012).
- More solar has been installed in the U.S. in the last eighteen months than in the 30 years prior.
- The market value of all PV installations completed in 2013 was $13.7 billion.
- Solar accounted for 29% of all new electricity generation capacity in 2013, up from 10% in 2012. This made solar the second-largest source of new generating capacity behind natural gas.
- Weighted average PV system prices fell 15% in 2013, reaching a new low of $2.59/W in the fourth quarter.
- We forecast 26% PV installation growth in 2014, with installations reaching nearly 6 GW. Growth will occur in all segments, but will be most rapid in the residential market.
- The U.S. also installed 410 MW of concentrating solar (CSP) in 2013, increasing total CSP capacity in the U.S. by more than 80%.
- The wave of concentrating solar power installations slated for completion at the end of 2013 into 2014 kicked off with the 280 MWac Solana project and the Genesis Solar project’s initial 125 MWac phase. In early 2014, BrightSource’s notable Ivanpah project also began operating and SolarReserve’s Crescent Dunes began commissioning.
The Evolving Thin Film Industry Growth Trajectory to Gain Further Pace Going Forward
Thin-film PV technology witnessed minimal research activities since early 1980’s. Post this period, it witnessed a constant advancement, in terms of manufacturing technology and materials used. The pursuit of cost-effective electricity generating technology lured major corporations and investors towards thin film PV industry. The industry saw more than 100 companies entering the market between 2001 and 2009. Thin Film PV technology has seen a major development leap from - only being associated with the little strip of PV cells that power calculators to sophisticated BIPV or solar chargers for mobile devices. From a mere 14 MW production in 2001 the market has grown to reach 2141 MW in 2009, at a CAGR of 58%. The market outlook for the coming decade appears promising as the major thin film producing countries - Japan, China, and the US - are announcing aggressive support for renewable energy expansion through incentives and regulations. In the retrospect, the Thin Film module production is projected to grow at the rate of 24% from 2009 to reach 22,214 MW production by 2020.

Thin film technology grabbing increasing share in the Solar Photovoltaic industry
Over the period of time the technology has also been successful in grabbing a growing share of the PV market. Thin film production market share in the global solar PV market grew from a mere 2.3% in 2001 to 25% in 2009, thus dictating a growing share in coming future. Thin film solar PV, as per our estimation, is set to increase its share to ~38% by 2020. Expectations are that in the long-term, thin film solar PV technology would surpass dominating conventional solar PV technology, thus enabling the long sought-after grid parity objective.

CIGS - The future market leader
CIGS technology is getting more popular than other thin-film technologies due to its higher efficiency and reduced manufacturing costs. The success of CIGS cells depends on the efficiency, faster and cheaper manufacturing process. The future of CIGS technology is encouraging as a lot of venture capitalist firms are investing in this technology. Investments in excess of $2 billion have already been made for the CIGS market development by various companies.

Global Market Outlook for photovoltaics EPIA 2013. Click here.

It is clear from the results of 2012 and the forecast for the coming years that Europe’s leading role in the PV market is coming to an end. In 2011, Europe accounted for 74% of the world’s new PV installations; in 2012 this number was around 55%. In 2013 it is almost certain that the majority of new PV capacity in the world will be installed outside of Europe. Part of the reason for the decline in Europe’s numbers is a natural cooling down period after very strong growth in the previous two years. To be sure, there are still markets in Europe which have strong and still-untapped potential and room for significant PV growth. But this will occur at a more stable – and sustainable – rate than it has in the last few years. Going forward, the driving forces will be in countries like China, the USA, Japan and India. The PV market is becoming truly global.
COMPETITIVE LANDSCAPE

A wide range of direct competitors within the flexible, low profile photovoltaic market, many already producing tested and mature consumer devices. As production increases globally, particularly in China and Taiwan, the price is likely to fall dramatically and the selection expand. This will present new entrants in the thin film PV cell market with high competitive pressure, where strongly distinguishing capabilities need to be paired with a very low price.

<table>
<thead>
<tr>
<th>Company</th>
<th>Website</th>
<th>Methods and examples of products</th>
<th>Comment</th>
</tr>
</thead>
</table>
SWOT ANALYSIS

The SWOT analysis for the potential to commercialise the invention within the market identified above. This analysis assumes that the technical hurdles can be met, and that an IP strategy devised to protect rights are effective.

