Flexible PV survivor: Uni-Solar banks on efficiency, cost, BOS improvements to weather the storm

By **Tom Cheyney**

One of the busiest of the couple-dozen solar manufacturing factory floors I've seen this year belonged to ECD Uni-Solar, at its Auburn Hills 2 (AH2) facility just up the road from the Palace where the NBA's Detroit Pistons play hoops. When I toured the plant in late July, the three production areas – cell deposition, cell finishing, and module stringing/lamination/final assembly – were humming, as the 1.5-mile-long rolls of flexible stainless-steel starting material were transformed into triple-junction amorphous-silicon thin-film PV laminates. The company's latest quarterly results confirm those observations at the factory, as production output grew some 58% over the previous period – from 21.2MW to 33.6MW – pushing capacity utilization to about 90%.

However, what I saw at AH2 stood in direct contrast to the ominous announcement that shook the industry the day before my visit: Applied Materials' shuttering of its SunFab division and de facto withdrawal from the a-Si thin-film sector. For Uni-Solar's Subhendu Guha, the news had a bit of déjà vu to it.

"The same thing happened to us when BP Solar pulled out of amorphous silicon [in late 2002], and people wrote amorphous silicon off, because if BP goes out, what does it mean?!" the Uni-Solar chairman and ECD CTO recounted. "We stood and we survived. So when Applied Materials pulls out, again there is this thing, 'oh my god, if Applied Materials can't do it, how can anyone else do it?'

"But what I tell people is that our business strategy is different. We're not trying to compete with First Solar [like Applied was] nor are we trying to compete with crystalline high-efficiency solar cells. We have a market, which is the rooftop market – that's where we want to be."

Uni-Solar is certainly a survivor in the PV market, and continues to be the only company capable of manufacturing high volumes of lightweight, flexible solar laminates in a roll-to-roll production scheme.

Although several companies (SoloPower, Global Solar, Ascent) have begun to make copper-indium-gallium-(di)selenide (CIGS) flexible modules with the building-integrated rooftop market in mind, they are just beginning to ramp up their lines and do not have the sun-soaked track record that the thin-film silicon pioneer does, even if their claims to higher efficiencies and lower costs raise concerns for Guha and his team.

Photos courtesy of Uni-Solar

"We are watching them very carefully," he said. "You cannot develop a business strategy assuming the other guys are going to fail. You have to develop a business strategy assuming those guys are going to succeed. CIGS has its challenges. The biggest one is moisture, but eventually they can solve that. CIGS being a lower bandgap material, we will typically produce 20% more electricity per kilowatt than CIGS, so we have that advantage. The third issue is bankability: Uni-Solar has bankability on its side."

"CIGS should come but they have some barriers, so we just have to stay ahead of them, ahead in terms of conversion efficiency, in terms of applying the product to the roof," he continued. "We have to make sure we can sell the kilowatt-hour per kilowatt advantage and, more importantly, we have to make sure we can reduce the installed cost even further by some of the innovations we are making. We're lucky we're the only large-scale manufacturer of flexible solar laminates, but you can't enjoy that position forever."

Uni-Solar is aggressively trying to stay ahead in the flexible-module game by finding ways to boost efficiencies and chip away at expenditures in the capital and operational areas, as well as the aforementioned balance-of-systems improvements for its differentiated products and a big-picture strategy to push its business model more downstream to garner more "projects" business.

The company says it has stayed on track with the efficiency and cost roadmap announced in June. The plan calls for 10% aperture-area conversion efficiencies at a cost of $1.15/W on its AH1 line, upgraded with a new very-high-frequency deposition process, before calendar 2011 ends.

Those numbers will improve to 12% and 95 cents, respectively, the following year, once the next-gen nanocrystalline technology is implemented. During the earnings call in early November, the company announced its extended roadmap, which aims for 14% efficiencies at 65 cents per watt by 2015.

(Guha told me they can hit $1.50/W at 150MW/year production levels, using the current 8–8.5% efficient technology. President/CEO Mark Morelli said costs were $1.61/W during the first quarter of FY2011. System-level ASPs are about $4/W installed now, and should go down to about $2.50 by 2012, once the efficiency and cost reduction metrics kick in, according to the chairman/CTO.)

Still in an earlier stage of Uni-Solar's gated-development path, the photon-harvesting "HybridNano" materials will replace the green and red light-absorbing layers in the triple-junction stack. One of the banes of thin-film silicon – light-induced degradation – is apparently not an issue with the nano films.

