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Emcore's Danzilio basks in the sunshine

Emcore has been winning multimillion dollar contracts for its terrestrial solar cells, modules and systems. Photovoltaics vice-president David Danzilio tells Richard Stevenson about the reasons behind this success and the advances that the company is making in its products for space applications.

You have recently netted some very large terrestrial concentrator photovoltaic (CPV) contracts. Was 2007 the year that CPV took off?
I'd characterize 2007 as the leading edge of CPV being a viable, commercial technology. [This technology has] had a couple of few-hundred kilowatt deployments and a 2.1 MW deployment in Spain by the Institute for Photovoltaic Concentration Systems (ISFOC), but we haven't seen the 10 MW projects getting deployed. It's going to be 2008 that CPV really begins to deploy.


David Danzilio

Which are Emcore's key contracts?
Our largest customer on the terrestrial side is Green and Gold Energy of Australia. We currently have more than 100 MW in backlog. We are producing today and shipping against that order, which is scheduled to be fulfilled in 2008.

We have other activities on the system side. Our investment in World Water and Solar has resulted in a supply agreement for up to 100 MW of system design and system-level products over the next few years. They are bidding for projects using the Emcore CPV system, but that's not the only thing that they are using. Depending on the geographical location of a particular installation, flat-plate silicon may actually be a better solution. Where CPV is preferable, World Water and Solar is bidding [with our technology].

We have put in a bid for 400 kW of CPV installation at the Castilla la Mancha location in Spain. That's the ISFOC project, which is a test-bed for CPV. It provides the first reasonable-sized installations for many new designs to get on-sun heritage. It was a wonderful concept by ISFOC and the Spanish government to fund this activity, because one of the biggest barriers to the development of CPV is acceptance of the technology.

David Danzilio CV

What has driven your recent terrestrial success?
We have actually won significant contracts in our space business as well. It's the result of a lot of investment over the last couple of years in technology, manufacturing and the business.

On top of that, the market is increasing in both space and terrestrial, and Emcore has positioned itself very well to be the preferred supplier. When somebody looks at placing a 100□MW product order for terrestrial, they have to make the assessment: can we fulfill that order? When they come, our terrestrial customers see that we do have the capacity. Look at our investment roadmap, look at our technology roadmap and it becomes clear that we are positioning ourselves to be the dominant supplier.

On the space side we've made a lot of investment in manufacturing. In space, the most important factors are reliability, reliability and reliability. Our solar cells perform and we have pushed the technology forward, but ultimately what our customers buy is a low-risk, highly reliable product, whether it be a solar cell or a solar panel. We've also made a lot of investment in advanced process control techniques for all of our manufacturing processes. These sorts of investment resonate very well with our space customers, because the key to high-reliability products is highly controlled, well characterized manufacturing.

Solar cell business

Emcore also makes fiber-optic components. How much of the company's business is solar?
In 2007, solar is going to be more than 35% of Emcore's revenue. Right now, 90% of this is derived from space activities. The balance is terrestrial and it's hard to say what the split is between cells and modules. We don't have any system revenues so far.

In 2008, I expect that the revenue split will be equal for space versus terrestrial, but in five years time – pure speculation – I see a growing market in space plus terrestrial. Clearly terrestrial is the bigger market by a factor of 300 to 500, so in five years we could be 75% terrestrial, 25% space. But it all depends on how successful CPV is and how successful we are in winning that CPV business.

Applied Materials says that CPV will only find a handful of niche locations where it can be economical, but others, such as SolFocus, say that CPV could ultimately

produce one-third of all PV energy. What is Emcore's estimate?
I tend to be more on the SolFocus side. I believe that the majority of electricity that is generated by renewable means is going to be generated in large utility-scale installations. That's the market segment that Emcore is addressing. Maybe 30% of the market is aggressive, but I estimate CPVs to be 15–20% of the total market. That is more than a niche.

Applied Materials' products provide turn-key manufacturing lines for silicon. This is silicon for rooftops. Although that's a big market, it's not going to be generating electricity on the scale of a multiple number of 10–100 MW utility-scale installations.

Applied Materials is focusing on silicon cells and is obviously a very influential company within the semiconductor business. Is it a complementary or a competitive technology?
I see it as complementary. I look at Applied Materials as enabling the flat-plate silicon market, which to a major degree is complementary, but to a minor degree competitive. So I don't see them as a threat and they are bringing a lot of good discipline and manufacturing expertise to the silicon PV market.

