July 31, 2006

Chairman, Rep. Judy Biggert
Ranking Member, Rep. Mike Honda

Re: The Subcommittee on Energy of the Committee on Science
Renewable Energy Technologies – Research Directions, Investment Opportunities, and Challenges to Deployment in the Developing World

Dear Honorable Representatives Biggert and Honda:

Thank you for the opportunity to testify before the distinguished Committee on Science. By way of background I am the CEO of Miasolé, a Santa Clara, California based manufacturer of thin-film solar cells. Miasolé has been in operation since late 2001 and exclusively focused on thin-film solar cells since early 2003. Miasolé occupies an 80,000 square foot manufacturing facility in Santa Clara and expects to commence high volume commercial production in the forth quarter of this year. The company's employment has grown from 16 employees this time last year to 58 in Santa Clara today. We expect to have over 100 local employees by year-end.

Miasolé is backed by several leading Bay Area venture capital firms including Kleiner Perkins Caulfield and Byers and VantagePoint Venture Partners, both of whom have a significant focus on alternative energy investments. Floyd Kvamme, a Kleiner partner, serves as co-Chairman of the President's Council of Advisors for Science and Technology. I have had the honor of speaking before this distinguished group regarding the potential for thin-film solar and have also met with Samuel Bodman, Secretary of Energy and Undersecretary, David Garman. There is widespread support for Miasolé's activities and for the potential for thin-film technologies to significantly reduce the cost of solar-generated electricity.

Miasolé's technology is highly disruptive and is expected to result in a 60-70% reduction in the cost of installed PV systems within five years, thus allowing PV to be competitive with conventional fossil fuel sources of electricity without the continuing need for subsidies. Our technology is based on thin-film solar cells incorporating $1/100^{th}$ the amount of expensive semiconductor material used in conventional crystalline silicon solar cells. Miasolé's PV modules will be made of flexible laminates, eliminating heavy glass encasements and frames required for today's silicon technology. We expect to integrate electronic functions into the PV module, further reducing costs and simplifying installation. Finally the form factor for Miasolé's solar material is highly flexible enabling true building-integrated photovoltaics ranging from residential roofing shingles that have the appearance of composition shingles to membrane roofing systems for commercial applications.

Solar Industry Background

The Department of Energy has funded solar research for more than 30 years with a total investment approaching $3 billion. Unfortunately the U.S. does not have much to show for its investment. After discovering the photovoltaic effect at Bell Labs 51 years ago, the U.S. enjoys only limited market penetration and a small share of global production.

Last year Japan represented approximately half of all global production and Germany more than half of all PV installations.

The US has the potential to regain manufacturing and market leadership with a new class of photoactive materials characterized as “thin-films”. Thin-films have been well-researched and have been widely viewed as having the potential for dramatic reductions in costs. What the industry has lacked is high volume manufacturing technology to leverage the achievements of government funded research. Miasolé believes the age of thin-films has arrived and that the industry is on the verge of major disruptive changes. Miasolé is one of several venture capital funded startups that are bringing high volume manufacturing technologies to bear on this market opportunity.

The early days of photovoltaics served primarily off-grid applications. In recent years the on-grid market has dominated driven by high subsidies and favorable legislation such as net metering which provides a credit mechanism for excess electricity fed back into the grid. The on-grid market is dominated by the retrofit market where PV systems are installed on existing roofs. For truly cost effective solar technology PV needs to become ubiquitous with new construction. This will eliminate retrofit labor and materials and a labyrinth of distributor markups while producing an aesthetically pleasing product that can be more easily financed.

Cost-effective building-integrated photovoltaics (BIPV) is a challenge with conventional crystalline silicon-based solar cells since they must be encapsulated with tempered glass to protect the fragile silicon wafer. The resulting PV modules are heavy and therefore limited in size. Thin-films can be manufacturing on thin flexible substrates and encapsulated with flexible materials. Form factors can be easily adapted to different building requirements with the substantially lighter weight allowing for larger modules and simplified installation.

Ninety-four percent (94%) of the photovoltaics market is based on crystalline silicon technology, a fifty-year-old technology. Another 5% is based on amorphous silicon technology, a more than thirty-year-old thin-film technology that suffers from inherently low efficiency. Two emerging classes of thin-film technologies have demonstrated high conversion efficiencies in government labs approaching that of polycrystalline silicon. These are cadmium-telluride and copper-indium-gallium-selenide (CIGS). Of these two technologies CIGS is the most efficient and is the technology of choice for most new entrepreneurial startups.

