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## **Baverstam Associates' Electronic Newsletter** **Volume #10, Issue #5**

Welcome to Baverstam Associates' fifth newsletter for the year 2010. In this issue, we are pleased to provide you with an update on the latest developments taking place in **photovoltaics** with a focus on materials technology.

We hope that you will enjoy this newsletter. We welcome any type of feedback or questions.

Sincerely,

Vassos Vamvas  
Frank Ross  
Editors

Past issues are on our website in PDF format at: <http://www.baverstam.com/newsletter>.

To subscribe or unsubscribe, or send comments, please send e-mail to: [info@baverstam.com](mailto:info@baverstam.com).

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# Introduction: Photovoltaic (PV) & Concentrating (CPV) Solar Power Technologies

## **A. Photovoltaics (PV)**

Two categories of PV cells are most commonly used in commercial PV modules today. They are primarily crystalline (c-Si) and also thin-film PV cells (TFPV). The first category includes mono-crystalline (mono c-Si) and multi-crystalline (multi c-Si) cells, called first-generation PV and they produce electricity from crystalline silicon semiconductor material derived from highly refined polysilicon feedstock.

TFPV cells, or second-generation PV, produce electricity from thin layers of amorphous silicon (a-Si), copper indium diselenide (CIS), copper indium gallium diselenide (CIGS) and cadmium telluride (CdTe). The second-generation PV technologies also include multi-junction PV cells. These use multiple layers of semiconductor materials to produce electricity. The multi-junction PV cells combined with light-concentrating and tracking devices, called Concentrating Photovoltaics (CPV), have achieved extremely high efficiencies (currently more than 41%) in the laboratory, surpassing by far the theoretical limit of c-Si of ~29%.

Emerging PV technologies with high efficiencies or low manufacturing cost, called third-generation PV, may become viable commercial solutions in the future. Today, the third-generation PV category includes dye-sensitized cells and organic PV cells (OPV), which have until now demonstrated only low efficiencies but offer the potential of low production cost.

This newsletter covers recent technology developments, materials used and trends in PV and CPV markets. In our last newsletter on the photovoltaic industry (Volume 8, Issue 9), we focused on TFPV, which gained considerable market share in the last two years, as segment leaders like **XXXXXX** entered high volume production of low cost modules. High demand for c-Si, polysilicon shortages and production capacity limitations had led to sharp price increases of c-Si cells in 2007. This resulted in an increase in manufacturing production capacity of c-Si. Due to polysilicon production increases and partially to the economic crisis, polysilicon prices declined sharply in 2009. Crystalline module prices dropped 37.8%, solar wafer prices fell by 50%, and polysilicon by 80%.<sup>1</sup> TFPV, however, had established itself in the market.

Despite the economic crisis the world PV market continued to grow. The PV installed capacity for 2008 was 6 GW, a 152% increase over 2.4 GW installed in 2007. In 2009 it was 7.1 GW and another 8.2 GW is expected in 2010.<sup>2</sup>

According to the U.S. DOE, Global PV production and demand will increase four-fold between 2008 and 2012, reaching roughly 20 GW of production by 2012. Germany is the clear leader at 3.8GW installed in 2009, in addition to the 5.3 GW it had installed cumulatively up to 2008. Germany is expected to install an additional 6.6 GW capacity in 2010, despite the recently announced tariff cuts. Following Germany are Spain, Japan and the United States. US based firms, nonetheless, are the global leaders in production of TFPV. The top US manufacturers for TFPV are **XXXXXX**, producing CdTe

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<sup>1</sup> [weblink]

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TFPV and **XXXXX**, manufacturing a-Si modules. **XXXXX** was the second largest global PV producer in 2008 and topped the ranking list for global PV suppliers surpassing all of its crystalline rivals, shipping more than 1 GW in 2009. **XXXXX**, the previous year's leader fell to second place, followed once again by **XXXXX** in third place. Also, China's **XXXXX** climbed two places, ranking in the fifth position, increasing last year's shipments by 90%.<sup>3</sup> **XXXXX** reduced its manufacturing costs for solar modules to 85¢/Watt, thus breaking the \$1 per Watt price barrier.<sup>4</sup>

