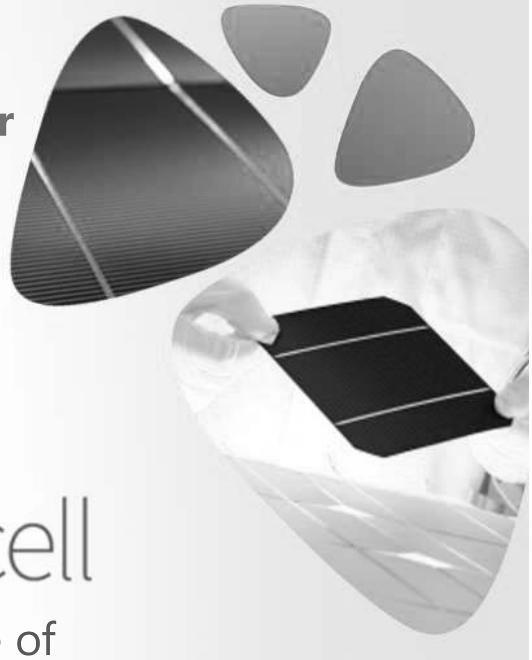
Sicrys™ inks family platform is the mass production solution for Digital Conductive Electronics



Changing the game of
Digital Conductive Printed Electronics

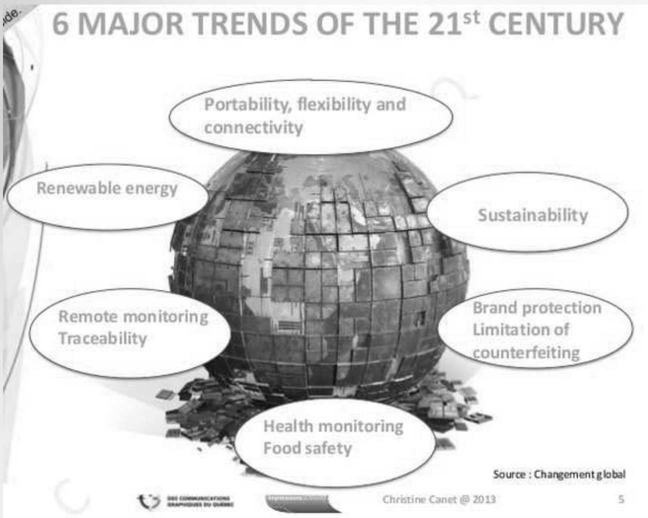
How Electronic Devices are Produced through Sicrys™ Inks

Dr. Fernando de la Vega

SMTA/ILTAM Association July 2nd 2017 Herzliya

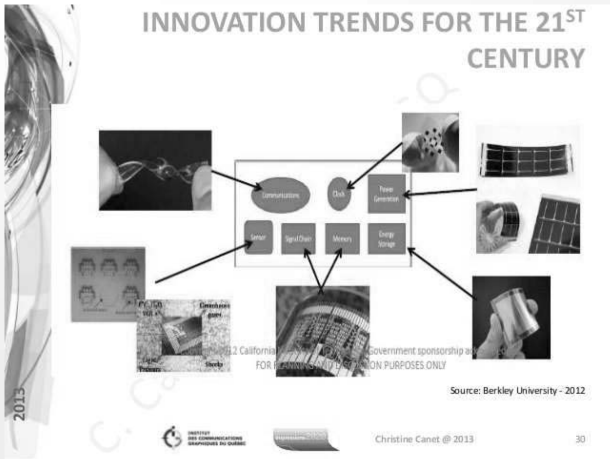
Safe Harbor

This presentation contains forward-looking statements. All statements other than statements of historical fact contained in this presentation are forward-looking statements. In some cases, you can identify forward-looking statements by words such as “believe,” “continue,” “estimate,” “anticipate”, “expect,” “intend,” “plan,” “potential,” “project,” “seek,” “will,” as well as the negative of these words or other comparable terminology. These forward- looking statements include, but are not limited to, statements about: the potential market opportunities for commercializing our current and planned products; our expectations regarding the potential market size for our current and planned products; estimates of our expenses, future revenue, capital requirements, and our needs for additional financing; our ability to develop and advance our current and planned products; the implementation of our business model and strategic plans for our business and products; our ability to maintain and establish collaborations or obtain additional funding; our financial performance; and developments and projections relating to our competitors and our industry. These statements reflect our current views with respect to future events or to our future financial performance and involve known and unknown risks, uncertainties, and other factors that may cause our actual results, performance, or achievements to be materially different from any future results, performance, or achievements expressed or implied by these forward-looking statements. Factors that may cause actual results to differ materially from current expectations include, among other things, those listed under “Risk Factors” in the Registration Statement on form F-1 (Registration No.: 333-206723) filed with the U.S. Securities and Exchange Commission on September 22nd, 2015 by the Company. Given these uncertainties, you should not place undue reliance on these forward-looking statements. Except as required by law, we assume no obligation to update or revise these forward-looking statements for any reason, even if new information becomes available in the future.