The R&D efforts on the morphologically complex materials need to demonstrate higher efficiencies (they're 11% now, need to reach 12%) as well as better large-area uniformities before any capital equipment is modified for the nano-secret sauce process, according to Guha. The team will make a decision in February/March 2011 about the design of the souped-up tool, knowing that they will have until October 2012 to start production with the technology.

Looking even farther out, Uni-Solar has reached 15.4% on small-area nanocrystalline silicon-hydride research devices. It believes there's headroom to get to 25% efficiencies through continuing

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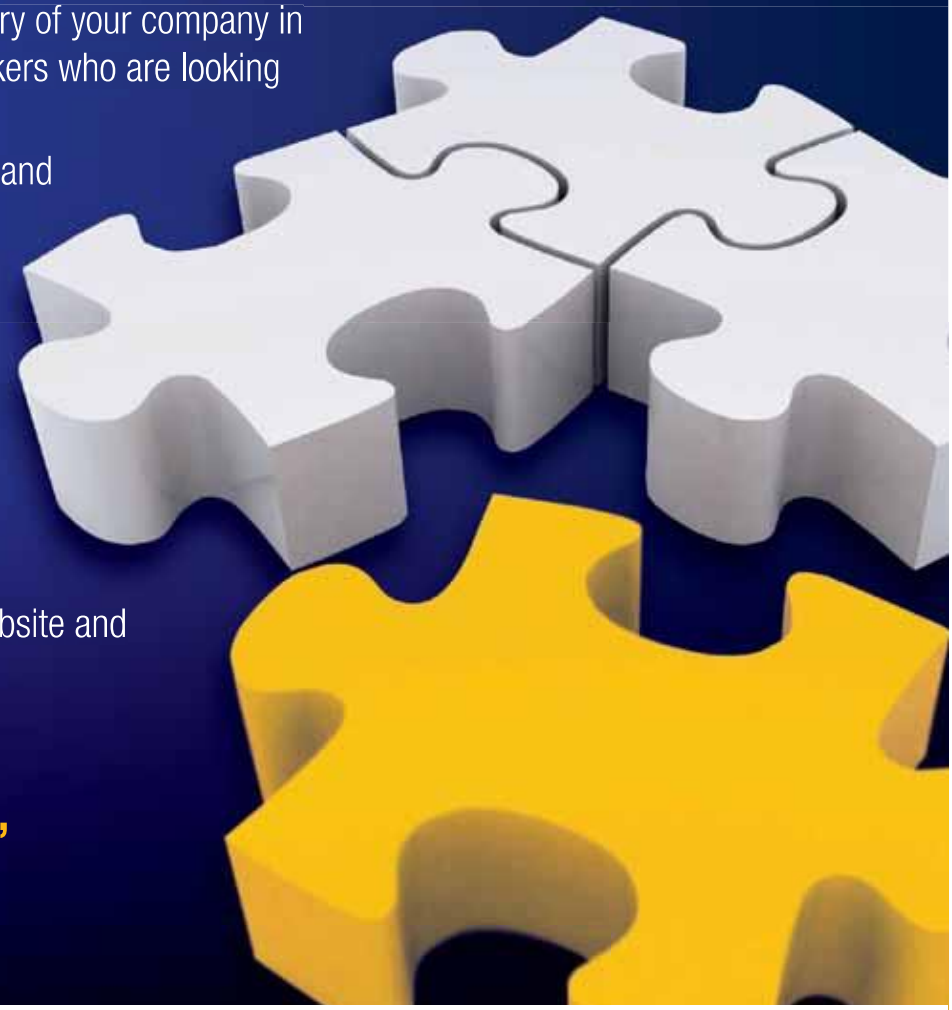

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to push the light-trapping envelope even harder – maybe even breaking the "random scattering barrier" – and thereby increasing short-circuit current density as well as fleshing out the fill factor from 75% to 85%, through the use of novel deposition methods (hot-wire CVD, rapid thermal annealing, etc.), interlayer enhancements, and plasmonic and other exotic back-reflector variations.

As for the tool being readied at AH1, Guha explained that the high rate of deposition that the modified very-high-frequency PECVD technology enables can be accomplished without changing the existing equipment set. The upgrade is accomplished by the incorporation of a new cathode design, improved power supplies, a new back-reflector material in the cell stack, and other "tinkering with various parameters to design of experiments."

