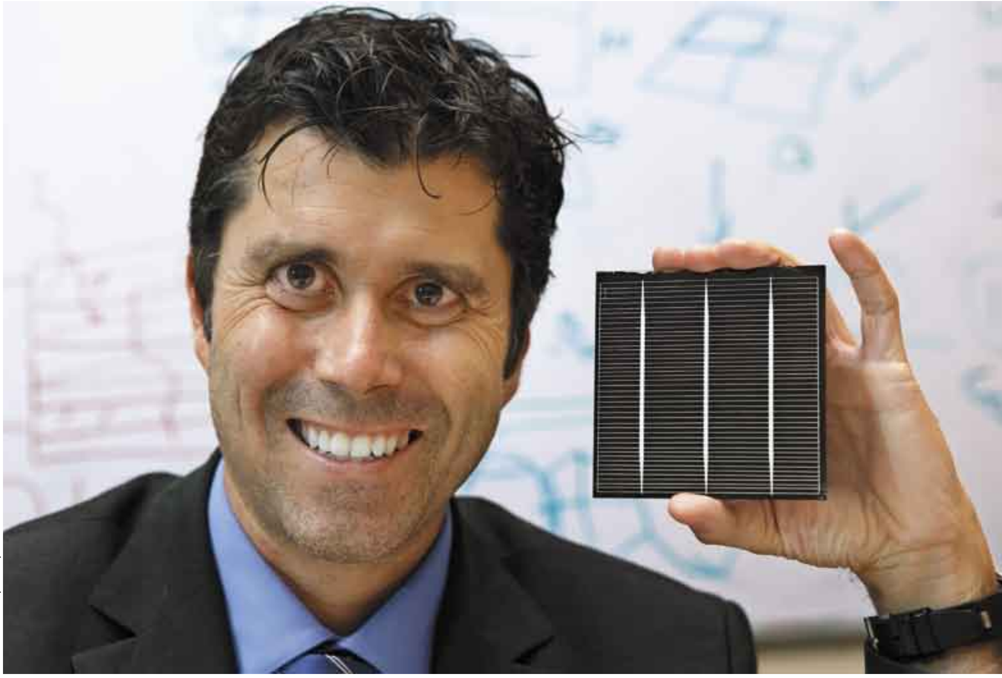
Not like the others

Consensus says it takes big money to scale a CIGS thin-film technology. AQT begs to differ.

You could say that Michael Bartholomeusz is walking with a bit of a swagger these days. He, his brother Brian and their VP of Technology, Mariana Munteanu, quit their day jobs in data storage a couple years back and started Applied Quantum Technology, Inc., a Santa Clara, California-based CIGS thin-film company. After 16 months of research and $4.75 million, they had a working prototype and a turnkey manufacturing line that should be up and running in just a few months. This time, they say, CIGS will be different.



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Silicon stand-in: CEO Michael Bartholomeusz shows off AQT's square CIGS cells, which can replace crystalline silicon cells in standard modules.

Not long ago, thin-films made with CIGS (a compound of copper, indium, gallium and selenium) seemed to be the next big thing in efficient PV technology. A couple of billion dollars later, it's begun to look as though their true efficiencies lie in burning through heaps of VC cash. When compared against older CIGS start-ups, with their hobbling growth trajectories, AQT seems like a Tesla Roadster speeding past money-guzzling Hummers. However, unlike the Roadster, AQT's production line is dirt-cheap, comparatively. The $20 million they hope to bring in through their Series B funding round should carry them through to mass production.

Echoes of the past

While the company's founders are visibly ecstatic about being close to commercialization – they're aiming for the end of the year – they're also strangely nonchalant about the path they've taken to get there. After all, their story doesn't sound much different from that of other CIGS start-ups that have been around much longer. So far, their method seems to just … work. Meanwhile, companies like Miasolé, Nanosolar, and Solyndra have soaked up hundreds of millions of dollars over several years with very little to show for it. And that says a lot about a company that was founded just at the onset of the thin-film start-up bust that's now beginning to shake out. Their position seems more precarious if we look back at what those other companies were doing in 2006.