PVN Sicrys™ inks platform address 21st century:

1) Supporting portability, flexibility and connectivity trends.
2) Improving Cleantech technologies performance.
3) Developing and implementing sustainable products and processes.
4) Supporting many of the innovation trends in electronics.



[196]

Additive Digital Manufacturing - Impact

- **My personal experience with electronics!**

My NEXT mobile!

Will be a reality with PVN Sicrys™ inks enabled Digital Printed Processes

Electronics Main Production Processes
All Analog Processes

- Etching (photolithography)
  - PCB
- Screen printing
  - Conductors touch screens
- LDS
  - Antennas

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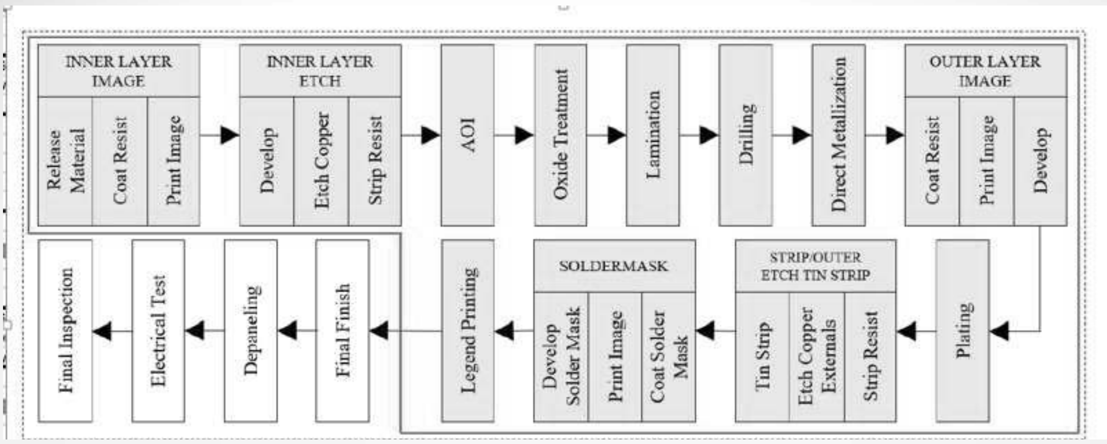
Analog Etching (photolithography)
PCB Technology



•**Photolithography** is the standard method of PCB and in electronic devices fabrication:

- Multi step process.
- Most of the materials are overall etched or striped and thrown away creating large quantities of hazardous wastes.
- Expensive capex and process.
- Long set up's.
- Limited performance (flexible, thin, 2.5D & 3D…).

Space needed

150 -250 m^2

Source: Tech-On

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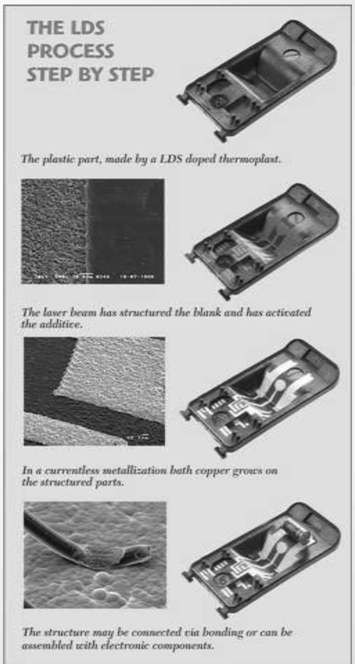
Screen Printing
Mature Screen Printing metallization

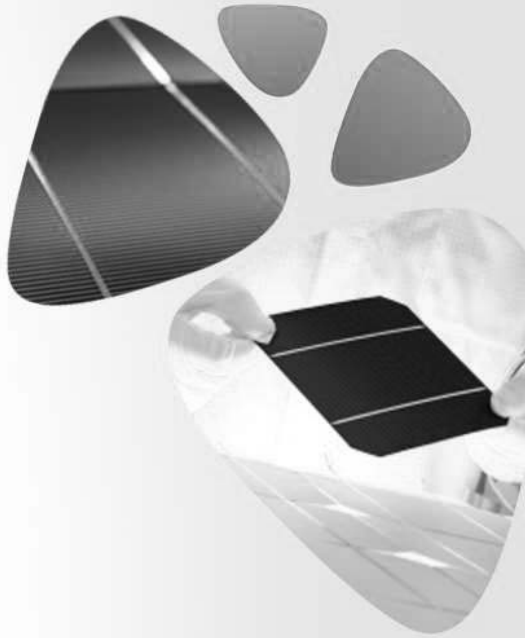
- Contact printing – limits use of brittle substrates, breakage.
- High costs – low ink yield, high maintenance costs (screens, cleaning..).
- Limited properties– wide patterns, lower electrical properties (high sintering temperatures).
- Printing accuracy changes versus time (screens become floppy, need to be replaced every shift).
- Difficult to achieve high accuracy aligning.