Compounded PV system growth rates exceeding 40% per year for the last five years have resulted in a significant shortage of polysilicon, the basic feedstock for crystalline silicon solar cells. This shortage has resulted in a doubling in feedstock prices and price increases at the PV module level of approximately 50%. Subsidies which were intended to stimulate the market by allowing economies of scale are having the opposite effect. The Senate recently requested a study of the impacts of supply constraints in the polysilicon feedstock industry with the understanding that polysilicon availability posed both a limitation to the growth of the PV industry and a floor to how low prices could go. There is growing concern that crystalline silicon-based PV technologies will not be able to achieve the Department of Energy’s goal for solar generated electricity achieving price parity with the grid by 2015. A disruptive change is required with both the Senate and DOE providing indications that they view thin films as a very strong solution to the polysilicon shortage.

The solar industry has recently attracted substantial private financing. Venture capitalists have been very active financing new management teams and the public financial markets have been quite receptive to initial public offerings and follow-on offerings. Equally important, the opportunities in alternative energy and solar in particular are attracting a new class of highly experience management teams, some of which are steeped in high volume, low-cost manufacturing. Most of these new entrants are focusing on thin-film technology. With the accomplishments of Federally-funded thin-film research, significant inflows of private capital and the attraction of experienced management teams, the stage is set for disruptive change.

It is important to note that most major technical innovations or disruptive business models have not come from venerable established corporations, but from entrepreneurial startups. Examples of industry changing startups that displaced mature organizations include Google, Cisco Systems, Apple, Genentech and Southwest Airlines, to name a few.

What can Congress do?

Congress should support the Solar America Initiative by fully funding the request of the Department of Energy. The current request for solar research, including funding national laboratories is $148 million per year, a substantial increase from prior funding levels. Awards should be granted to the most promising cost-effective high-volume technologies. A byproduct of this is expected to be strong support for disruptive thin-film technologies and a favoring of entrepreneurial companies over mature industry incumbents focused on 50 year old crystalline silicon technology.

Congress should reevaluate the funding level of the Department of Energy’s Building Program currently slated to receive $19.7 million of funding in fiscal 2007. This program focuses on energy efficiency with a goal of providing energy and technology programs needed to achieve “Zero Energy Homes” (ZEH) by 2020. With a shift in population to the south, west and desert southwest where solar irradiance is high there is a tremendous opportunity to adapt BIPV in new residential construction; however, there appears to be a disconnect between the technology goals of the Solar America Initiative and the level of emphasis in the Building Program. Every new major residential development without PV represents a lost opportunity as it will be twenty years before a roof replacement is needed. PV retrofits are not nearly as cost-effective as new construction. Congress should consider a step increase in the Building Program with the incremental funds dedicated to BIPV applications for new large scale residential development.

Congress should approve the extension of the investment tax credit for PV systems and lift the cap on the size of residential systems which at the current 2 KW limit is insufficient to meet the electrical needs of most residential housing. Congress should consider a more aggressive funding level in support of solar installations on new residential buildings, perhaps a direct buy down of the builder’s cost of PV systems in new construction.

There is a tremendous opportunity to install PV systems on commercial roofs, particularly with new thin-film technology that allows PV modules to be built into membrane roofing systems. Membrane roofs represent a $10 billion a year industry in the U.S.. The challenge with commercial roofs is capital. For example, consider a big box retailer with acres of roof space. Senior executives of these companies often have a myriad of capital projects and make funding decisions only for projects with two to three years payback. Solar is akin to buying a new car and prepaying the gas for the next ten years even with cost parity to the grid. The PV system goes on to produce essentially free electricity for twenty-five years or more but virtually the entire cost must be paid up front. Businesses would have far more incentive to install PV systems if additional financing options were available such as third party financing backed by Federal loan guarantees. The Federal Government already provides loan guarantees for large scale utility plant construction. Congress should give consideration to a financing program that encourages smaller-scale distributed PV systems on commercial rooftops. Consideration should also be given to a funding mechanism for manufacturing assets for PV manufacturers that operate in the US. This would allow the US to compete for PV manufacturing jobs that are now going to Europe and Asia due to very large capital grants and/or heavily subsidized income tax rates.

Thank you for the opportunity to voice my opinions on behalf of Miasolé and the solar industry.

Sincerely,

David B. Pearce
President & CEO

Addendum
Additional Detail on the Solar Industry and Emerging Thin-film Technologies

The crystalline silicon PV industry

The photovoltaics industry has grown in excess of 40% per year for the past five years, largely stimulated by government incentives. These subsidies were expected to lead to an increase in the rate of market adoption which in turn would lead to economies of scale and lower installed system prices. Unfortunately high demand has had the opposite effect of increasing costs and increasing industry profit margins. During the past two years a significant shortage of polysilicon feedstock, the basic material for making a silicon solar cell, has emerged, causing a major run-up in the price of the feedstock, silicon wafers, solar cells and PV modules. A significant reduction in the cost of installed PV systems is required to realize the potential of solar technology and to make significant inroads in reducing our dependence on fossil fuel sources for electricity generation.

