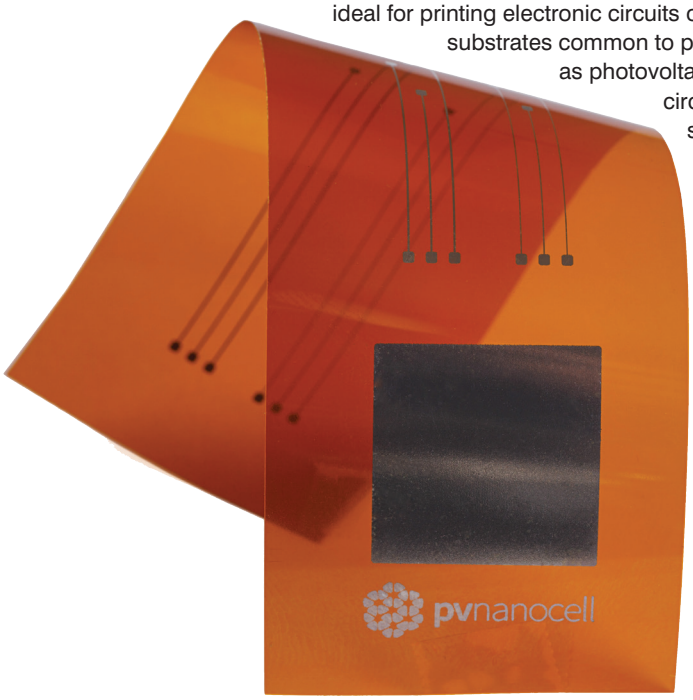
A new approach to practical inkjet printed electronics

Inkjet printed circuits have long sought a place in high volume manufacturing (HVM), but achieving low cost, fast throughput has proved elusive. PV Nano Cell offers a solution through its unique inks that have printer and IC manufacturers taking note.

PRINTED CIRCUITS are not printed the same way that ink on paper makes a magazine page. But what if printing circuits was simplified? The potential is great. Ink maker PV Nano Cell believes it has a novel, paradigm-changing solution, setting the stage for printed electronics growth.

PV Nano Cell founder and CEO Fernando de la Vega (PhD) faced a challenge. He saw his company's nano particle-based 'Sicrys' family of conductive inks as ideal for printing electronic circuits on the varied substrates common to products such as photovoltaic (PV) cells, circuit boards, sensors, smart cards, antennas, and touchscreens. But the industry has long been wary of inkjet printing in high volume. Traditional inks were expensive, had short shelf lives, and printer technology wasn't as adaptive to HVM as was silk screening or stencil printed circuits. He could wait for industry to evolve, or, he could become a catalyst for change; not the sort to sit and wait, de la Vega became a catalyst.



"Inkjet (printing) is a digital additive process which is and should be the way the industry wants to go. I believe the main obstacles to implementing this technology in mass production were first that the inks were prohibitively expensive and second, no mass production tools were available. A 'chicken and egg' situation, so if we could provide inks with quality and price to support mass production applications, we would be able to change this situation … We have done that, and in this approach we don't have many competitors," he remarked.

PV Nano Cell was founded in 2009 in Migdal Ha'emek, Israel, and has steadily grown its portfolio of conductive inks. Starting with silver-based formulations, the company expanded its portfolio while seeking manufacturing partners. The company added copper-based inks most recently, which offer added resistance to oxidization and a substantially improved cost profile compared to silver-based products.

In 2015 the company product line grew with its newest ink designed for enhanced durability in humid environments. This ink led to PV Nano Cell

being chosen for an IDTechEx Award as "Best Development in Materials for 3D Printing" and later as one of the Global Cleantech "100 Ones to Watch." The company also entered into a manufacturing agreement with a major printed circuit board (PCB) manufacturer in 2015 using single nanoparticle ink technology for their operations in the US and Asia.