**Strengths**
- Access to economies of scale with IC and display producers
- Cost advantage provided by low raw material requirement
- Innovative aspects

**Weaknesses**
- Lengthy timeline for energy product commercialisation
- Profit margins limited by increased competition

**Opportunities**
- Market growth
- Enter new markets or segments due to new functionality
- Competitor vulnerabilities due to traditional limitations

**Threats**
- Competitive pressures
- Global influences from overseas manufacturers
- Threat of new entrants with similar technology capabilities

SUMMARY OF MARKET ANALYSIS

The total market for solar photovoltaics is growing rapidly, but this is being easily matched by an increase in supply capacity, and development of new technologies to deliver unique benefits as prices fall across the board. The industry exists within an atmosphere of intense competition, driving down profitability and requiring constant introduction of new capabilities and segments to maintain an edge. Focus on the niche field of micro-solar cells for embedded and other atypical applications may present a unique opportunity for strong and profitable commercialization in this industry. The technology may have to prove its advantages over other "flexible" type solar cells in order to achieve this.
POTENTIAL PARTNERS

Once you have secured your IP, you may choose a licensing or joint venture pathway. We have listed some organisations below that may be of interest for establishing a partner relationship.

Siemens Energy
Siemens AG
www.energy.siemens.com
Freyeslebenstrasse 1
Erlangen, 91058
Germany
Phone: +49 (0)180 524 70 00
Fax: +49 (0)180 524 24 71
Description: Siemens AG is engaged in electronics and electrical engineering. The Company is an integrated technology company with activities in the fields of industry, energy and healthcare. Siemens operates in six segments: Industry, Energy, Healthcare, Equity Investments, Siemens IT Solutions and Services and Siemens Financial Services (SFS). Industry, Energy and Healthcare are reported along with 14 divisions, which comprise the divisions, Industry Automation, Drive Technologies, Building Technologies, OSRAM, Industry Solutions and Mobility, belonging to the Industry Sector, the Divisions, Fossil Power Generation, Renewable Energy, Oil and Gas, Power Transmission and Power Distribution, belonging to the Energy Sector and the Divisions, Imaging and Information Technology (IT), Workflow and Solutions and Diagnostics, belonging to the Healthcare Sector. In November 2009, Siemens acquired a controlling interest of 100 % in Solel Solar Systems Ltd., Beit Shemesh/Israel (Solel).

First Solar, Inc. - Corporate Headquarters - US
http://www.firstsolar.com/
Joseph Kishkill - Chief Commercial Officer
joseph.kishkill@firstsolar.com
350 West Washington Street
Suite 600
Tempe, AZ, 85281
United States
Phone: +1 419-662-6899
Phone: +1 877-850-3757
Fax: +1 602-414-9400
Description: First Solar, Inc. manufactures and sells solar modules with an advanced thin-film semiconductor technology, and it designs, constructs, and sells photovoltaic (PV) solar power systems. The Company is a thin-film PV solar module manufacturer and a PV solar module manufacturer. The Company produced nearly two gigawatts of solar modules during the year ended December 31, 2011. It operates its business in two segments: components segment and systems segment. Its components segment involves the design, manufacture, and sale of solar modules, which convert sunlight into electricity. Its systems business involves the sale of its solar modules coupled with the engineering, procurement and construction of the solar PV power plant. In January 2011, the Company acquired RayTracker, Inc.

Abengoa Solar - Corporate - North America
http://www.abengoasolar.com/
Kenneth May - Chief Technology Officer
Description: Abengoa Solar develops and applies solar technologies for generating electricity from the sun, fighting against climate change and contributing to the progress of the communities in which it operates, using mainly solar thermal technology, and photovoltaic. Thanks to continuous efforts in research and development, Abengoa Solar has its own technology, which is at the forefront of technologies capable of generating, cost-competitive, clean and efficient energy from the sun. This proprietary technology is used in their own plants can also be supplied to third parties.

Sharp Corporation
http://www.sharp-world.com/
22-22 Nagaike-cho, Abeno-ku
Osaka, 545-8522
Japan
Phone: +81-6-6621-1221
Description: Mr. Hayakawa continued to research and improve the techniques for making metal writing instruments, and in 1915, he invented a mechanical pencil that, after further improvements, would take the world by storm. In 1916, Mr. Hayakawa's mechanical pencil was named the "Ever-Ready Sharp Pencil." The present name of the company and its trademark are derived from that product.