LDS
Manufacturing of antennas

- Process
    - Plastic with metal precursor (expensive ~ x 5 regular plastic).
    - Single-component injection molding.
    - Selective laser activation of the precursor.
    - Plating metal (on the activated area), wet chemistry.
    - Wash and dry the antennas.

- The LDS process is patented by LPKF Laser & Electronics AG- Exclusive material supply.

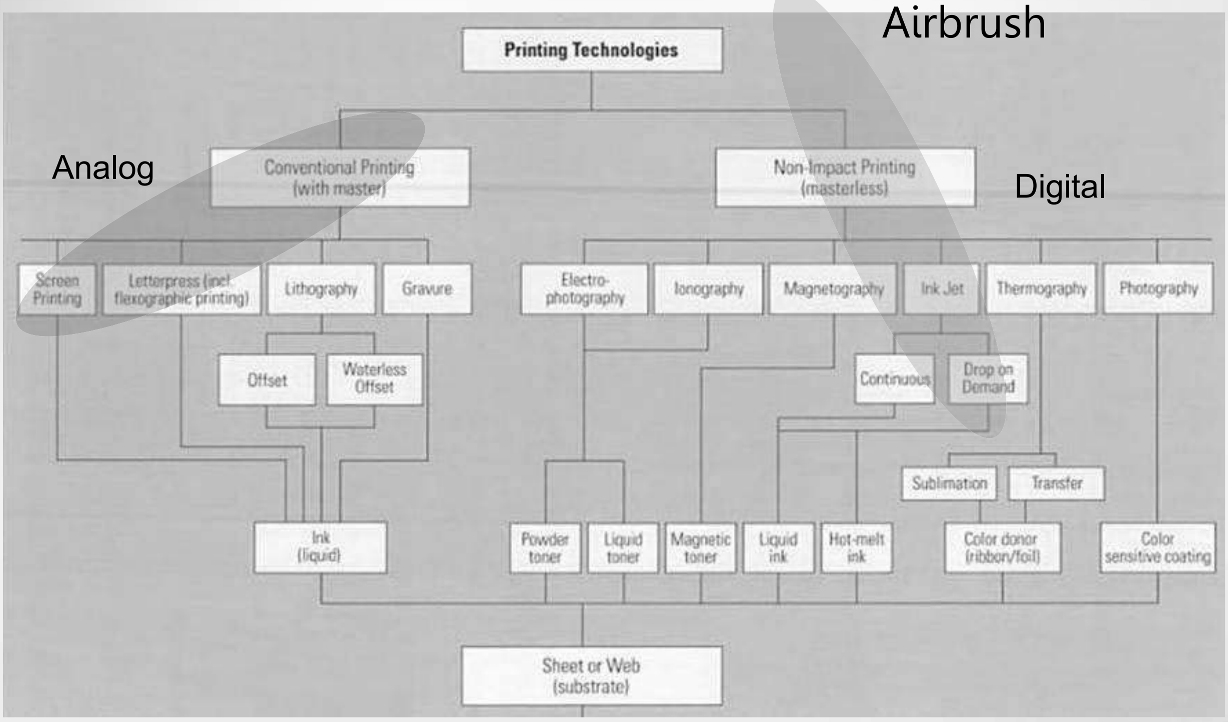




Printing

Printing Technologies

Digital:
Inkjet
Airbrush



Printing Technologies

Digital:

Inkjet
Airbrush

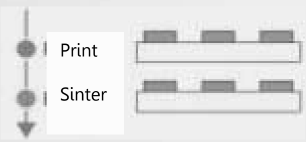
The graphic industry was revolutionized in the 80's by the implementation of **digital printing**.

Electronic devices production revolution by digital printing – **today**!

Changing the World with
Sicrys™ inks and digital inkjet 3D printing

Inkjet Sicrys™ Printing

Additive Manufacturing



Digital process
Non-contact
Low wastes
Allows for cost reduction

A cleaner technology.

Sicrys™ Inkjet Conductive Printing

Creating New technology routes

Narrow pattern printing

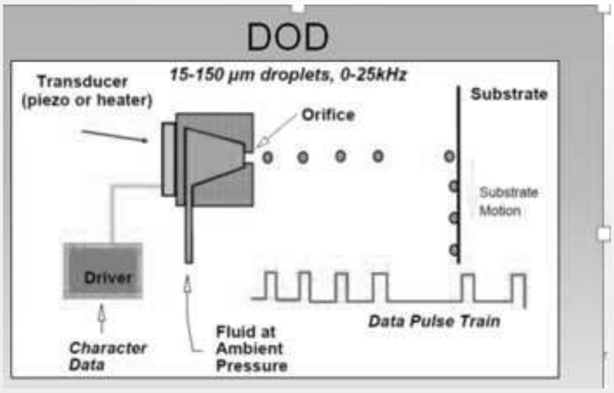
3D Printed Electronics

PVN's "complete solution" approach and Sicrys™ nano silver and copper inks are expected to be THE enablers for Digital Conductive 3D printing in mass production applications (quality, performance and costs).