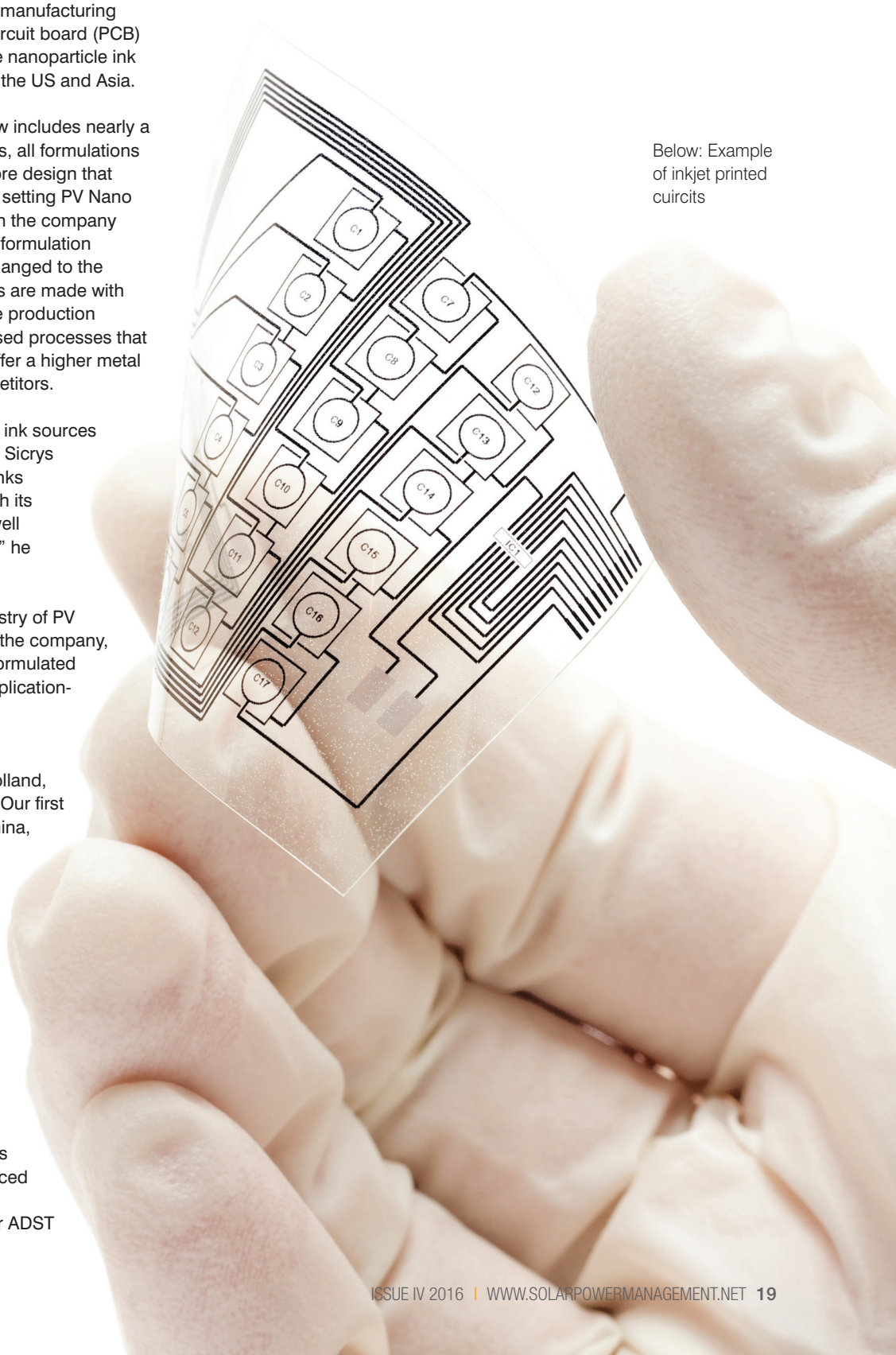
While the company's portfolio now includes nearly a dozen standard nano ink products, all formulations are based on the single crystal core design that de la Vega considers a key factor setting PV Nano Cell apart from competitors. When the company first began, it had a different core formulation which de le Vega and his team changed to the single crystal approach. Their inks are made with a viscosity tailored to high volume production requirements. They use water-based processes that employ no toxic chemicals and offer a higher metal concentration compared to competitors.

"There are quite a few nano silver ink sources in the market. We believe that our Sicrys family of nano metal conductive inks differentiates itself from others with its properties and performance, as well as stability and robust printability," he remarked.

Although much of the core chemistry of PV Nano Cell inks was originated by the company, de la Vega said some inks were formulated by partners, typically to create application-specific solutions.