Soitec Microelectronics Pte. Ltd.
http://www.soitec.com/
sales-solar@soitec.com; sales-electronics@soitec.com
Dr. Enno D. Bibow
enno.bibow@soitec.com
Parc Technologique des Fontaines
Chemin des Franques
Bernin, 38190
France
Phone: + 33 (0)4 76 92 75 0
Phone: + 33 (0)4 38 92 17 8
Description: Soitec is the world leader in generating and manufacturing revolutionary semiconductor materials for electronic and energy industries. As an industrial company, we have built our reputation developing and manufacturing our flagship material, SOI (Silicon-on-Insulator).

STMicroelectronics
www.st.com
39, Chemin du Champ des Filles
Plan-Les-Ouates, Geneva, CH1228
Switzerland
Phone: (+41) 22 929 29 29
Fax: +41 22 929 29 88
Description: STMicroelectronics, based in Switzerland, is one of the world's leading semiconductor companies. STMicroelectronics has a strong research and development sector, from state-of-the-art process development to advanced assembly and packaging technologies, from new system architectures to advanced product design.
II-VI, Inc.
http://www.ii-vi.com/
info@ii-vi.com
Francis Kramer - CEO
375 Saxonburg Blvd.
Saxonburg, PA, 16056-9499
United States
Phone: +1 (724) 352-4455
Fax: +1 (724) 352-5284
Description: II-VI Incorporated (II-VI), develops, refines, manufactures and markets high-technology materials and derivative precision components and products for precision use in industrial, military, telecommunications, photovoltaic, medical and aerospace applications. The Company’s products are supplied to manufacturers and users in a range of markets, including industrial, military, telecommunications, photovoltaic and medical. II-VI focuses on providing components to its customers’ assembly lines for products, such as high-power laser material processing systems, military fire control and missile guidance devices, fiber optics and wireless communication systems, photovoltaic systems, medical diagnostic systems and industrial, commercial and consumer thermal management systems. II-VI consists of four segments: Infrared Optics, Near Infrared Optics, Military and Materials, and Advanced Products Group. In July 2011, it acquired Aegis Lightwave, Inc.

HelioVolt
http://www.heliovolt.com/
Baosheng Sang - VP of Technology
6301-8 E. Stassney Lane
Austin, TX, 78744-6000
United States
Phone: +1 (512) 767-6000
Description: HelioVolt was founded in 2001 in order to commercialize a technology widely believed to be one of the most exciting and promising in our industry today. HelioVolt is the first thin-film company combining high-efficiency products with low-cost manufacturing capabilities to create a new generation of Copper Indium Gallium (di)Selenide (CIGS) based solar modules. Based in Austin, TX, HelioVolt is producing thin film solar PV modules for commercial rooftop, utility-scale ground mount, BIPV and custom installations. Our 125,000 sqft world class research and manufacturing center, is a LEED certified facility setting new standard for high-quality low-cost manufacturing while maintaining sustainable practices.

Fairchild Semiconductor Corporation
http://www.fairchilddeni.com/
Vijay Ullal - Chief Operating Officer
vijay.ullal@fairchilddeni.com
3030 Orchard Parkway
San Jose, CA, 95134
United States
Phone: +1 408-822-2000
Phone: +1 207-775-8100  
Fax: +1 302-636-5454  
Description: For more than 50 years Fairchild Semiconductor has focused on customer success. Our commitment to your success drives us to design, manufacture and supply power and mobile semiconductor technologies to make home appliances more energy efficient, enable mobile device manufacturers to deliver innovative new features, and boost the efficiency of industrial products. Our global presence is supported by internal and external manufacturing and a flexible, multi-source supply chain. Fairchild partners with customers to understand their business and design challenges. We invest in continual research and development, advanced materials science and supply chain innovation to stay ahead of the demand curve. Our semiconductor solutions for automotive, mobile, LED lighting, and power management applications help our customers achieve success every day.

Samsung Electronics Co.  
http://www.samsung.com/sec/  
Dr. Mikhail Silin  
silin.michael@samsung.com  
Samsung Electronics Bldg 1320-10, Seocho 2-dong Seocho-gu  
Seoul, 137-857  
Korea (South)  
Phone: +82-2-22550114  
Fax: +82-2-22550117  
Description: Samsung Electronics Co., Ltd. is a Korea-based company principally engaged in the provision of consumer electronic products. The Company operates its business under two divisions. The End Product division manufactures and sells digital media products such as digital televisions (TVs), monitors, printers, air conditioners, refrigerators and others, as well as information and communication products such as third-generation (3G) phones, smart phones, communication systems and others. The Component division manufactures and sells semiconductors such as memory chips, system large scale integrated circuit (LSI) products, storages and others, as well as liquid crystal display (LCD) products such as LCD displays used for TVs, monitors, notebook personal computers (PCs) and others. In January 2011, it acquired display technology firm, Liquavista BV.