Source: Tech-On

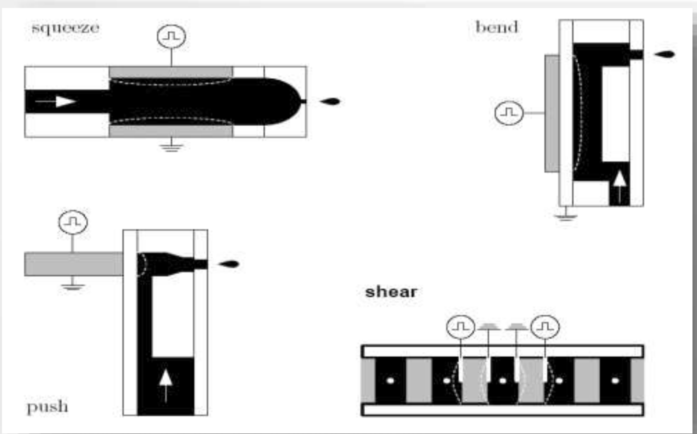
Sicrys™ Enabled Printing Process - Inkjet

- Inkjet printing – a system which delivers ink drops to form patterns.
- An ink reservoir with a nozzle is digitally activated to generate a drop.
- DOD – drop on demand, mostly Piezo induced actuation.



Sicrys™ Enabled Printing Process - Inkjet

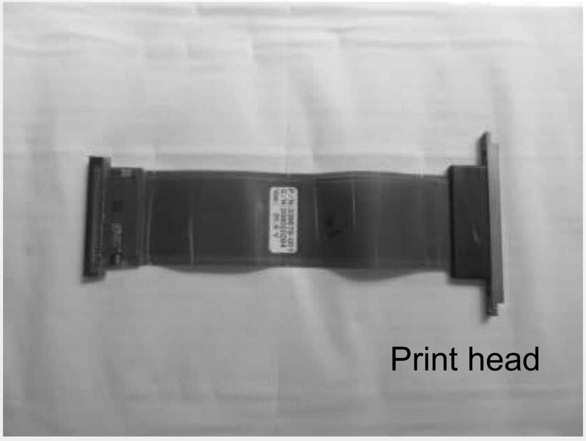
- The drops are jetted at high frequencies (many drops per time) – 1 – 50 kHz.
- Different head set-ups and systems available.

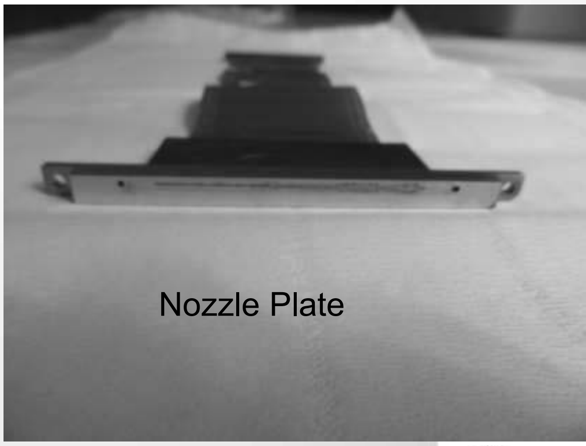


Sicrys™ Enabled Printing Process - Inkjet

Different print heads available:

- ❑ Drop size range: 1 – 84 pL
- ❑ Orifice size (diameter): ~ 20 – 30 µm
- ❑ Hundreds of nozzles per head

