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New PV cell coating
increases efficiency and durability

An innovative new coating technology from MetaShield can make photovoltaic (PV) cell surfaces more durable while it increases efficiency more than 1 percent, all without significant changes in cell or module production processes. By Mark Andrews, Technical Editor.

IMAGINE working years to develop a product to enhance photovoltaic (PV) efficiency, and then at a critical juncture – after more than 40 trials – a test batch falls to the floor, shattering into pieces.

The average researcher would have been doubled-over at the loss. But for MetaShield founder and CEO Martin Ben-Dayan, the lab accident proved to be just the sort of break he had been looking to find.

When everything crashed it seemed the incident was just another frustration in the life of a new business. Anyone who has built a company or worked at a startup can attest that setbacks often outnumber 'eureka!' moments. But as researchers and Ben-Dayan were literally picking up the pieces, they discovered something unexpected. Instead of shattering every test slide, the fall left some intact.

But only slides coated with their 43rd formulation had survived. Every other slide was cracked if not smashed. MetaShield would eventually determine that their breakthrough formula was capable of increasing the break resistance of glass up to four times.

"Up until then, we had been working with polymers; we subsequently transferred over to a silica-based approach," said Ben-Dayan. "When the tray fell some slides broke and others didn't. We found only one group survived and we realized at that point we had something on our hands that was potentially much bigger than we had planned. The coating was super-light and thin and could host nanoparticles. When dried it was super-tough; it made things like glass (or PV cells) much stronger."

Once durability was established, MetaShield moved on to its primary goal: create a coating to improve PV performance. Enhancing nanoparticles were added to the base formula and more tests were conducted.

"Durability is great, but could (the coating) enhance efficiency? We found that it could. So now we had a new formulation that could be sprayed on a solar cell; it dried at room temperature without any special treatment. We (also) found it could go on top of the antireflective coatings that PV manufacturers were already using. It increased efficiency one percent or more. That is significant in the solar industry."

Polymers, and to a lesser extent silica coatings, are of course not new in 21st century industry. According to Ben-Dayan, employing nanotechnology made the difference. As MetaShield also discovered, their nanoparticle formula simplified production compared to typical silica or polymer coatings.

"By now we started to realize that we were part of something very new. If you have a material with all of the benefits of polymers but has the properties of glass, then it is disruptive, even revolutionary. With (traditional) silica coatings you have to use very expensive deposition and baking processes.

As we spoke to more people in the industry, we realized that while the break resistance and efficiency (gains) in our formulas were impressive, what most

MetaShield formulations are typically delivered to customers in 1-20 gallon containers tailored to manufacturing needs and transportation requirements.

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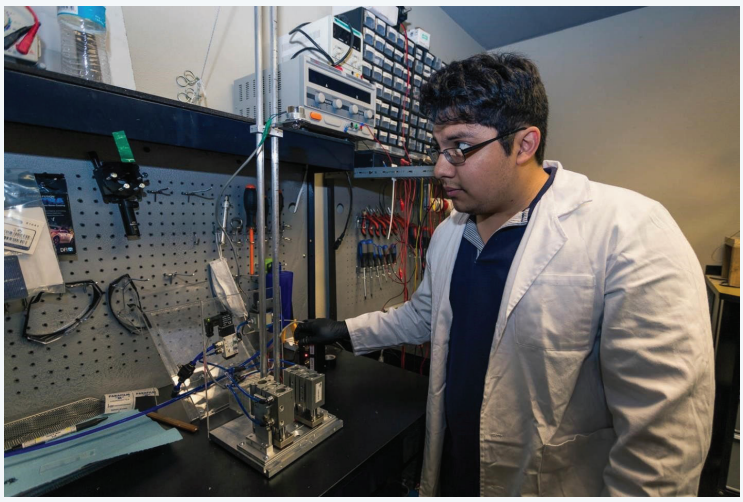
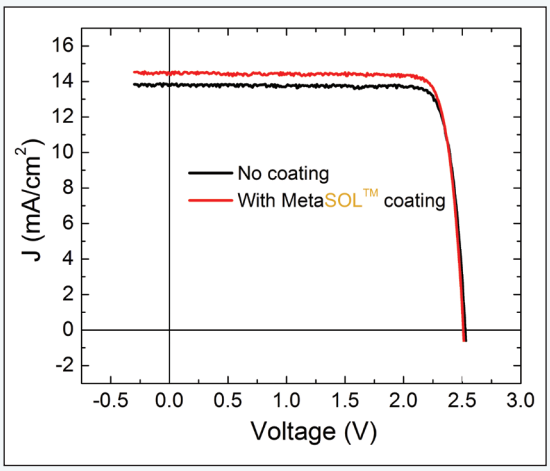


Ernesto Arevalo, MetaShield Lab Technician, tests a coating using a drop ball test (Photo courtesy of USTAR.)