FUJITSU LIMITED - Regional Headquarters - USA  
http://www.fujitsu.com/  
gdc@fla.fujitsu.com.  
Marni Carmichael - Director of Business Development  
mcarmichael@us.fujitsu.com  
733 Third Avenue  
New York, NY, 10017  
United States  
Phone: +1 212-599-9800  
Phone: +1 202-331-8750  
Fax: +1 212-599-4129  
Description: FUJITSU LIMITED is a Japan-based company engaged in the information technology (IT) business. It has three segments. The Technology Solution segment manufactures and sells products such as various servers, storage systems, various types of software, network management systems and optical transport systems, as well as the provision of system integrations services, consulting services, front technology services, network services and system support services. The Ubiquitous Solution segment offers products such as personal computers, mobile phones, as well as audio navigational devices, mobile communication equipment and automobile electronic devices. The Device Solution segment manufactures and sells large scale integrations (LSIs), semiconductor
packages, batteries, relays and connectors, optical transmitter and receiver modules, among others. On March 31, 2012, the Company dissolved Fujitsu International Finance (Netherlands) B.V.

Fujitsu Laboratories of America, Inc.
TODO: make url www.fla.fujitsu.com
1240 East Arques Avenue
Sunnyvale, CA, 94085
United States
Phone: +1 408-530-4500
Fax: +1 408-530-4515
Description: Fujitsu Laboratories of America was founded in Silicon Valley to extend the global reach of Fujitsu R&D and support our collective vision of a human centric intelligent society – a prosperous and sustainable future where an abundance of knowledge will be generated to the benefit of humankind and the planet. Through our advanced research, we aspire to put people first and integrate information and communications technology (ICT) seamlessly into our daily lives to solve the many challenges our customers and society face. We leverage our locations in North America to foster an open and networked innovation ecosystem, working closely with top universities, research institutions, standards groups, the startup venture community, and our Fujitsu North America companies and their customers and partners.

Texas Instruments Incorporated
www.ti.com
12500 TI Boulevard
Dallas, TX, 75266-0199
United States
Phone: (972) 995 3773
Fax: (302) 655 5049
Description: Texas Instruments Inc. (TI) designs and makes semiconductors, which it sells to electronics designers and manufacturers globally. As of December 31, 2011, the Company had design, manufacturing or sales operations in more than 35 countries. The Company operates in four segments: Analog, Embedded Processing, Wireless and Other. The Company sells custom and catalog semiconductor products. Custom products are designed for a specific customer for a specific application, are sold only to that customer and are sold to the customer. The life cycles of custom products are determined by end-equipment upgrade cycles and can be as short as 12 to 24 months. Catalog products are sold through both distribution and direct channels. On September 23, 2011, the Company completed the acquisition of National Semiconductor Corporation (National).

Flextronics International Ltd.
http://www.flextronics.com
Renee Brotherton - Corporate Communications
renee.brotherton@flextronics.com
2 Changi South Lane
Singapore, 486123
Singapore
Phone: +65 6876-9899
Phone: +1 408-576-7000
Fax: +65 5431-888
Description: Flextronics International Ltd. (Flextronics) is a global provider of vertically integrated advanced design and electronics manufacturing services (EMS) to original equipment manufacturers (OEMs). The Company designs, builds, ships and services electronics products for its customers through a network of facilities in 30 countries across four continents. The services the Company
offers across all the markets it serves include design and engineering services, original design manufacturing (ODM) services; components design and manufacturing, systems assembly and manufacturing, printed circuit board and flexible circuit fabrication, logistics and after sales services. In April 2012, it acquired Stellar Microelectronics. In June 2012, Tessera Technologies, Inc.’s wholly owned subsidiary, DigitalOptics Corporation (DOC), acquired certain assets of Vista Point Technologies from the Company. In December 2012, the Company acquired Saturn Electronics & Engineering, Inc.