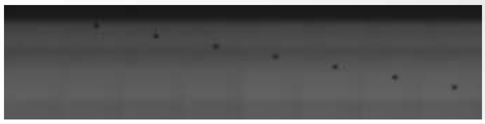




Printing Process

- Droplet generation – Droplet ejection

Strobe



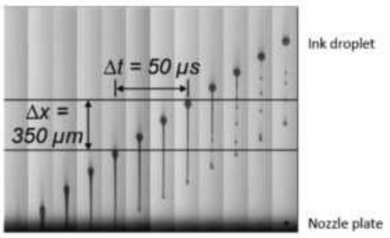
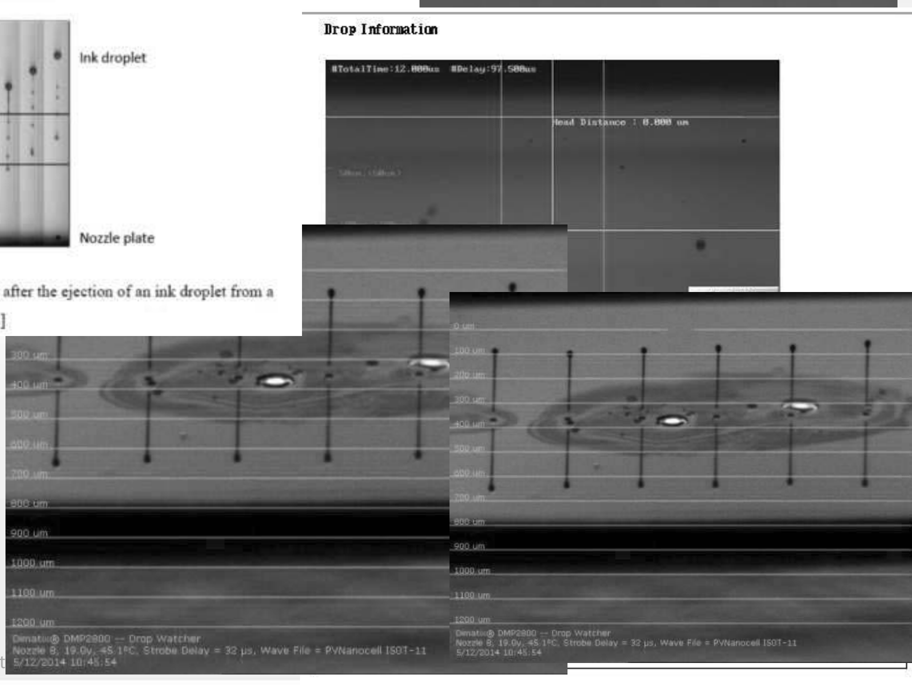


Fig. 3-9 Sequence of snapshots at different instants after the ejection of an ink droplet from a nozzle.[22]



Need to control:

- Drop size and shape
- No satellites, tailing..
- Speed
- Frequency
- Plate wetting
- Nozzles open

A New Era of Electronics

PV Nano Cell is leading the way into a new era of electronics:

smaller, thinner, lighter, flexible, customized, lower costs…

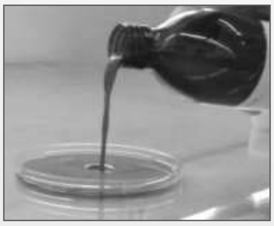
enabling **Additive Digital Printing Processes** in the

mass production manufacturing process of electronic devices

with its conductive **Sicrys™** inks.

The Next Revolution is Here!

Silver Ink



Printer

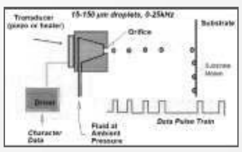
Cell Phone Antenna

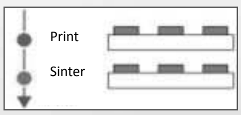
Manufacturing Electronic Devices
Digital Printing

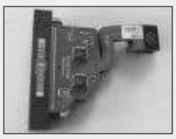
Emerging Production Methods – Additive Digital Mass Production

- **Inkjet printing** is a system which delivers ink drops to form patterns:
  - Drop-on-demand (DOD), Piezo induced actuation of ink from the nozzle.
- **Digital Inkjet 3D Printing**
  - Digital with short setup.
  - Non-contact.
  - One step process.
  - Low waste.
  - Flexible wide technology.
  - Multi layer.
  - Inks based on nano metals, therefore low sintering temperatures and narrow patterning possible.
  - Quick set up's
  - Low space requirements (50-60 mt^2).
  - Flexible and customized electronics.