Take Miasolé, a single-process CIGS sputtering company, that was making waves in the start-up world due to its low cost of capital and the knowledge its CEO and founder, David Pearce, who was brought over from the data storage industry. By that time, the company had developed 10 percent efficient cells on proprietary machinery for under $20 million, and was gathering funds for their first big scale-up. They were promising commercial shipments by 2007. Daystar Technologies, Inc. was also developing CIGS cells on glass substrates. A year later, Miasolé's mass-production lines were putting out seven percent efficient cells and they'd replaced their CEO.

They were in stealth mode again until late 2009. Daystar has yet to offer up a product.

Think before you act

But Bartholomeusz, for all his confidence, is humble about one thing. He says that the difference between AQT and the others is »leverage.« And as the clean-tech investment community has finally gotten savvy, dodging big capital investments in favor of incremental improvements to existing technologies, the AQT story reads a little bit like an »I told you so.« After all, there was plenty of money sloshing around three years ago when the founders of the company looked at the other CIGS start-ups and decided to take a different route. »If you build machines, you're an equipment manufacturer first,« Bartholomeusz says. Their idea was to skip that part.

The founders started out by strategizing. They wanted to take technology that was already available for making thin films and improve it, not overhaul it. Or as Bartholomeusz puts it, »There just simply isn't enough money and time in the world to green-field everything.« Once the company had decided to work with technology adapted from the hard disk and optical storage industries, they bought the research tool for sputtering that still sits in their headquarters, and set about what Bartholomeusz calls a »concerted and sensible« process for developing their deposition technique. They narrowed the multitude of possible reaction pathways – combinations of inputs and steps to turn starting materials into a CIGS cell – down to 80. Then they worked methodically through each, led by Munteanu. The goal of reaction pathway research is not only to produce the most efficient cell possible, but also to find a way to produce it fast. The cells are now 12 percent efficient in internal tests (NREL has confirmed 11.2 percent), and AQT says they should be up to 14 percent by the time they go commercial at the end of the year.

Bartholomeusz says their process is incredibly flexible, too. He refers to sputtering, the deposition process, as »micro-processing« because it allows not only for flexibility in materials, but also for great precision – since manufacturers can deposit materials in atomic layers. With some process optimization, Bartholomeusz thinks the company can use their existing machinery to modify the layers, or maybe even make tandem-junction cells. And they'll be looking at even higher efficiencies. They make it sound simple.

Harder than it looks

But if AQT does get to market as planned, it seems as though their success will have involved a lot of skill and no shortage of luck. »It's possible to make CIGS by sputtering, but no one's ever really succeeded in getting good quality material,« says Bill Shafarman, a scientist specializing in CIGS at the University of Delaware Institute of Energy Conversion. CIGS sputtering can occur in two different ways. Manufacturers can either sputter their raw metals in separate layers on the substrate, then use another process to chemically transform them into a CIGS compound, or they can apply the CIGS already in compound form. The process for turning the raw metals into a CIGS compound on the cell surface is tricky, Shafarman says, and the companies that have been most successful at this make their cells in a two-step process, putting them in a separate furnace to create the compound. On the other hand, if a manufacturer wants to apply the CIGS in compound form through sputtering, it is very difficult to keep the unstable material from deteriorating during the manufacturing process – before it ever gets deposited on the substrate.

But the founders are confident about their process, emphasizing that the key to their technology is as much someone else's development as it is their own. Intevac, Inc., the company providing AQT with its turnkey manufacturing platform, has been making equipment for the computer industry since 1991. The Lean Solar machine is an adaptation of an already-existing hard disk manufacturing platform – and Intevac owns the rights. It looks like a server rack and comes in modules of four vacuum deposition chambers, which, depending on the layers, can process up to 1000 substrates in an hour (though they grant that, given the thickness of the PV layers, it will likely be slower). The modular format means that the machine can be expanded, either for faster throughput or to add complexity to the series of layers. AQT's machine currently consists of five of these modules. Each of the 20 total chambers can carry a different material for a different sputtering layer.