TFPV has grown faster than crystalline silicon over the past two years. TFPV market share was 22% vs. 78% of c-Si cells, in 2009. The **XXXXX** Association (**XXXXX**) expects TFPV to increase its share to 25% by 2013. The c-Si PV producers are becoming more competitive as polysilicon prices are dropping as production capacity increases globally. For instance, **XXXXX**, a large vertically integrated c-Si PV manufacturer with production facilities in Germany and the US, has acquired a 29% stake in the joint venture, **XXXXX**. The joint venture will invest more than \$500 million in the construction of a new polysilicon manufacturing facility, which will commence production in 2012. Its annual capacity will reach 3,600 tons of high-purity polysilicon.<sup>5</sup>

An advantage of conventional c-Si over TFPV is the higher module efficiency, which is important when the available is limited or finite (e.g. a rooftop) and also favored by the structure of current subsidy schemes. Currently, the typical efficiency of a commercial mono c-Si module ranges from 13-19% and for a multi c-Si from 11-15%. TFPV a-Si module has 4-8% efficiency, CI(G)S ranges between 7-11% and CdTe's is about 10-11%.<sup>6</sup> Third-generation cell laboratory efficiencies range from 5-10%.

The highest efficiencies on Si have been achieved on mono-crystalline cells. The most common c-Si cells in the market today use boron-diffused p-type silicon. Higher efficiency modules use n-type silicon. This type offers better PV electricity production because of better impurity tolerance and less worsening due to light induced degradation. On the manufacturing arena, top-tier c-Si producers use non-standard (customized) production lines and not complete turnkey systems. **XXXXX** utilizes expensive Si wafers to produce mono c-Si PV modules, reaching 22% conversion efficiency. The **University of XXXXX** achieved 25% c-Si efficiency and **XXXXX** currently uses its technology. Meanwhile, **XXXXX** produces innovative double-sided (bifacial) panels that can generate an extra 30% of electricity, utilizing the ambient light reflected off surrounding surfaces.

PV research labs focusing on enhancing conversion efficiency, as there is an opportunity for disruptive R&D. Nanotechnology examines new elements, in order to enhance efficiency. For example, transparent nanoporous TiO<sub>2</sub> enhanced dye sensitized PV lab efficiency from 5.92% to 7.13%.<sup>7</sup> The **XXXXX Laboratory** is conducting lab research on CIGS THPV and has achieved 20% efficiency on this non-polysilicon PV with the potential to be produced using low cost roll-to-roll continuous manufacturing.

New materials are being tested for modules and components to achieve durability and long-term performance. Polymers are used in many components including encapsulants, backing sheets, frames,

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sealants and adhesives, thin film substrates, glazing, Fresnel lenses for CPV, photoactive components for OPV, cable insulation and connectors.

**XXXXX** has invested \$300 million in new capacity to serve the PV industry. Its **XXXXX**<sup>®</sup> film is used in front sheets, **XXXXX**<sup>®</sup> ethylene-vinyl acetate (EVA) in encapsulants, **XXXXX**<sup>®</sup> PET in junction boxes and structural parts. Polyvinyl fluoride (PVF), such as its **XXXXX**<sup>®</sup> film and PET products **XXXXX**<sup>®</sup> and **XXXXX**<sup>®</sup> are found in the backsheets. In thin films, **XXXXX** **XXXXX**<sup>®</sup> polyimide, **XXXXX** **XXXXX**<sup>®</sup> polyethylene-naphthalate (PEN) and **XXXXX**<sup>®</sup>ST polyester are used for substrates.