DOD







Sicrys™ Enabled Printing Processes
Inkjet Systems

PiXDRO

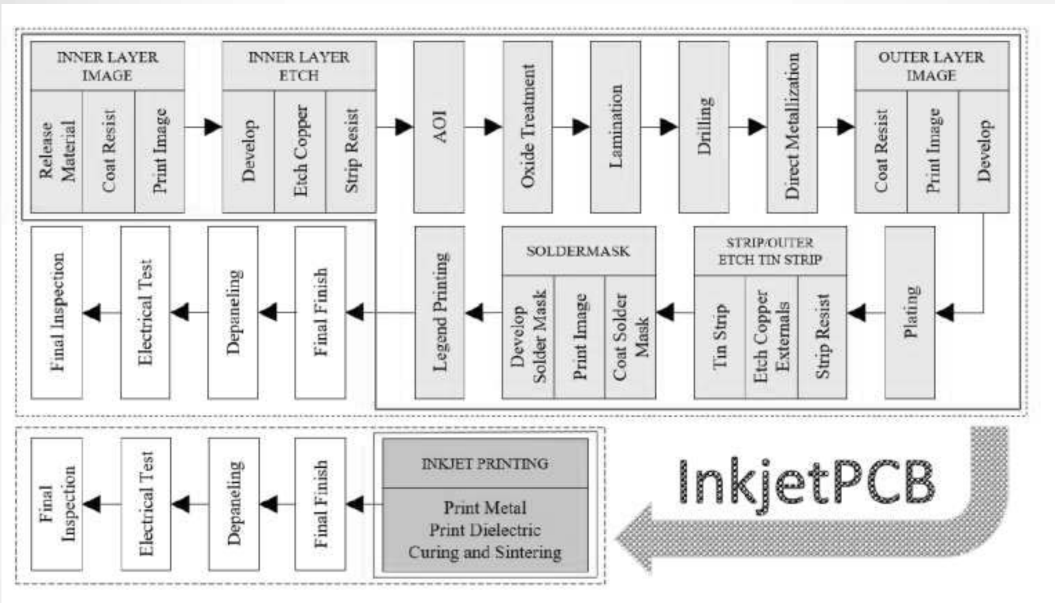
ROTH & RAU CELL & COATING SYSTEMS

orbotech Be Sure

UniJet

pvnanocell

Analog Etch –PCB technology



Multi steps replaced, less space, lower costs, cleaner, lower costs

pvnanocell

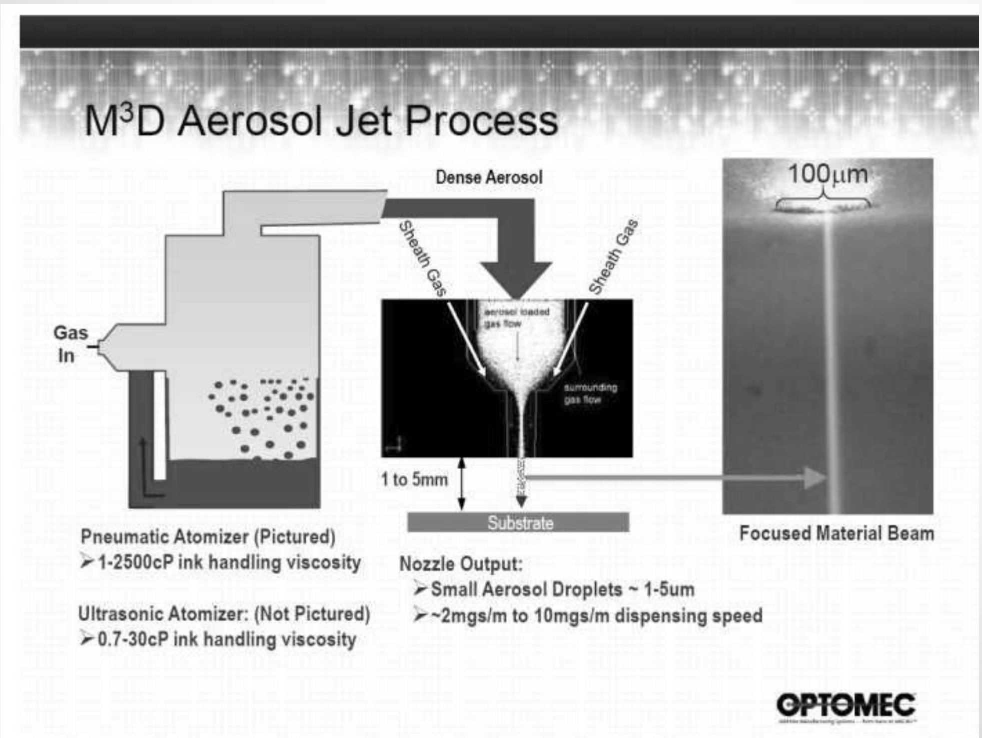
Source: Tech-On

Sicrys™ Enabled Printing Processes
Airbrush Systems M³D Optomec

- Airbrush system.
- Ink is atomized and transported to substrate by air flow.
- Specially designed nozzles allow accurate and narrow printing.
- Robust, easy to operate digital system.
- Fast set up.
- Quick product changing.
- 2.5D (non flat) and 3D printing.

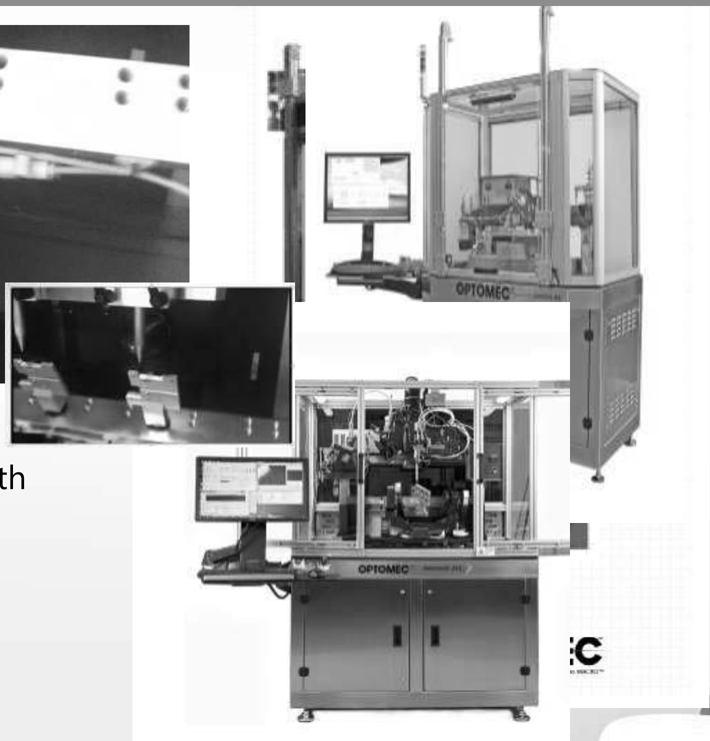
- System supported with Sicrys™ nano inks family allow to print on temperature sensitive substrates (polymers).