Silicon Valley Product Innovation Center
Phone: +1 408-576-7000
Description: The Silicon Valley Product Innovation Center is located in Milpitas, California, and is the ‘center of excellence’ gateway for the Company’s customers worldwide. The Center works with companies of any size, from small start ups to large established industry leaders. The Silicon Valley Product Innovation Center has extensive capabilities beyond the traditional new product introduction (NPI) services, to include advanced engineering, design for manufacturing and supply chain optimization, prototyping, failure analysis, testing, production and transfer. The Center provides an environment and culture that promotes the best possible speed and flexibility necessary to manage the NPI process. Flextronics partners with customers to develop powerful supply chain solutions that transform industries. We support customers’ products early in the life cycle from concept to reality and with end-to-end solutions across the entire supply chain.
INDUSTRY INFORMATION

Associations/Advocacy

Global Semiconductor Alliance
www.gasaglobal.org
Churchill Tower
12400 Coit Rd, suite 650
Dallas, TX, 75251
United States
Phone: (972) 866 7579
Fax: (972) 239 2292
Description: GSA has made a significant impact on the industry since our inception in 1994, playing a vital role with the emergence and worldwide adoption of the fabless business model. Today, we continue our efforts with initiatives and focus to ensure the growth and profitability of the semiconductor industry.

Institute of Electrical and Electronics Engineers (IEEE)
www.ieee.org
ieeeusa@ieee.org
2001 L Street, NW
Suite 700
Washington, DC, 20036-4910
United States
Phone: (202) 785 0017
Description: IEEE is the world’s largest professional association dedicated to advancing technological innovation and excellence for the benefit of humanity. IEEE and its members inspire a global community through IEEE’s highly cited publications, conferences, technology standards, and professional and educational activities. IEEE creates an environment where members collaborate on world-changing technologies – from computing and sustainable energy systems, to aerospace, communications, robotics, healthcare, and more. The strategic plan of IEEE is driven by an envisioned future that realizes the full potential of the role of IEEE in advancing technology for humanity. The IEEE Brand Identity Toolkit explains the basic usage rules for all corporate identity elements and how to utilize them to create powerful and consistent communications pieces. IEEE is led by a diverse body of elected and appointed volunteer members. The governance structure includes boards for operational areas as well as bodies representing members in the 45 societies and technical councils and ten worldwide geographic regions.

PVthin
www.pvthin.org
PVthin a.i.s.b.l. c/o Becker Buettner Held
Avenue Marnix 28
Brussels, 1000
Belgium
Phone: +32 2 / 204 44-00
Description: PVthin is an international, not-for-profit coalition representing global leaders in the Thin-Film Solar Industry that manufacture and market products based on chalcogenide compounds. The founding members are Calyxo, First Solar, GE Energy and 5N Plus.
Semiconductor Industry Association

www.sia-online.org
1101 K Street NW
Suite 450
Washington, D.C., 20005
United States
Phone: (866) 756-0715
Phone: (202) 446-1700
Fax: (202) 216-9745
Description: The Semiconductor Industry Association, SIA, is the voice of the U.S. semiconductor industry, America's number-one export industry over the last five years and a bellwether measurement of the U.S. economy. Semiconductor innovations form the foundation for America's $1.1 trillion technology industry affecting a U.S. workforce of nearly 6 million. Founded in 1977 by five microelectronics pioneers, SIA unites over 60 companies that account for 80 percent of the semiconductor production of this country. The SIA seeks to strengthen U.S. leadership of semiconductor design and manufacturing by working with Congress, the Administration and other key industry groups. The SIA works to encourage policies and regulations that fuel innovation, propel business and drive international competition in order to maintain a thriving semiconductor industry in the United States.

Solar Energy Industries Association

www.seia.org
info@seia.org
505 9th Street, N.W.
Suite 800
Washington, D.C., 20004
United States
Phone: 202-682-0556
Description: As the national trade association in the U.S., the Solar Energy Industries Association (SEIA) is the power behind solar energy. Our member companies research, manufacture, distribute, finance, and build solar projects domestically and abroad.

Consultants

Cambridge Consultants

www.cambridgeconsultants.com
info@cambridgeconsultants.com
101 Main St
Cambridge, MA, 02142
United States
Phone: (617) 532 4700
Description: For 50 years, Cambridge Consultants has led the way in innovative product development. We are the development partner of choice to many of the world’s leading blue chips as well as the virtual development team for ambitious start up companies.