**XXXXX** in collaboration with **XXXXX** recently launched a new thin white reflective solar PV encapsulant sheet, called **XXXXX**. This latest addition to the **XXXXX** Series sheets is based on white reflective polyvinyl butyral (PVB) polymer technology. **XXXXX** claims that its PV5223 sheet provides longer service life and increased light reflectivity >50% versus paint, to an almost perfect 94% reflectivity.<sup>8</sup> **XXXXX** also offers the PV5300 encapsulant product line, which is ionomer based and has been offered for many years with glazing to meet hurricane codes. Compared to PVB based encapsulant of similar thickness (0.9 to 1.5 mm) it is 100 times stiffer and 5 times tougher.

Encapsulant materials include also EVA from **XXXXX** and silicone from **XXXXX**. Sealants and adhesives for PV must maintain their function for many years under the influence of heat, UV radiation, humidity, oxygen and aggressive trace gases in the air. **XXXXX** provides polyisobutylene (PIB) based sealants and **XXXXX** ultra-rapid hardening cement and adhesives. The supportive frame of PV modules is traditionally made of aluminum. **XXXXX**, a **XXXXX** subsidiary, offers a polyurethane casting system utilizing reaction injection molding (RIM) for PV module framing. The system allows for flexible shapes and different shades of color.<sup>9</sup> Solar photovoltaic technology requires specific cabling systems that need to be resistant to UV radiation, moisture, heat, chemicals and abrasion. **XXXXX**, offers a fully compliant solution with its **XXXXX** compound with zero halogen and flame-retardant insulation.<sup>10</sup>

## **B. Concentrating Photovoltaics (CPV)**

Concentrating photovoltaic systems (CPV) employ concentrated sunlight onto PV cells in order to boost their electrical power production. Solar concentrators, mounted on sun-tracking devices, focus the sunlight upon PV cells.

Low CPV systems have solar concentration with sunlight intensity of 2 to 100 suns. The heat flux created is low enough and the cells do not need to be actively cooled. Also they do not need solar tracking because they have high acceptance angle. From 100 to 300 times sunlight concentration, the CPV systems require both cooling and solar tracking. High concentration photovoltaic (HCPV) systems employ concentrating optics with dish reflectors or Fresnel lenses that concentrate the sunlight to intensities of 300 suns or more. The solar cells require high-capacity heat sinks to prevent thermal destruction and manage temperature-related performance losses.

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<sup>8</sup> [weblink]

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An award winning multi-junction CPV system, developed last year at XXXXX in XXXXX, demonstrated a remarkable 41.1% efficiency. The system utilizes tracking optics and three single-junction sub-cells on top of each other made out of gallium indium phosphide, gallium indium arsenide and germanium, respectively. Each one utilizes a different wavelength range in the solar spectrum. Fresnel lenses concentrate the sunlight by a factor of 500 and focus it onto the tiny 3 mm<sup>2</sup> cells. Each cell is mounted on a copper plate to avoid overheating. Due to the concentrating optics the system makes use of only the direct solar radiation and therefore the system must track the sun. Since solar radiation scattered by clouds or water droplets cannot be concentrated, these systems are only suitable for areas with clear skies and direct sunlight. The system employs two-axis tracking and achieves high power output even in the mornings and evenings. This technology produces more power per unit of PV area, substituting effectively the associated expensive semiconductor material with inexpensive acrylic lenses, thus reducing the solar electricity cost. The XXXXX researchers claim that their technology will be 20 to 30% more economical than Si PV systems.<sup>11</sup>

CPV systems, although being developed in laboratories since the 1970s, are the newest entrant into the commercial solar market. The CPV industry faces the challenge to prove that its systems will produce energy reliably over a period of 20 to 25 years. Also it needs to demonstrate that CPV volume manufacturing will lead to lower costs. In addition, HCPV systems, which need tracking accuracy in harsh environments, may require high maintenance costs. The CPV industry is trying to address these issues to secure financing, amidst declining Si PV pricing.