Skeptics say that CPV is unproven. Are there any potential show-stoppers?
I don't see any potential show-stoppers. The component that's going to be seeing the most stress and strain is the solar cell, followed by the optical components. On the solar cell side, we've designed these parts to operate well in excess of 1000× – that's the design of the tunnel junctions and the current-carrying components. There is enough design margin in there based on our experience with space and our understanding of the degradation mechanisms and we feel very confident that our solar cells will provide a useful life in excess of 20 years.

In fact, for a number of our systems customers where we are providing components, we have already agreed to a performance warranty on par with that of silicon. I feel quite confident and comfortable that the solar cell will be reliable for the life of the system. Once you get beyond that there is still the stability of the lenses and plastics and then the motors and structures. There is still a lot to be learned about the long-term stability of the optical components, the lenses and the secondary optics, but I don't see any reliability issues with electric motors – they just need to be maintained.

What is your view of copper indium gallium diselenide (CIGS) technology?
CIGS is interesting. It has the potential to have a very low manufacturing cost and it is going to find application in areas where available land is plentiful and has a moderate solar resource. The low efficiency requires you to have fairly large-area installations, which drives up installation costs, but it has the potential to see broad deployment.

You've invested quite a bit in equipment recently. What is your capacity?
That depends on what type of capacity you are talking about. The way I do my calculations is to work out how much capital asset is applied to terrestrial and apply an appropriate concentration factor.

Using a 1000× concentration factor, in 2008 we will have in excess of 200 MW of terrestrial production capacity, while simultaneously supporting about 200 kW of

production capacity for space. But depending on the business levels for space, I can choose to allocate some of that capacity to terrestrial.

Another way to look at it is wafer throughput. We currently have the capacity to produce 300,000 [4□inch] wafers per year and we're running at about 70% capacity. We are expanding and I expect to be at around 400,000 wafers per year by late 2008.

Do III-V chip costs dominate the $/W equation?
No. That's the unique characteristic of CPV – the solar cell is a very small proportion of the overall system cost. For a typical silicon flat-plate module, 75% of the cost is the solar cells. But for CPV, because you use concentration, you're using much less of what is a more expensive solar cell. In the order from Green and Gold Energy the solar cell costs $0.23/W.

Many of the systems developers are targeting an overall installed system cost in the $3/W range, which gets you under the threshold of $0.1/kWhr. If you use $3/W as a target – and no-one has got there – $0.23/W is less than 10% of the cost of the system. I've been telling my customers that I've got there and I've got there very, very fast, because I have a unique design that uses a high concentration and takes very good advantage of the power available on the wafer.

Is your triple-junction solar-cell technology completely optimized?
No, there's room for improvement. For space, our flagship technology is a 28.5% efficient solar cell. We have a 30% cell that is going to be released in late 2007 or early 2008 that will probably be the last embodiment of the typical Ge/GaAs/InGaP triple junction.

The next architecture is going to be the inverted metamorphic (IMM), which has demonstrated 31.9% efficiency under space conditions. The target is 33% and the cell should be available in the 2009/2010 timeframe in commercial quantities. In parallel we are working on four-junction IMM, targeting an efficiency of 35% under space conditions.

One of the highly desirable, unique aspects of multi-junction technology is that you have many more degrees of freedom in terms of materials, bandgap engineering and all aspects of materials science. That is a tremendous advantage over silicon, which has hit its limit. There are a couple of tricks that you can do to get the efficiency higher by putting the contacts on the back, but there is a fundamental limit.

How long will the standard triple-junction cell be the leading product?
Well into the next decade. In space, demonstrated reliability is much more important than technical innovation, and our space products have a fairly long life cycle, such as 5–6 years. I believe that our 28.5% cell deployed last year will be selling well into the next decade. The 30% cell that will be deployed late this year, or early next year, will be shipped through 2012/2013 and the IMM being deployed in 2010 will probably enjoy a 5–7 year product life cycle.

In the terrestrial area, the adoption of technology is more rapid. The driver is efficiency, because efficiency drops directly to the bottom line in terms of the number of kilowatt

hours that a system can generate. The market is driving towards the low 40s by 2010 and I believe that we can get there with our next-generation triple-junction cell.

About the author

Richard Stevenson is features editor of *Compound Semiconductor* magazine.