PHOTON Consulting

https://www.photonconsulting.com
info@photonconsulting.com
200 Clarendon Street, 50th Floor
Boston, MA, 02116
United States
Phone: +1.617.874.5500
Fax: +1.617.262.4309
Description: PHOTON Consulting is a research and consultancy firm focused on the fast growing global photovoltaic market within the solar power sector. PHOTON Consulting provides consulting, data, research and analysis to our global clientele, allowing them to make actionable decisions and anticipate future trends in an evolving global PV sector. PHOTON Consulting’s team has a rich knowledge base. The team includes MBAs and PhDs from top-tier academic institutions, former senior executives from publicly-listed solar companies and mainstream energy consultants from top global strategy consulting firms. Our deep domain expertise, broad horizontal experience in a range of functional disciplines and functional backgrounds in economic, financial, market and policy analysis gives us the inherent flexibility to service diverse and challenging client requirements. Coupled with the most extensive sector research, the most accurate data, and the most rigorous models available, PHOTON Consulting provides industry leading solar intelligence.

SEMATECH
www.sematech.org
257 Fuller Rd
Albany, NY, 12203
United States
Phone: (518) 649-1000
Description: SEMATECH (from "semiconductor manufacturing technology"), a not-for-profit consortium, performs research and development to advance chip manufacturing. SEMATECH has broad engagement with various sectors of the R&D community, including chipmakers, equipment and material suppliers, universities, research institutes, and government partners. The group is funded by member dues.

Sgurr Energy Ltd.
www.sgurrenergy.com
225 Bath Street
Glasgow, G2 4GZ
United Kingdom
Phone: +44 (0)141 227 1700
Description: SgurrEnergy is a leading renewable energy consultancy, providing engineering and technical advisory services in onshore and offshore wind, solar, wave and tidal and hydro projects. Our global team of over 180 engineers and consultants has extensive international experience, having worked on over 110GW of renewable energy developments worldwide.

Solarbuzz
http://www.solarbuzz.com/
contact@solarbuzz.com
900 West Shore Road
Port Washington, NY, 11050
United States
Phone: 1.888.436.7673
Description: No organization covers the global solar PV industry as extensively or as passionately as NPD Solarbuzz. Our analysts are located across the globe and within key regional PV activity centers – critical within an industry that has a global reach. They come from many cultures and speak our clients’ languages. They live where our clients live. And they have direct experience working within the PV industry, often in roles similar to our clients. Our analysts come from every segment of the PV value and supply chain, providing them with the key tools necessary to fully understand issues
relating to our clients’ business activities. Clients frequently call upon our analysts to gain their informed perspectives on the nuances and complexities within the solar PV industry. Examples include: Analyst inquiry calls, available as needed by the hour or on a regular subscription basis. Analyst presentations, delivered by phone, through webcast or in person. Analyst speaking and panel moderating engagements. Their voices are expert and varied, their experience is evident, and their drive for perfection unrivalled; just three of the reasons our analysts are recognized as the most respected and sought-after within the industry.

Directories/Mailing Lists

**GlobalSpec**


30 Tech Valley Dr
Suite 102
East Greenbush, New York, 12061
Phone: 800.261.2052
Phone: 518.880.0200
Fax: 518.880.0250
Description: GlobalSpec is the leading specialized vertical search, information services and e-publishing company serving the engineering, manufacturing and related scientific and technical market segments. The company provides its buy-side users with domain-expert search engines, a broad range of proprietary and aggregated Web-based content and over 70+ product and industry e-newsletters that help engineers and related professionals perform their key job tasks with the highest levels of accuracy and productivity. GlobalSpec provides its sell-side client base of companies seeking to reach the worldwide engineering audience with highly filtered sales leads, product promotion and brand advertising platforms and a wide range of e-media advertising and marketing services.

**Semi-Directory**

SEMI

[www.semi-directory.com](http://www.semi-directory.com)

Description: Semi-Directory, the approved supplier guide for SEMI®, is most comprehensive semiconductor directory available. Our aim is to bring customers and suppliers together to provide the greatest amount of supplier and industry resources available to the semiconductor industry.

**SemiResources.com**

[www.semiresources.com](http://www.semiresources.com)

Description: We are proud to have had this site become the most complete and up-to-date site of it's kind. The focus has become serving the semiconductor user and manufacturer as well as the supporting industries associated with them. Users from all over the world are kept up to date with timely news, information on new start-up companies and current technologies through the use of this website. It is our sincere hope that you will too, and that you'll come back as often as you need to find the information you seek.