Five years ago there was less than 1 MW of CPV installed worldwide. By 2009, tens of megawatts had been installed globally and the expectations exceed 200MW for 2010. Today, according to XXXXX, there are about sixty companies that develop CPV products and another two supplying equipment. Large-scale CPV research sites have been established, like the XXXXX, in XXXXX. ISFOC XXXXX operates a 3 MW CPV plant, incorporating different concentrating technologies for research and production purposes. XXXXX researchers predict that CPV is the most promising energy resource for the future. According to XXXXX “XXXXX” report, HCPV will overtake tracked flat-plate PV, as it is the most cost effective PV for commercial/utility scale applications. As the HCPV technologies advance and their costs drop due to economies-of-scale, its electricity production costs are expected to come down as low as 7¢/kWh by 2015, according to the same XXXXX study.<sup>12</sup>

There is an industry wide focus on multi-junction cell systems development. XXXXX will start producing its XXXXX cell for solar applications in its facilities in XXXXX. XXXXX recently announced that it achieved 35.8% efficiency using a XXXXX solar cell. Canadian XXXXX announced a ~40% efficiency CPV cell, which the company produced utilizing XXXXX nanotechnology. XXXXX utilizes a two-component optical system with concentration of 476 suns. It uses XXXXX cells, consisting of a stack of cells of different composition, so that the cells in the top of the stack absorb higher energy photons than those of the bottom part. These cells are made by XXXXX. They resist the concentration of the radiation very well and have an efficiency of around 35%. XXXXX’s module uses a proprietary optical system to focus the sun’s rays 1,200:1 onto XXXXX PV cells. The optical path is composed of Fresnel lens and advanced secondary optics. The Fresnel lens is made out of a composite structure constructed with XXXXX technology.

In March 2010, XXXXX developed a 330 kW HCPV power plant in XXXXX. It has a guaranteed investment return due to its feed-in-tariff agreement. It features dual-axis tracker-XXXXX HCPV

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<sup>11</sup> [weblink]

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panels, which can focus more than 500 suns onto XXXXX cells. To concentrate the sunlight each panel uses silver polymer sheets that have the same performance as heavy glass mirrors, but at a much lower cost and much lower weight. They are also much easier to deploy and install. These glossy sheets use several layers of polymers with an inner layer of pure silver. XXXXX develops a HCPV system based on proprietary acrylic based XXXXX coupled to XXXXX PV cells. Injection molder XXXXX recently invested in XXXXX and will manufacture the XXXXXs.

Optical coatings used on lenses or reflectors may darken over time. They can trap dirt and moisture, which accelerates degradation. A big challenge for the HCPV XXXXX systems is to employ optical materials with high environmental durability and spectral performance. The energy losses due to the build-up of dirt and dust can be 4-6%, and due to reflections, 4% at noon and ~15% in morning and evening hours. Enclosure design is also a challenge. It must be designed to avoid dirt burning onto the optics and moisture condensation, which obscures the optics. If the enclosure is sealed, atmospheric pressure variations can cause the optics to deform. On the other hand, if the enclosure does not “breathe” well, the optics may act as insulation, causing the cells to run hotter.

The soiling of CPV modules is of great concern. Self-cleaning processes involve coatings with photocatalytic and hydrophilic properties that utilize the ultraviolet light from the sun to loosen dirt, which in turn is removed by the water. For example, XXXXX offers its patented XXXXX<sup>®</sup> glass technology. Anti-Soiling and anti-reflecting technologies will allow more light to reach HCPV cells. XXXXX and XXXXX have developed a new low-cost antireflective technology, which keeps light reflection below 1%, which is much lower than the typical 4% of solar modules. It is based on thin films of nanoporous silica and a layer of glass full of tiny invisible bubbles. XXXXX won an XXXXX government grant to develop anti-soiling coating for CPV systems.

In the following sections we cover the most recent technological developments in the PV and CPV industry today.

