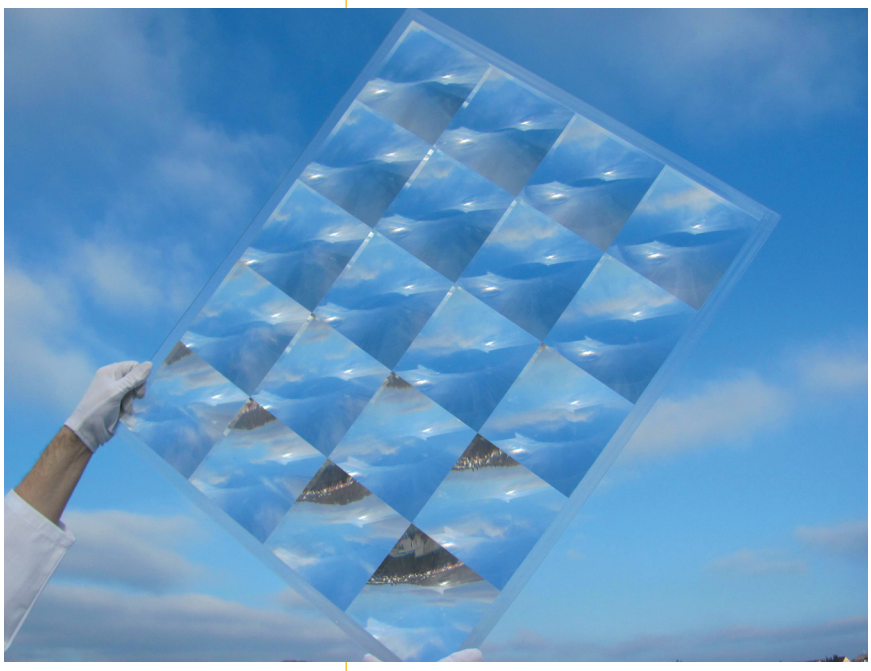
Maturing HCPV supply chain looks to volume production issues

Once the HCPV industry starts shipping hundreds of megawatts, its supply chain will have to transition to volume production as well. And a high volume business can't be built all on custom components and custom assembly equipment.



Concentrator Optics Fresnel Lens Parquet (Courtesy of Concentrator Optics)

"Performance data that we can talk about will help the bankability of the whole sector," explains Ralf Leutz, Concentrator Optics.

Some helpful steps would be openly available data on the performance of some HCPV optics components, coordinated optimization of the design of the primary and secondary optics to work together, and coordinated optimization with manufacturing technologists to design efficient volume production. So Concentrator Optics founder and GM Ralf Leutz cooked up a plan to work with secondary optics supplier Isuzu Glass and cell and receiver maker AZUR SPACE to make test mockup HCPV modules to compare various combinations of three different Fresnel lenses, two different secondary optics and two different multijunction cells, to get module performance data that could be released publicly. "With tighter tolerance budgets, the design of the primary and secondary optics have to be optimized together with multiple iterations, but when we make these products for customers we can't share how results compare to other designs or materials," says Leutz. "Performance data that we can talk about will help the bankability of the whole sector." Aiming for quick results, the three companies each simply supplied their components for the mockup modules for testing.

Early results are showing relatively small differences between PMMA and silicone-on-glass (SOG) Fresnel lenses, and are quantifying the difference between the relatively higher performance kaleidoscope secondary optics and the lower cost half-egg alternatives. With the data on the optimized optical designs, next step is to work with assembly companies to design efficient production processes for these components. Then HCPV makers won't have to do the iterations of the optics design themselves, but they can choose the appropriate balance of performance vs cost, and the tooling will already be there. "Customers can then buy components off the shelf, like in a mature industry," says Leutz, noting that some users might for example prefer the lighter weight of PMMA, while others installing in areas with frequent sandstorms may prefer more scratch-resistant glass.

"We've played with the process long enough," asserts Leutz. "There will have to be some standardization." He argues that though leading companies will continue to distinguish themselves with their particular technologies, much of the industry will go to a mainstream volume production option using Fresnel lenses, secondary optics and triple junction cells. "Once the HCPV industry gets to a few hundred megawatts, it will start to look a lot more like the flat panel PV market," suggests Leutz. "The key issues will move beyond technology, to the financing, the marketing, and the big companies. We have to be prepared for that."

While a second tier of upstart HCPV players might economically ramp production of these more standard systems, currently all the leading HCPV systems makers choose quite different options to optimize their systems. Soitec uses SOG Fresnel lenses but skips the secondary optic for easier and cheaper manufacturing, and instead compensates with extra accuracy in its trackers. Amonix uses lighter acrylic Fresnel lenses for its large units, but with a low cost, reflective aluminum secondary optic. SolFocus uses mirrors for both the primary and secondary optics, but does use a rod-shaped refractive third optic to gain a particularly large acceptance angle to allow more tolerance for imprecision in assembly and installation.

Isuzu Glass: Design for manufacturing, optimization with primary, may reduce secondary optics cost

Systems makers have had to design their solutions without fully knowing manufacturing costs for their custom designed components. Molded glass optics specialist Isuzu Glass reports that many HCPV companies have come to it with their designs for

secondary optics to convert the Fresnel spot to more homogenous light, to avoid hotspots that can damage the cell, and to allow a wider acceptance angle for better performance with less strict requirements for accuracy on the part of the tracker. However, typically, says Isuzu sales manager Mehmet Sinan Ata, the module makers provide the glass maker with the drawings for the glass parts, and then discover afterwards that their design is not possible to actually manufacture for anything close to the $1 or so per unit target price they expected, so few have yet to move the systems to volume production.