Sicrys™ Enabled Printing Processes
Airbrush Systems

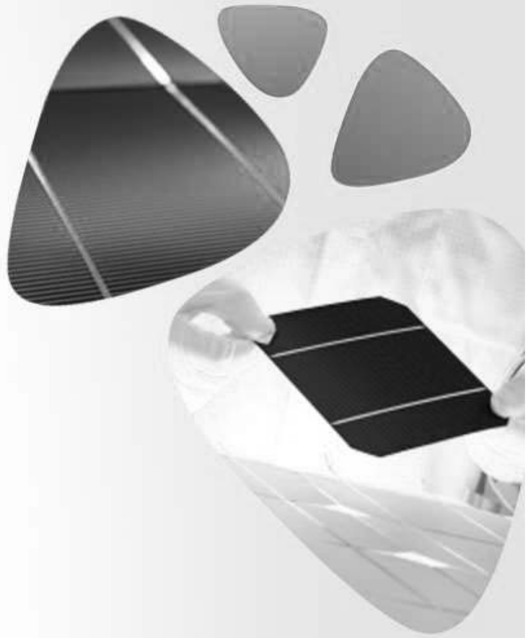


Sicrys™ Enabled Printing Process

Airbrush Systems



Above movie (activate link with mouse double click) shows antenna printing.
Mass production systems are multi nozzles.
Throughput ~ 1 min per antenna.

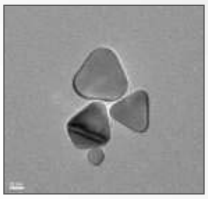


Sicrys™ Inks

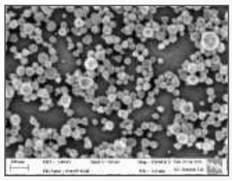
PVN's Solution: Sicrys™ Inks

- Sicrys™ a platform technology based on the **<u>new patented single crystal Nano metal particles dispersions and inks.</u>**
- 70 – 80 nm (D50) nano particles have been developed in silver and copper, which are formulated into inks.
- Utilizing **Sicrys™** inks digital conductive printing is possible in mass production:
  - Lower cost advantage.
  - Higher stability - shelf life.
  - Robust printing – BEST in the market[1].
  - High throughputs.
  - Silver and copper availability.
  - Enhanced properties (electrical, adhesion).

Copper Nano Particles



Silver Nano Particles



Sicrys™ ink

(1) FujiDimatix and M-Solv PVN Inks Evaluation Reports

Enhanced Inkjet Conductive Inks Portfolio

- **Silver Inks** – most common metal for conductive inks.
- **Copper Inks** – <u>unique</u> offering by PV Nano Cell:
  - Nano copper inks provide <u>substantial cost savings</u> without reduced performance.
  - Metal costs reduced to 1/80 – 1/100 in copper relative to silver based inks.

Silver Metal Price

16.8$/Oz

$539 kg
May 19th, 2016
http://www.lbma.org.uk/pricing-and-statistics

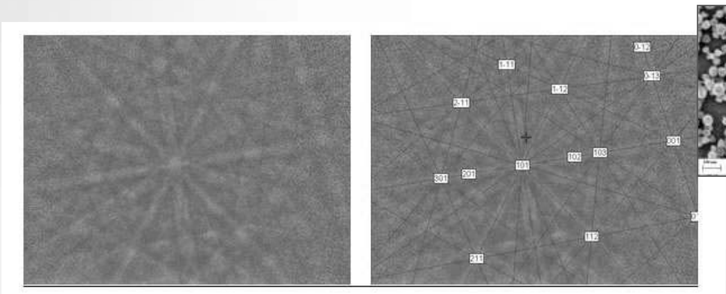
Copper Metal Price

0.19$/Oz

$5.6/kg
May 19th, 20172017
http://www.lme.com/en-gb/metals/non-ferrous/copper/

Sicrys™
Ag - a majority of Single crystals particles

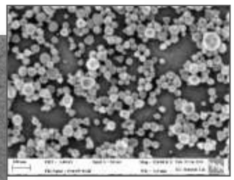
- SEM & EBSD (electron back scattered diffraction)

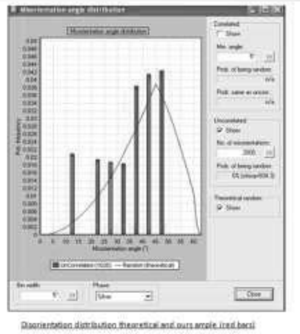


Diffraction pattern from our sample

The solution for the diffraction ("kikuchi lines")

Silver Nano Particles

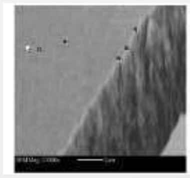




Each one of the obtained diffraction determines a different orientation. Analysis of the disorientation distribution shows very close distribution to the theoretical random distribution meaning that there is no preferred orientation in our sample.

randomly chosen points/places were scanned. In most of the places a perfect match for a silver single crystal was obtained.