## **Latest Materials Technology Developments in PV, TFPV & CPV**

### **A. Crystalline Si and Thin Film PV**

#### **XXXXX Sees Strong Demand for XXXXX for Contact Structures**

May 2010

XXXXX announced in May 2010 that Chinese manufacturers would use its XXXXX Technology for approximately 2 GW of annual PV cell manufacturing in just a few months. This is a high-precision XXXXX technology for contact structures, which is designed to raise the efficiency of c-Si cells as much as 0.5% and also reduces the consumption of silver printing paste by 14%. The combination of higher efficiency and reduced material expenses will lower the manufacturing cost by 3 cents/W and deliver a return on investment in 8 months.

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#### **Novel Ultra-Thin PVB Solar Encapsulant Increases PV Module Efficiency**

April 2010

XXXXX, a business unit of XXXXX, developed, in collaboration with XXXXX, an ultra-thin white PV module encapsulant. Compared to standard encapsulants, it uses 33% to 55% less material. It is based on 3G PVB chemistry. Test results confirm that XXXXX PVB is less moisture sensitive. This enables high adhesion, especially at the edges, even as environmental conditions, including humidity, fluctuate. The encapsulant increases the module's efficiency as well. It reflects back the light that is not initially absorbed by the active layers.

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#### **XXXXX Supports XXXXX's Product Development and Commercialization of CdTe Technology**

March 2010

XXXXX and XXXXX will launch mass production of efficient, low-cost cadmium telluride (CdTe) PV panels. XXXXX is a majority investor in XXXXX, which is leveraging CdTe technology developed by XXXXX in XXXXX. XXXXX is now mobilizing its global R&D efforts to support the development and commercialisation of this technology. Note that the TFPV market leader, XXXXX, also uses CdTe technology.

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### **XXXXX Receives Funding for New Process for PV Manufacturing**

March 2010

**XXXXX** based in **XXXXX** and **XXXXX** Professor **XXXXX** received \$4 million from **XXXXX**-Energy and another \$5 million from private funding to develop their innovative PV manufacturing process. This new process produces wafers directly from molten silicon without any sawing. It aims to reduce the manufacturing cost of the c-Si wafers by 80%.

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### **XXXXX PV Technology Embeds Si XXXXX in Flexible Polymer**

February 2010

**XXXXX** scientists discovered a new way to make Si solar cells using Si **XXXXX** in polymer material. Instead of using conventional PV brittle wafers, they use Si in the form of **XXXXX**. These Si-**XXXXX** are encased into flexible polymer. The resulting module can be rolled or bent. This technology makes Si solar cells cheaper. It also combines the flexibility of the new organic containing films with the efficiency of silicon.

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### **XXXXX Produces Solar Cell Made from Earth-Abundant Materials**

February 2010

**XXXXX** used a particular collection of earth-abundant **XXXXX** materials to manufacture a solar cell. The combination of these materials resulted in 6.7% efficiency.

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### **XXXXX Receives Patent for Low Cost CIGS Solar Cell Fabrication**

February 2010

**XXXXX** received a U.S. patent for its low-cost, nano-particle solution based, high-volume production method for large area CIGS photovoltaic devices. The **XXXXX** used are compatible with roll-to-roll manufacturing of PV cells and modules. This method allows for high production volumes.

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### **XXXXX Plastics Barrier Backsheet Materials for Si and Thin Film PV**

December 2009

**XXXXX** developed a halogen-free, metal-free, high gas barrier backsheet for PV applications. The **XXXXX** sheet bonds easily to encapsulation material, such as ethylene-vinyl acetate (EVA). The material is based on the **XXXXX** product line for medical and pharma applications with water vapor barrier properties as high as  $10^{-4}$  g/m<sup>2</sup>/day. **XXXXX** offers two types of back-sheets, one for crystalline silicon solar modules and one for TFPV cells with 0.2 and 0.02 g/m<sup>2</sup>/day water vapor barrier properties.