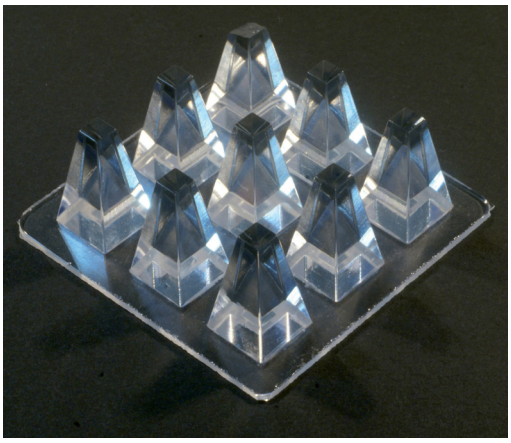
The high cost of the precision molds and tooling make high performance molded optics expensive unless those costs are spread over high volumes, so initial requests for quotes for relatively small orders are expensive, and not particularly profitable nor of much interest to the optics companies that churn out lenses for projectors and cell phone cameras in serious high volumes. Costs can however be reduced by making the lenses as small as possible, and keeping the shapes simple and rounded for easier molding.

"We've gotten many inquiries from different companies with totally different module designs, and we are currently supplying several module manufacturers' pilot plants around the world, but so far none have moved into high volume production," says Ata. "We decided to work with other components suppliers to help push development ahead faster, instead of waiting for the market, to help the business move ahead more quickly."

Supply chain matures towards automated production, 20-year warranty for solar acrylic

Leutz argues that the challenge of high volume, low cost production of precision optics can effectively be met only with full automation, and with a parallel production system to replicate all units from one initial master, at high speed and high optical quality. "This automated high volume production system does not fall out of the sky," he notes. "Even companies that wanted to do it in house are needing partners." Then to eliminate shipping costs, the optics production lines will have to be located close to the final assembly of the modules, which currently realistically means plants in the southwestern US.

Concentrator Optics makes Fresnel lenses in both acrylic and silicone on glass, and Leutz argues that the differences are actually relatively minor. "Concerns over PMMA yellowing or cracking are issues of the past," he asserts. Only PMMA has been under the sun for 20 years, but accelerated test results on both materials look good. Major PMMA supplier Evonik and Concentrator Optics now offer a 20-year performance warranty for lenses made of their UV-enhanced material, developed specifically for solar to let in more



Rod lens (Courtesy of Isuzu Glass)

light and be more stable under extreme temperatures. Processing that heats the material thoroughly before embossing to avoid introducing stress also helps to avoid cracking or corrosion later in the field. SOG meanwhile remains slightly more expensive because of the material costs.

AZUR SPACE: Clear roadmap to 45% cell efficiency

AZUR SPACE also joined the project with Concentrator Optics and Isuzu Glass to try to help push the HCPV market along to more serious volumes, designing the receivers for the systems. "The most important thing is that HCPV needs to start deploying tens of megawatt projects," says Gerhard Strobl, director of business development, AZUR SPACE Solar Power. "It needs volume to decrease costs—though it also needs to decrease costs to get to volume."

Efficiency of the multivolume cells is key to the efficiency—and ultimately the cost—of the HCPV systems, and luckily also perhaps the part of the system with the clearest roadmap for significant improvement. AZUR says it is currently shipping 40% efficient cells, aims at 42% in two years by moving from lattice matched to metamorphic cells, and then to four junctions for 45% efficiency in 4-5 years. In the long run 50% cells will be possible, says Strobl.

AZUR has sufficient capacity to make the terrestrial cells on its existing lines for space applications, and steady demand for additional volumes that allowed the lines to run steadily at higher output would be key to maintaining tight process control and reducing costs. Based on optics from Concentrator Optics and Isuzu Glass, AZUR is able to deliver essentially off-the-shelf receivers for Fresnel systems and dense array receivers for mirror systems.

"One gigawatt of HCPV means four square kilometers of lenses and 160 million secondaries and cells," notes Leutz. "This is a challenge the supply chain is prepared for."

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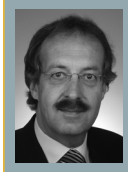
"Then to eliminate shipping costs, the optics production lines will have to be located close to the final assembly of the modules," added Leutz.

Dr. Ralf Leutz, co-founder, CTO and CEO, Concentrator Optics
He is also author of the book Nonimaging Fresnel Lenses: Design and Performance of Solar Concentrators (Springer, 2001). He earned his PhD from Tokyo University of Agriculture and Technology.

Mehmet Sinan Ata, Sales Manager, Isuzu Glass Deutschland
Dedicated to the company's optical glass, lenses and color filters across the optoelectric, medical and photovoltaic industries. Previously he did overseas procurement for DMW Corp. in Japan. He has a masters degree from Rheinische Friedrich-Wilhelms-University in Bonn, Germany.



Dr. Gerhard Strobl, Director Business Development, AZUR SPACE Solar Power GmbH
Dr. Gerhard Strobl is now with AZUR SPACE (or its predecessor companies) since 25 years. For many years he was responsible for the space silicon solar cell development and later for the GaAs triple junction development within AZUR. Under his responsability AZUR introduced in 2003 the first fully European space triple cell with 25% efficiency (AM0, 25°C), in the last years he and his team improved the technology and the cells to 30% for space (AM0, 25°C) and 40% for CPV (500x AM1.5d, 25°C).
Since 2007 as director business development, he is not only responsible for all R&D topics, but also for bringing new products such as CPV cells and receivers to customers and to the market.