Silicon PV suppliers are trying to bring down their costs through several means which include greater economies of scale (plants are already of significant size), reduced wafer thickness to lessen the use of expensive polysilicon feedstock (with increased manufacturing complexity and higher losses due to breakage), improved photovoltaic conversion efficiencies (a relatively mature 50-year-old technology) and more efficient manufacturing processes, offshore manufacturing, etc. Compounding the problem is that the polysilicon feedstock industry, which supports both solar and semiconductor industries, is demanding and getting higher prices while also requiring long term commitments to insure supply. Polysilicon feedstock costs have more than doubled in the last three years and represent a significant portion of the cost of a completed silicon PV module. Polysilicon feedstock shortages are expected to be address by 2008/9 but high costs are being locked in for five years or longer under long-term supply agreements.

Before the advent of the polysilicon feedstock shortage, the solar industry historically realized 4-5% per year price declines. In order for PV systems to be competitive with conventional sources of electricity without subsidies PV modules prices need to decline from the prevailing rate of approximately $4.00 per peak Watt to the range of $1.00-$1.50 per peak Watt. The goal of the Solar America Initiative is to achieve price parity with the grid by 2015. This will require a compounded price decrease of more than 10% per year for the next nine years. Many doubt that crystalline silicon technology can reach this goal.

Besides the expense of making crystalline silicon cells there is considerable added expense associated with silicon technology. First, silicon based PV manufacturing plants are staggeringly capital intensive, on the order of $2-$3 million for each megawatt of annual capacity with factories needing several hundred million dollars of fixed assets to achieve scale. Second, the rigid and fragile silicon wafer must be protected with a tempered sheet of glass. This requirement limits module size due to weight considerations, requires aluminum frames for mounting, bulky mounting hardware, poor aesthetics and high installation costs. Thin-films offer a disruptive path to significantly lower manufacturing costs, simplified and light weight module packaging, ease of installation and the potential for truly “building integrated” photovoltaics (BIPV) where solar becomes ubiquitous with installing a roof during new construction.

To summarize:

- Crystalline silicon solar cells are a 50-year-old technology representing 94% of solar industry sales
- Crystalline silicon manufacturing processes are relatively mature; significant economies of scale have already been achieved
- Manufacturing costs have been rising due to polysilicon feedstock shortages; new supply is coming on line in 2-3 years but at high contracted long-term prices
- Market based subsidies have created high demand which in turn have caused escalating costs and have enabled expanding margins
- Crystalline silicon costs aren't likely to decline fast enough to meet the goals of the Solar America Initiative… i.e. price parity with the grid by 2015

Thin-film photovoltaics

Thin-film photovoltaics involves the deposition of a thin film of photoactive semiconductor material on a low cost substrate. The amount of semiconductor material in a thin-film solar cell is approximately 1/100th that of a crystalline silicon cell. In addition, thin-film solar cells can be manufactured over large areas, including roll-to-roll continuous deposition processes. To put this in perspective, crystalline silicon cells are nominally 6 inches by 6 inches in size and are manufactured in discrete, batch-oriented processes. Contrast this to Miasolé's process which continuously deposits thin films on meter wide rolls of stainless steel foil two miles or longer in length moving at two feet per minute.

Thin-film solar materials have been researched for more than 30 years and have been in modest volume production for the past ten years for both commercial and residential use. The most mature thin-film technology is amorphous silicon. The first significant markets for amorphous silicon were handheld calculators. Today amorphous silicon represents about 5% of the rooftop solar market. The principal drawback to amorphous silicon is its inherently low conversion efficiency, equal to about half that of crystalline silicon. Amorphous silicon deposited on thin flexible metal substrates and encapsulated with flexible laminates yields a PV module that is lightweight, flexible and easy to install. It is this unique flexible module capability that has generated most of the demand for amorphous silicon rooftop applications.

There are two other classes of thin-film technologies currently in commercial scale production which together represent about 1% of the world market: Cadmium-Telluride and Copper Indium-Gallium di-Selenide (CIGS). The U.S. has long led the world in thin-film solar research holding the world records for high efficiency cad-telluride and CIGS solar cells. What the market has lacked is a high volume manufacturing process to leverage the progress made at the laboratory level for these technologies. Entrepreneurs have seized the opportunity in the past several years with the formation of several new startups funded by the venture capital industry all with the intent of pursuing high volume, low-cost manufacturing technologies. The majority of these startups are pursuing CIGS solar cell technology since CIGS has demonstrated the highest conversion efficiencies of any thin-film technology, very close to that of polycrystalline silicon (19.5% for CIGS vs. 20.3% for polycrystalline silicon).