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### **XXXXX Develops an Ultra-Thin HIT PV Cell with High Efficiency**

November 2009

**XXXXX** researchers developed an Ultra-Thin HIT (hetero-junction with intrinsic thin layer) Si PV cell that measures just 98  $\mu\text{m}$  in thickness (half of standard HIT cells). Normally, reducing the thickness of the silicon wafer results in less optical absorption and causes energy conversion efficiency to drop. However, this new ultra-thin cell demonstrated 22.8% efficiency in the laboratory. This paves the way for the development of a new generation of low cost, high efficiency solar cells from **XXXXX**.

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### **XXXXX Wall Project Using XXXXX's XXXXX Technology**

November 2009

**XXXXX** and **XXXXX** launched the first curtain wall pilot project that will integrate **XXXXX**'s **XXXXX**® into a wall structure at **XXXXX**'s office building in **XXXXX**. The solar panels will generate 1.5 kW of power for the facility. The curtain wall is an array of solar panels, glass and aluminum, with a peak output of 40 watts per panel.

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### **XXXXX Launches Innovative Conductive Adhesives for High-Throughput PV Manufacturing**

September 2009

**XXXXX** has launched a new electrically conductive adhesive for the manufacturing of crystalline or thin film PV modules. **XXXXX** is ideally suited for high-throughput production processes. The innovative adhesive creates a flexible electrically conductive bond with high peel strength and great long-term reliability for contact resistance.

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### **Scientists Discover New Ultra-Thin and Flexible Solar Cells**

March 2009

Scientists from the **University XXXXX** developed a new method to make efficient and flexible solar cells. These new cells are flexible enough to be rolled tightly onto a pencil without being damaged. They are imprinted on semiconductor wafers, using a standard lithographic technique, and a soft rubber stamp transfers them onto the surface of practically any material. Possible uses include printing on glass, plastics, and cloth materials.

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### **Researchers Develop New Bismuth-Based Crystals For Solar Cells**

March 2009

Researchers at **XXXXX University** discovered unusual electronic properties of bismuth-based crystals. These properties allow the crystals to act as reversible diodes and generate current when light falls on them. They exhibit particular sensitivity to light, particularly at the blue end of the spectrum. The efficiency has not been fully tested, but it shows promise to be an alternative to current technology.

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## **B. Concentrating Photovoltaics (CPV)**

### **XXXXX Solar Arrays Provide CPV Solar Power in XXXXX**

April 2010

XXXXX will provide solar power using XXXXX solar arrays at XXXXX Airport in XXXXX. The airport power station will deliver approximately 600 MWh of electricity directly to the airport's internal electricity grid, which is roughly 28% of the airport's electricity demand. The airport will be powered by XXXXX CPV arrays. The project will receive \$1.1 million from the XXXXX government and will complete its development by the end of 2010.

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### **XXXXX Gains \$XXX Million of Venture Funding to Expand CPV Manufacturing**

April 2010

Concentrating photovoltaics (CPV) manufacturer XXXXX announced that it has secured USD XXX million of venture funding. The lead investor is XXXXX. XXXXX reports that the new investment will allow the company to accelerate CPV shipments and expand manufacturing capacity.

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### **XXXXX will Distribute XXXXX's Anti-Reflective Coating for Solar Modules in XXXXX**

February 2010

California's XXXXX announced a strategic partnership with XXXXX, in order to distribute XXXXX's anti-reflective coating equipment in XXXXX. The XXXXX anti-reflective coating is a proprietary material that can be manufactured relatively easily at room temperature and non-vacuum conditions. After coating and curing, silica is chemically bonded to the glass surface, keeping light reflection below 1%. Utilizing the XXXXX coating, solar module makers can expect a 3% increase in peak power output and a 4% increase in energy produced on a kWh basis. According to XXXXX 50% of all solar modules will use such coatings, by 2015.