Terry Bluck, the VP of new product engineering at Intevac, who is developing Lean Solar to be ready for AQT in April, doesn't consider the equipment to be significantly different from any of the other deposition equipment that the company makes – except that this is the first equipment they've made to work with 125 mm square substrates. Square grips had to be engineered for the mechanical arms that carry the substrates through the machine. The standard substrate for the optical and hard disk industries is about the same size as a silicon solar cell, but round.

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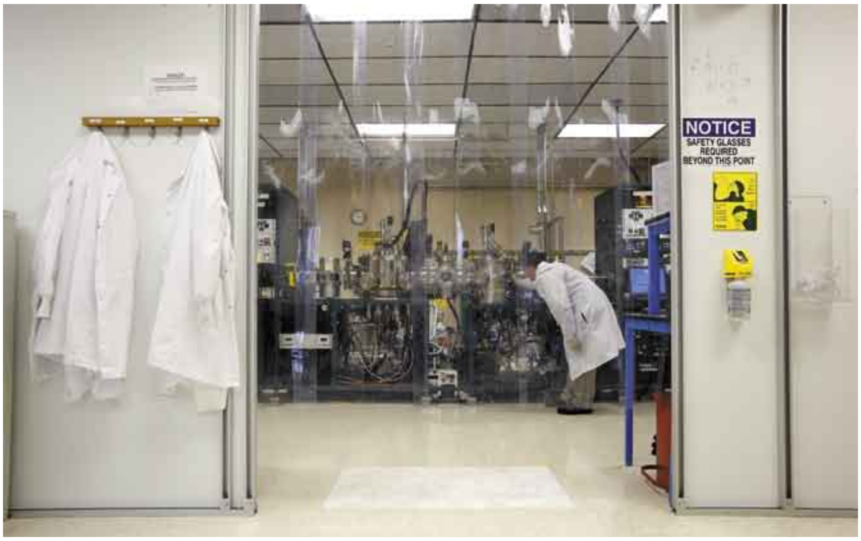

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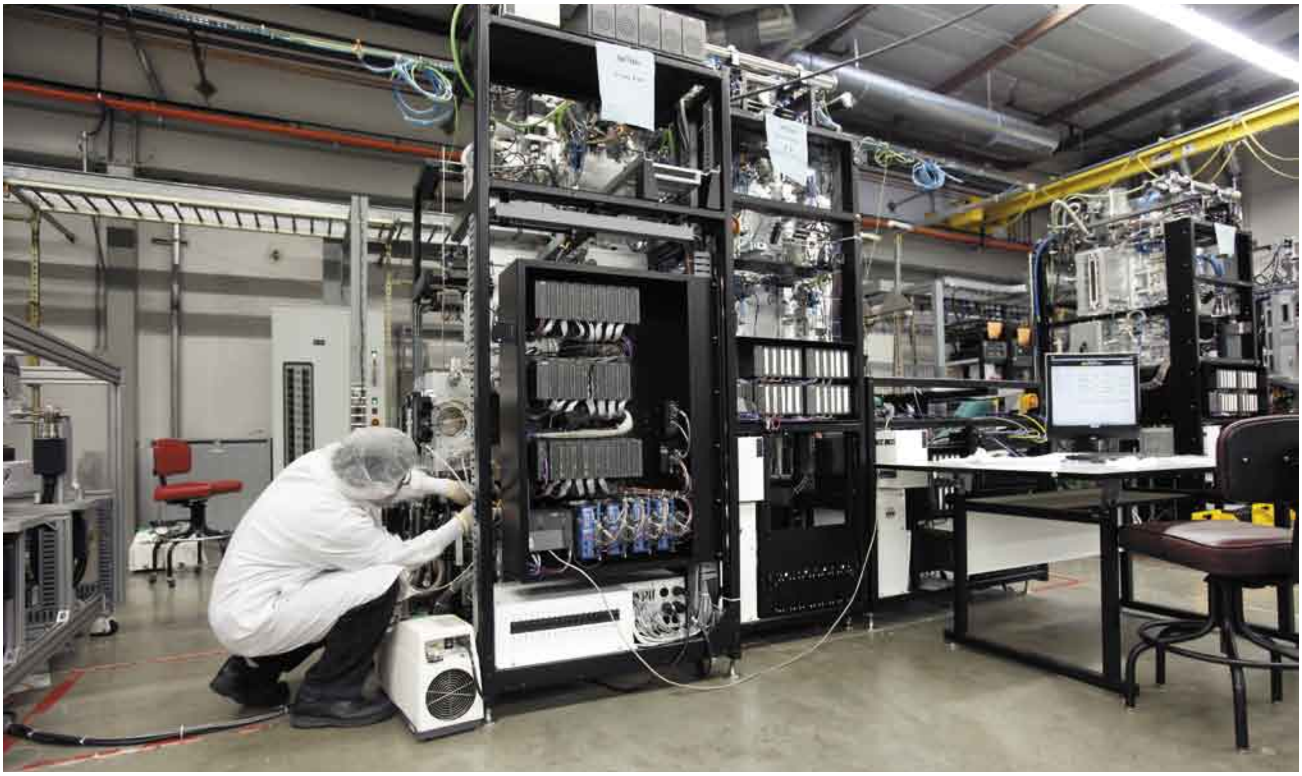
Work in progress: The research tool AQT uses to develop their cells has two sputter deposition chambers. Their new turnkey line will have 20.