"We are working with major inkjet producers in Europe including Holland, Italy and France, and in the USA. Our first main customers are located in China, Europe and the US … Mostly, the process we follow now is that the equipment producer develops the tool to meet the application and the customers' needs. We develop the ink to meet printer and applications specifications. This willingness to meet requirements is needed to be able to provide a 'complete solution' to our customers," he said.

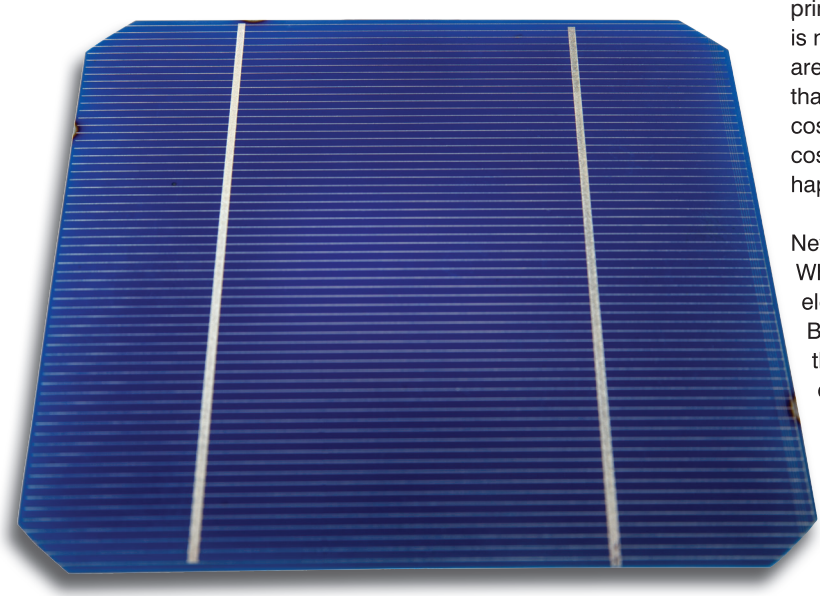
The appeal of PV Nano Cell inks is spreading. The company announced in April 2016 that it had signed an agreement with Korean distributor ADST



Below: Example of inkjet printed cuircits

as part of a move deeper into Asia. This expansion followed similar announcements in 2015 that focused on the company's business in the US and Europe, pointing to greater uptake of printed electronics by mass production companies serving global markets.

While 3D and so-called 2.5D (irregular surface) printing of electronic circuits saw a start with PV cells and smartphone antennas, adoption is spreading to other applications. Nanometric inks can be used on flexible substrates such as plastics, fabrics and even paper. The company's newest ink designed for applications in wet environments opens additional markets for sensors, antennas and touchscreens, while the resolution afforded by high definition inkjet printing means that line width can be decreased in some applications, which reduces the cost impacts of silver-based formulations. Manufacturers have sought the greater flexibility that printing circuits can provide compared to traditional manufacturing techniques that involve more complex tooling and more costly machinery. Printed electronics can reduce assembly and materials costs while shrinking the supply chain and enabling faster industrial throughout and quicker time to market. While de la Vega did not dwell on the market development time he and others in the company invested, the results and expansion into a wider range of manufacturers has undoubtedly changed the minds of some who thought the high volume manufacturing and digital inkjet printing were incompatible.



"The market was previously (accustomed) to the old processes. It takes a while to prove new technology and because the printers themselves are expensive; all this takes a while. We have focused on customers willing to work with new technology, to bring them the benefits from the start, and that has worked for us. I see the long-term future as good, but I am a bit biased. We are seeing huge projects in China, the US and elsewhere," he remarked.

When asked if there was any misconception about his company or inkjet technology, de la Vega said the biggest disconnect that he encounters comes from manufacturers who still do not consider inkjet printed electronics as the wave of the future.

"There is one big misconception: the idea that (inkjet printed circuits) are not for mass production; that it is not economical. We are disproving all that, and we are working with many printer companies to show that. We are proving that it can work and that our costs are much less than in the past. Yes, production costs still need to be brought down, but this will happen. Inkjet is working," he said.

New ideas often take time to establish themselves. Whether inkjet printing becomes a mainstay of electronics production is still an evolving subject. But companies such as PV Nano Cell are showing that sometimes it doesn't matter whether the chicken or the egg comes first, what matters is a determination to change paradigms and in so doing, create a market that did not exist a decade ago.