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### **New Solar Cell Package Design for CPV Cells**

February 2010

XXXXX introduced a new solar cell package design for CPV devices. The package incorporates the XXXXX design that integrates a thick copper base with a standard lead-frame structure in a high temperature LCP thermoplastic enclosure. This ensures excellent heat transfer from cell to heat sink via the copper lead-frame in order to support increased cell efficiency.

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## **XXXXXX launches new range of products for Photovoltaic Applications**

January 2010

The European manufacturer of silicone elastomers **XXXXXX** launched a new range of products for PV applications. Non-corrosive PV adhesives and CPV clear, UV stable and non-yellowing encapsulants provide environmental protection and improve light transmission. These adhesives and encapsulants are compatible with most of the materials commonly used in the assembly of Solar collectors. Also, thermally conductive potting compounds aid the fast and efficient removal of heat in CPV applications. [weblink]

## **XXXXXX Achieves High Efficiency**

December 2009

**XXXXXX** in partnership with **XXXXXX** announced **XXXXXX™ XXXXX** Module with conversion efficiency of 31%. **XXXXXX** manufactures the triple-junction gallium arsenide cells for the **XXXXXX**. The cells are housed in a highly specialized ground-mounted dual-axis tracking device. This system concentrates 750+ suns onto the cells. [weblink]

## **XXXXXX Gas & Electric Tests Innovative Water Suspended CPV Technology**

October 2009

**XXXXXX** CPV innovative technology utilizes acrylic lenses and a tracking system **XXXXXX**. The glass optics spread the sunlight evenly over advanced photovoltaic cells to generate electricity. The CPV system water acts as a huge passive heat sink to decrease cell temperature and increase the efficiency of the solar cell. The objective of the 18-month demonstration project is to validate the technology for potential broad commercial applications. [weblink]

## **Record-Breaking c-Si Efficiency at the Photovoltaics Centre of Excellence of XXXXXX**

August 2009

The **University of XXXXXX** achieved a 43% conversion efficiency. The researchers used concentrated sunlight and combined five cells, each of different materials, in order to maximize the amount of electricity produced by the solar spectrum. The silicon cell used for the red and near-infrared part of the sunlight spectrum was able to convert up to 46% of light into electricity. However, it is reported that this technology is currently very expensive to mass-produce. [weblink]

## **A New Light-Guiding Optic Combines Low Cost with High Efficiency**

February 2009

XXXXX developed an acrylic component, called XXXXX. The XXXXX is a thin optical structure made from XXXXX components that internally concentrates the sunlight. The concentrated sunlight is redirected onto small PV cells attached at the centre of the optics. The XXXXX is a new concept in the field of low cost CPV systems. It eliminates the bulkiness and the related material costs common to most CPV systems. Heat is dissipated without the need for expensive cooling systems.

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## **Project Listings Available Online**

Our project listings have been updated to segment our past project works into five main categories. Please follow the links to the PDFs on our website. This should provide you with a better idea of our range of services:

- Assisting clients with various aspects of [new product development](#), including technology searches and technology roadmaps.
- Providing [technology assessment](#), including state-of-the-art technology and future projections.
- Assessing and recommending improvements for clients' existing [manufacturing processes](#), including quality aspects and costs.
- Assisting clients with all aspects of [new business development](#).
- Providing a variety of [strategic market studies](#) in our clients' existing market segments.

## **Feedback**

We welcome any feedback or questions. Please contact us at [info@baverstam.com](mailto:info@baverstam.com).

## **Visiting the Baverstam Offices**

If you are in the vicinity of Boston or Geneva and would like to meet with us to discuss your ongoing requirements for technology or market focused intelligence, we would be happy to arrange an appointment. Please call us at +1-617-928-3037 (Boston) or +41-22-823-2460 (Geneva) or email us at [info@baverstam.com](mailto:info@baverstam.com).