The aluminum zinc-oxide film currently sputtered as the back reflector will be replaced with a texturized silver zinc-oxide cocktail, which is said to be superior in capturing a greater spectrum of light and helping trap those elusive photons.

Having demonstrated uniform deposition over the requisite large-area substrates, the VHF process will double the throughput of the R2R triple-junction a-SiGe:H cell processing machines from 30MW to 60MW in addition to popping the aperture-area efficiency up to 10%.

Modifications to the Auburn Hills 1 tool, the twin of AH2, have been completed, and the system has been going through its optimization paces for a few months. Certain minor changes have been made to the cathode since R&D, Guha told me during Solar Power International, noting that with the VHF approach, for example, "grounding can be rather tricky; as the frequency increases, there can be losses at the contact, so one thing we want to do is, the stainless steel" – all 1.5 miles of the moving substrate – "has to be grounded."

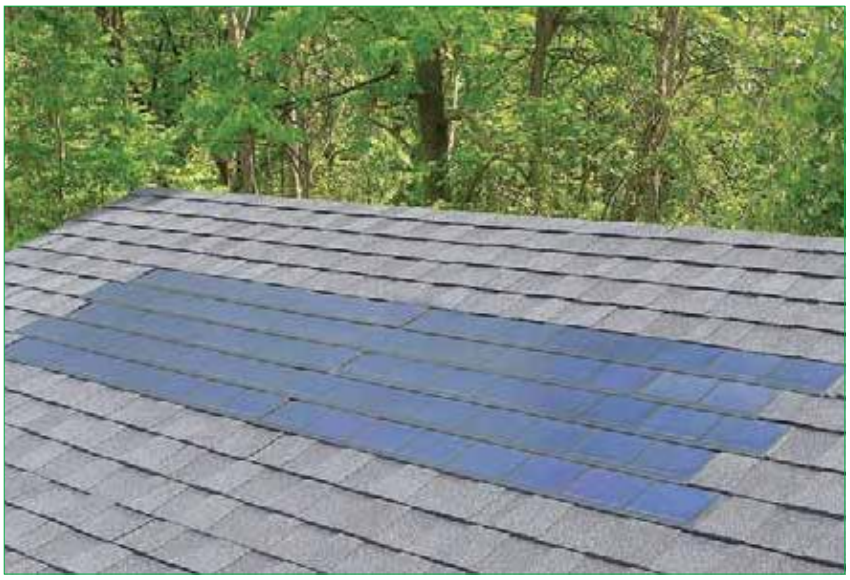
Morelli said during the conference call for the quarter ended Sept. 30 that the big vacuum tool had been through 40 optimization runs already and would continue to be optimized (and tested/qualified) in order to be ready for commercial production of the new, improved laminates by summer 2011. He also noted an area of roadmap acceleration: the VHF retrofit of AH2 has already begun.

Speaking of those deposition machines, when you walk alongside one of them, it's hard not to be struck by the level of sheer ingenuity and innovation. Six of those massive spools of thin steel roll through the 70-meter-long system at a time, the foil flipped up vertically, entering and exiting the 34 N-, I-, and P-layer process chambers over the course of the 62-hour cycle time.

Interferometric sensors check film thickness throughout the process sequence; those and other performance measurements are monitored assiduously in the impressive control room, providing data for the curiously acronymed YETI (yield, efficiency, throughput, improvement) team.

It's readily apparent that if Uni-Solar had not devised a way to retrofit the expensive behemoths, the price tag for replacing them could have led to a potentially bank-breaking dilemma for the already cost- and profit-challenged company, well beyond the revised fiscal-year capex guidance of $40 million offered by CFO Kriss Andrews.

Another area of operational savings came when it was decided that back-end assembly operations would be



discontinued in AH2, and those activities then focused in the company's lower-cost Tijuana 150MW facility. This move was made just a few weeks after I had had to dodge workers as they interconnected the cells into series strings and polymer-encapsulated those strings into laminates on that hustly-bustly part of the shop floor.

In a surprise announcement, it has been revealed that Tijuana will soon have a sister assembly line in Ontario, just across the border from Auburn Hills. ECD has decided to take advantage of the province's lucrative rooftop market via its neighbor's FiT "domestic content" provision and set up a 30MW production facility in an as-yet-unannounced location. The first 15MW line will come up in the second or third quarter of next year. The company would not confirm if the back-end toolset sitting idle in AH2 will indeed be the capital gear redeployed to the Ontario factory.