**SolarEnergy**


Description: The ultimate guide to the world of solar energy products, their history, where we are today, and what is likely to be happening tomorrow.
Trade Magazines

**Journal of Microelectromechanical Systems**

http://ieeexplore.ieee.org/xpl/RecentIssue.jsp?punumber=84

Richard S. Muller
r.muller@ieee.org

Description: IEEE/ASME Journal of Microelectromechanical Systems (JMEMS) typically covers advances in Microsystems as defined by new methods, technologies, and applications in this field. The topics covered include: microsensing, microactuation, micromechanical structures, materials for Microsystems, and the design and construction of microelectromechanical systems. The dimensions of MEMS components typically range from nanometers to millimeters, and the field is sometimes referred to as NEMS as well as MEMS to emphasize that engineering on the scale of nanometers is included in the tiny world of today's Microsystems. JMEMS covers a very diverse field of applications including communications, biomedical engineering, micro-optical systems, microfluidics, micropower generators and storage devices.

**RenewableEnergyWorld.com**

www.renewableenergyworld.com

98 Spitbrook Road
Nashua, NH, 03062
Phone: 603-891-0123
Fax: 603-891-9351

Description: RenewableEnergyWorld.com was started in 1998 by a group of Renewable Energy professionals who wanted their work to relate to their passion for renewable energy. With this passion and the desire to create a long term sustainable business, we have created perhaps the single most recognized and trusted source for Renewable Energy News and Information on the Internet.

**Semiconductor Today**

Juno Publishing and Media Solutions Ltd

www.semiconductor-today.com

Mark Telford - Editor
mark@semiconductor-today.com

Description: Semiconductor Today’s editorial content covers: - III-V materials, e.g. gallium arsenide (GaAs), indium phosphide (InP) and nitrides (InGaN). - II-VI materials, e.g. cadmium mercury telluride (CdHgTe) and zinc selenide (ZnSe). - IV-IV materials, e.g. silicon carbide (SiC) and silicon germanium (SiGe). - Advanced silicon technology such as strained silicon and silicon-on-insulator (SOI). Applications covered include wireless communications, fiber-optic communications, LEDs, and solar cells. In addition, attention is given to areas where compound semiconductor and advanced silicon technologies converge.

**Solid State Technology**

PennWell Corporation

www.electroiq.com

Description: Solid State Technology (www.solid-state.com) is a global resource for the latest electronics manufacturing insights, news, analysis and product information related to semiconductor manufacturing, wafer fabrication, integrated circuits, thin-film microelectronics, flat-panel displays and microstructure technologies, processes, equipment and more. Publishing since 1958, Solid State Technology is the longest-running and most complete source of electronics manufacturing-related information for engineers, operators, managers, tool and materials suppliers, and semiconductor-related technology researchers.
Trade Expositions

Photonix 2014
http://www.photonix-expo.jp/en/About/Laser/
16/April - 18/April, 2014
Tokyo Big Sight, Japan
Description: Specialised exhibition inside Photonix EXPO & CONFERENCE gathering various kinds of laser solutions for high power, low power and nano processing. Professionals from automobile, photovoltaic power generation, electronics manufacturers, universities/research institutes, etc. meet the cutting-technologies from around the world.

SEMICON West 2014
www.semiconwest.org
08/July - 10/July, 2014
TBA, USA
United States
Description: More than a tradeshow, SEMICON West connects you to hundreds of manufacturers and suppliers of semiconductor and related microelectronic products and services. Find innovative products, learn new manufacturing solutions, network with other industry professionals and stay up-to-date on the latest market and technology...all in one place—SEMICON West.
What is the name of your invention?
Draft for Tekcapital

Give a short description of your invention.
https://ip.sandia.gov/technology.do/techID=103

Give a detailed description of your invention.
Microsystems Enabled Photovoltaics (MEPV)
Technology Summary
Revolutionary microsolar technology utilizes glitter-sized photovoltaic cells to change how we generate and use solar power. The significantly reduced size and 100 times less silicon used, allows for increased versatility of photovoltaic applications. Traditional solar cells are 6” square wafers which restricts location, performance, and manufacturing. Other unique factors to this technology include solar tracking, self assembly, and power management techniques.
Description
Despite the significantly reduced size, the cells perform comparably to traditional solar cells which can allow for installation in more non-conventional areas such as tents and possibly clothing to recharge small electronics while in the field or outdoor recreation. The glitter-sized cells can also be used on more traditional applications such as roofing.
Benefits
• 10 times thinner than conventional solar cells
• More versatility
• Highly efficient microsolar devices
• Lower costs in manufacturing and installation
• Can be fabricated from any size of commercial wafer
• More resilient and reliable
Applications and Industries
• Solar energy generation
• Energy storage
• Battery charging applications
• Satellites
• Remote Sensing
• Integrated solar on unusual, non-traditional items
• Solar energy harvesting

Have you done background research on your invention? If so, when and how was it done?
Upload information you have collected.
National Lab development

What is new and innovative about your invention?
See above
Can you demonstrate that your invention works? Do you have any proof of concept, or data from tests? Have you made a prototype? If not, do you have any plans to do so?