Production processes for cadmium-telluride and CIGS thin-films remain relatively immature. This situation is expected to change rapidly as volumes increase and manufacturing learning curves improve product performance, production yields and lower costs. Equally important, thin-film processes typically require dramatically lower fixed asset expenditures for a given level of production.

Unisolar, a division of Energy Conversion Devises, is the world leader in amorphous silicon and First Solar is the world leader in Cadmium-Telluride. Miasolé believes it will quickly become the world leader in high volume, low-cost CIGS production.

Thin-films represent the opportunity for the US to regain the lead in solar technology, cost competitiveness, volume production and market penetration. With these goals achieved, widespread market adoption becomes possible without the need for continued subsidies.

To summarize:

- Thin-film solar technologies have been widely researched and have achieved laboratory conversion efficiencies closely matching polycrystalline silicon technology
- The industry has lacked a high volume manufacturing platform to leverage the discoveries made in a laboratory environment
- Entrepreneurs and investors are aggressively pursing the high volume manufacturer of thin-film solar with CIGS based solar cells the technology of choice amongst most startups
- Thin-films offer the potential for substantially lower costs per peak Watt, up to a 70% cost reduction from crystalline silicon for installed systems.

Challenges to commercializing thin-film technologies

Challenges associated with scaling laboratory technology demonstrations:

Most government and university thin-film research has focused on optimizing the efficiency of thin-film solar cells and improving the understanding and characterization of these films. Unfortunately most of the laboratory processes are not easily scaled. Little effort has gone into researching large-scale production platforms. Miasolé is leveraging the core experience developed by NREL but is using a different vacuum deposition process known as “sputtering”. Sputtering is widely used in the architectural glass industry (sheets of glass 12’ x 20’ in size) and the data storage industry for making hard disks. In Miasolé’s case a significant portion of the Company’s technical team came from the data storage industry augmented with engineers from the glass coating industry and engineers and scientist with specific CIGS experience.

One of the challenges to the high volume production of thin-film solar cells is that commercial production equipment does not exist. The industry is similar to the early days of the semiconductor industry where companies developed their own manufacturing tools. Today there is a discrete and separate semiconductor capital equipment industry. Fortunately Miasolé has years of experience designing and manufacturing high volume vacuum deposition systems with several core patents covering major elements of its technology.

Challenges associated with the time to develop high volume processes:

A second challenge is that each high volume process has its unique properties that are different than laboratory processes. It frequently takes several years to develop a production tool and an equal amount of time to perfect a production process. Government funded research offers an excellent platform for getting started, but substantial additional process and system development is required. Historically most of the solar startups were founded by scientist out of government and university research programs. While these scientists had a core understanding of the technology, they lacked volume manufacturing and general business experience. Venture capitalists tend to back experienced management teams and had difficultly backing early scientist turned entrepreneurs. All of this is changing with the advent of a large scale solar industry and more plentiful investment dollars. The industry is now attracting experienced management teams, several of which have deep domain experience in high volume manufacturing, and significant private equity.

Challenges to locating manufacturing in the US:

There are challenges to locating factories in the US and California in particular. Silicon based PV cells and modules are relatively labor intensive favoring overseas production in low labor-cost countries. Thin-film processes, if properly executed, are less people-intensive but labor costs remain an issue in a highly cost sensitive marketplace. Many countries offer significant financial incentives for establishing PV manufacturing plants. Several European countries offer capital grants equal to 50% of the cost of a factory. With large scale PV factories costing hundreds of millions of dollars, these subsidies are very substantial from both a unit cost standpoint and the amount of capital required. Asian countries favor tax holidays with some countries offering five year income tax holidays, another five years at 7.5% tax rates and permanent long term income tax rates of 15%. Often countries that subsidize factories also offer some of the highest market incentives and thus represent large domestic outlets for production.

At the state level, California not only has inherently high labor, facility and utility costs, but it also is one of only eight states in the US to tax manufacturing assets. Miasolé anticipates spending approximately $30 million for fixed assets next year for installation at its Santa Clara facility plus an additional $2.5 million for use tax that the Company would not incur if operating in most other states. California talks about wanting high paying manufacturing jobs but does little to encourage industry to expand, particularly those that are fixed-asset intensive. On the plus side, California’s PV market incentives are among the best in the country.