Asset reorganization and process enhancements are not the only pathways that Uni-Solar has utilized to reduce costs and improve its products. Guha showed me an enhanced laminate design, which incorporated a scaled-down junction box and ongoing reductions in the "dead area" – those inactive zones around the sides of the module.

Historically, the total area of the laminate included about 18% dead area, contributing to the wide discrepancy between aperture- and total-area efficiencies. At that point, the team had reduced the inactive area to 12%, mainly by narrowing the edge areas, with a goal of whittling that down to 5% by 2012. If all goes well, by then the efficiency gap would be tightened to 12% (aperture) and 11.4% (total).

The junction box has been made smaller and thinner, freeing up even more potential photoactive area. The design has already been approved, and the new j-box is expected to go into production in December, build inventory for a few months, then launch to the market in February or March of next year, Guha told me during SPI. The goal is for the compact j-box to be a standard component on all products by mid-June.

The laminate and the j-box have both been submitted in parallel to IEC and UL for certifications, which should be signed off by late 2010 or early 2011, according to Guha.

While the PV laminates continue to be Uni-Solar's core offering, the growing suite of commercial and residential rooftop products has become a key part of the company's growth engine. Along with that expanded portfolio comes repetitive branding, with names such as PowerTilt, PowerBond, PowerMembrane, PowerTile, and PowerShingle hammering the messaging into customers' brains that these products can carry a charge, by golly.

One of the most aesthetically appealing of these offerings is UniSolar's version of the solar shingle, which it believes has strong upside for parts of the U.S. residential rooftop market. It's not a new idea, as an earlier incarnation of the concept fell flat when launched more than 10 years ago, largely because they were hard to install and had to be connected in a roof-penetrating manner.

The reborn shingles, set for market re-entry in mid-2011 after a prelaunch at SPI, use flat connectors and are nonpenetrating. During my visit, Marcelino "Mars" Susas, VP of corporate strategy and marketing, escorted me to the residential display area and showed me the first- and second-generation of the current shingle design.

Noting how they're trying to incorporate the "thought process of the roofing companies, in terms of how to install using standard roofing materials and tools," he said that they "wanted to get as much above the deck as we could" with the new shingle design, with all module-to-module connections on top.

Cut into 5- and 10ft lengths, the first-gen shingles are covered with channels or "raceways," with each kilowatt section separated into three channels, including two columns of 10ft modules, 20 rows high, according to lead engineer, Troy Glatfelter. By next year, the second-gen shingle system will do away with the raceways, be much more integrated, and feature further improvements to the connectors. In effect, the first product is BAPV, while the second one is BIPV.

The installation procedure consists of "putting the module down, snapping the connectors together, aligning the module, then nailing it in," he said. "It's that simple, almost as fast as [laying down] asphalt shingles."

The engineer detailed a clever aspect of the wiring approach. "They're connected in series, plus/minus, all the way up the deck. But how do you get the first negative up to here," as he gestured at the roof mock-up, "without carrying a wire up or putting something under the deck that might get pierced later?"

"What we do is run a neutral bar through all the modules and then on the first module, we put a shorting connector there," explained Glatfelter, channeling his inner contractor. "This shorts the negative to the neutral, and now the negative's on the top. So as the roofer installs, these panels are not live, there's no voltage across the leads, so it's very safe for them to work with. Even if they pierce it with a nail, there's no voltage there, there's no complete circuit."

Hence the "trades" are separated, with the roofer-installer doing his thing and the electrician coming in with the final components to finish the circuit, making for a very safe work environment, according to Uday Varde, director of product development.

Mother Nature almost used me to complete a circuit as I drove south on I-75 toward Detroit airport from Uni-Solar's Auburn Hills campus. Mind-boggling torrential squalls and instantaneous flash-boom lightning/thunder dowsed, illuminated, and shook my rental car, as a satellite radio garage-rock program boomed from the speakers inside the cab.

That brush with the elements triggered my mythic imagination: I wondered if the downpour was some kind of omen of the prospects of the first company in flexible PV, a sign of turbulent times ahead or perhaps what happens when the storm has passed.

The reality is anything but epic: ECD Uni-Solar must stay on or accelerate its technology and cost roadmap, expand its "demand creation activities," and find its way back to profitability if it expects to weather the storm.

This feature is a revised version of a blog that originally appeared on PV-Tech.org.