Development Stage
Prototype - Prototype III - Demonstrated “proof of concept”;

Have you sought any protection for your intellectual property, such as filing a patent application, registered design, trademark, placed a copyright mark on your work, or done something else?

Have you sought legal advice?
U.S. Patents 8,329,503; 8,614,395; 8,592,249; Over 30 patents pending

If it’s not already clear above, what types of products and/or services do you think could be made based on your invention?
New application to support mobile computing (battery charging)
Non-traditional power generation in confined spaces

What countries do you think these products/services would be sold in, and in what industries?
Worldwide

Do you know of any products and/or services that are similar to those described above, or that would be competitors?
No

Have you told anyone about your idea? Published any papers? Put it on a website? Put it on a social media site? Presented a seminar?
NA
APPENDICES

Appendix A.

A patent is an exclusive right granted for an invention, which is a product or a process that provides, in general, a new way of doing something, or offers a new technical solution to a problem. In order to be patentable, the invention must fulfil certain conditions. An invention must, in general, fulfil the following conditions to be protected by a patent:

- It must be of practical use.
- It must show an element of novelty, that is, some new characteristic which is not known in the body of existing knowledge in its technical field. This body of existing knowledge is called "prior art".
- It must show an inventive step which could not be deduced by a person with average knowledge of the technical field.
- The subject matter must be accepted as "patentable" under law. In many countries, scientific theories, mathematical methods, plant or animal varieties, discoveries of natural substances, commercial methods, or methods for medical treatment (as opposed to medical products) are generally not patentable.

For an excellent overview of Patents and the Patent system, see:

→ World Intellectual Property Organisation
→ United States Patent & Trademark Office

Appendix B.

About the Google Scholar Search. Our methodology for online search is to conduct searches online using keywords from our understanding of the invention through the above analysis. We typically use Google Scholar, but sometimes we supplement with general web searching as well.

We aim to do both broad searching of the field, as well as specific searching focused on the innovative aspects of the invention to determine if we can find any relevant literature. We do not read the entire articles, only the abstracts. This is due to the large amounts of data we find and time constraints.

The aim of the search is not a conclusive novelty determination, but rather to ascertain if there is relevant literature.

We hyperlink our searches so that if relevant literature is found, you can easily replicate the search. This allows you to expand on the search, and follow up on literature which may be relevant. Some commentary may be provided as to why the analyst thinks the particular piece of literature may be relevant to the current invention.
Appendix C.

We use Espacenet for our searching, using the Worldwide database of documents from 80+ patent offices, including USPTO and WIPO. These preliminary searches attempt to find relevant literature in available public databases. We have attempted to understand the essence of your invention through your submission and the above technology analysis. This is then used to generate keyword searches, reading only the abstracts (not the entire patent document). We search for relevant terms and/or phrases in Titles and Abstracts, and occasionally in other fields. This is not an exhaustive search, and there may be other terms which are relevant but not included, or in fields such as the specification, which we have not searched here.

Espacenet offers free access to more than 60 million patent documents worldwide, containing information about inventions from 1836 to today. We use the Advanced Search and SmartSearch options to query. SmartSearch queries utilise Contextual Query Language (CQL). Click here for a booklet that introduces Espacenet and includes more information about SmartSearch, which may be useful to further understand our searches.

Appendix D.

Other Intellectual Property Rights

Circuit Layout Rights

The circuit layout rights automatically protect original layout designs or plans (topographies) of integrated circuits and computer chips, used in computer-generated equipment. These rights are based on copyright principles but fall under a separate form of protection, which currently requires no formal registration as they are automatic rights. A circuit layout is a two-dimensional representation of a three-dimensional layout or topography of electronic components in an integrated circuit.

The protection period is dependent upon each jurisdiction and when it was attempted to be commercially exploited, thus protection can last from 10 to 20 years pending circumstance.