Do one thing well

Shafarman says one thing that may make scaling easier for AQT is the fact that most other CIGS start-ups, like Miasolé, have hoped to take their cell technology and translate it to large, flexible metal foils. AQT's only goal is to optimize their cells. And that may be the key to the AQT business model – they're making their product with features like those of a silicon wafer, to allow it to work with existing module assembly machinery. This way, they only need equipment for one step in the process. And module manufacturers who buy silicon cells from any standard mono- or polycrystalline cell manufacturer can just as easily drop the AQT cell into their process. The comparative thickness of AQT's glass substrates, 1.6 mm, hasn't been a problem, they say.

But while the size of the cells in the AQT process may be an advantage for compatibility, it could also be a disadvantage. Part of the cost proposition of thin-films has to do with the ability to deposit materials on entire modules at once, which saves money on module



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Putting the pieces together: The Lean Solar platform from Intevac comes as a set of several modular pieces, which are currently in assembly.

assembly compared to manufacturing with silicon cells. In this way, it's not so much a question of novel technology, but rather of whether the business model will allow these CIGS cells to compete with silicon cells that are 20 percent efficient or more. Bartholomeusz, of course, thinks that it will. He says their capital expenditure out of the gate should be about \$0.70 per W, and in the not-so-distant future they can halve that, bringing module production costs down to less than \$0.50 per W. For the first 12 to 18 months of production, cells from their first 15 MW line are already spoken for. AQT won't say who the company's partners are (the announcements should be coming out within a few months), but Bartholomeusz says two of the four companies that have successfully made modules with AQT cells are »first-tier« module manufacturers. He describes another – a start-up – as a »game changer.«

Refining the formula: AQT's VP of Technology Mariana Munteanu (center) leads the company's research efforts.

Like the company's cofounders, Bartholomeusz has experience with the type of machine they are now adapting to solar. He seems at a loss to say why other companies haven't succeeded in doing the same thing. Or why this particular technology has become notorious for burning through cash. »I don't think that's inherent to CIGS,« Bartholomeusz says. That said, Shafarman adds that the distance to greater efficiency, or from a single-junction cell to a tandem-junction cell, can be a lot further than most start-ups estimate. However, if Bartholomeusz is right, plenty of very well-funded CIGS ventures will have much to envy in a few months. If he's wrong, at least he will have a lot less to explain to angry investors.

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