Graphical representation of a test solar/photovoltaic cell with and without MetaShieldPV coating.

people were interested in was the fact it could be applied and dried at room temperature. That made a real difference," he remarked. Ben-Dayan said his company's quest to enhance PV cell efficiency started six years ago. With offices in New York and Utah, the company had originally pursued optical filters to boost solar cell efficiency. They struck on the idea of using holographic optical elements to change the direction of light to strike the active areas more effectively, thereby boosting the yield of PV cells.

"That product worked, but the value metrics for us and the economics were not beneficial. So after a year or so, we transitioned into nanotechnology to help manipulate what was going on as the light waves entered through the filter (layer). We had tried quite a few formulations with various nanoparticles, but in the process we discovered it did so much more."

Dr. Puruswottam Aryal, MetaShield Senior Physicist, reviews crystal formations during a recent formula test session. (Photo courtesy of USTAR)

Now armed with a product that could appeal to many industries, Ben-Dayan set out to market his technology. Since the product increased durability and efficiency, MetaShield representatives spoke with aerospace companies developing satellites for defense and commercial applications that rely on high-performance, triple junction PV technology for electrical power in space.

The company also received a grant from the Utah Science Technology and Research Initiative (USTAR) to prove the potential of its new coatings and thereby establish greater credibility with potential customers.

That study was conducted at MetaShield R&D facilities in Utah with results verified late in 2016 by OAI-Optical Associates, a leading testing company in San Jose, California.

Tests found that MetaShieldPV, when applied to triple junction solar cells, boosted their efficiency 1.2 percent (absolute). This increase amounts to what industry watchers like GTM Research expects from five years of conventional PV cell technology evolution as manufacturers pursue product improvements over time; about 0.2 percent each year is average.

The initial study focused on triple junction GaInP/GaInAs/Ge solar cells. These devices were coated with MetaShieldPV; before they were not encapsulated; they had already received commercial

antireflective (AR) coatings. The current-voltage measurements (J-V curve) of the devices were measured under AM1.5 simulated solar spectrum illumination at OAI-Optical Associates, before and after the coating was applied. The comparison revealed an increase in device efficiency from 29.39 percent to 30.59 percent, an absolute increase of 1.2 percent.

While test results with more conventional c-Si cells coated in MetaShieldPV are still pending, Ben-Dayan said he expects the company's own performance reviews to be verified by OAI-Optical Associates.

The precise formulation of MetaShield base coating products is proprietary, but Ben-Dayan said the base is primarily silica, water and ethyl alcohol. The nanoparticle formulation is also proprietary. Upon application, the product solidifies in the open air at room temperature without any special industrial gases, heating or pressurization. The liquid hardens into a thin film layer with a refractive index of ~1.5, according to the company.

The MetaShieldPV coating employs plasmonic and dielectric nanoparticles to enhance the forward scattering of light incident on solar cells and through this process increases the short circuit current and the overall photo-conversion efficiency of PV cells, explained Glenn Mesa, MetaShield's director of research and development.

Once the core of its lineup was fashioned, Ben-Dayan and his team went to industry events and conferences, this time to introduce their new products. They leveraged early aerospace contacts, expanding outreach to defense contractors. They have also engaged with major smartphone and glass manufacturers because of the coatings' ability to protect any glass-like material including mobile device screens.

The current product line includes MetaShieldPV for the solar energy industry, MetaShieldGLASS for consumer electronics applications and MetaShieldUV for aerospace markets. "The application and the principle is disruptive technology with seamless

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integration. We are mindful that the solar industry is a graveyard for companies that came up with different ideas that did not sell.

Those products always seemed to have a deficiency along the way, and we observed that most of the efficiency boost ideas (that failed) required changes in manufacturing or processing—that was their challenge.

"MetaShield represents practically zero change from what manufacturers are doing now. It is simply another coating that goes on before encapsulation. But it makes the cell more durable and it could increase efficiency 1 percent or more. It's that easy," he said.

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