Measurements were performed on (SEM) Quanta 200 (FEI, USA) equipped with attachment for orientation image microscopy (OIM) Channel 5 (Oxford Instruments, England).
The "solution" of the diffraction is matched, depicting the orientation of the crystal, correlating every kikuchi line to its fitting crystallographic plane in the lattice. If there is a perfect match between the kikuchi lines and the crystallographic planes (according to the reference) the diffraction determines the orientation of a single crystal.

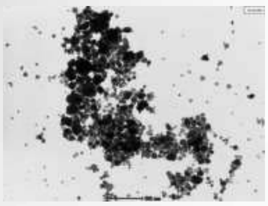


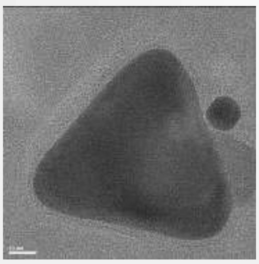
SEM micrograph depicting the scanned points by EBSD

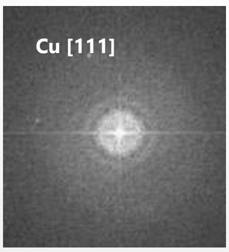
HRSEM and EBSD - IEC, Materials Lab, Dr. Shmuel Ariely

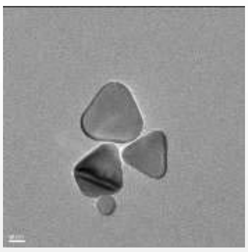
Sicrys™
Cu - a majority of Single crystals particles

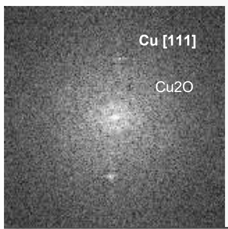
- TEM, EBSD (electron back scattered diffraction) & XRD



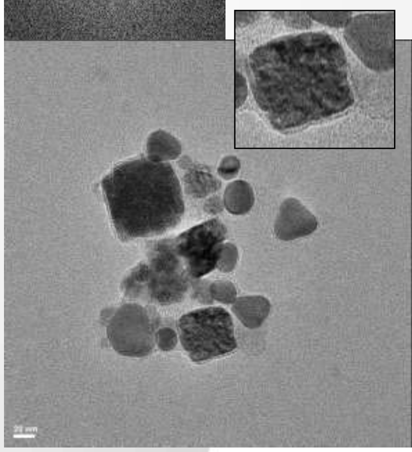








Polycrystalline Cu

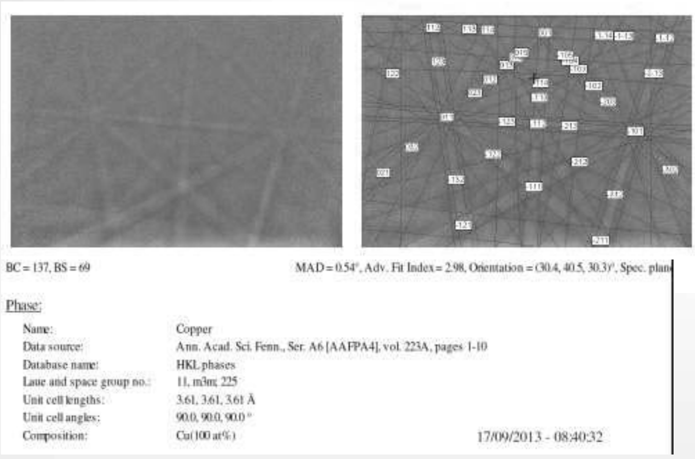


Triangular shaped particles are single crystalline FCC Cu

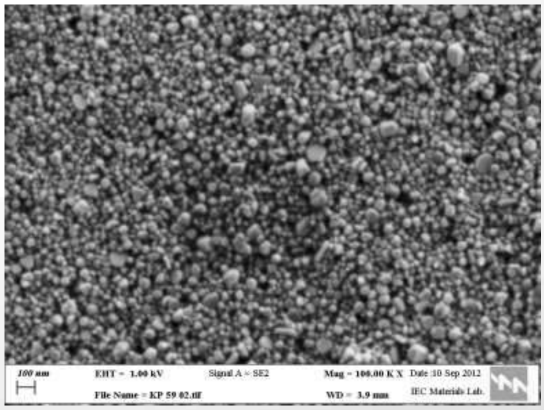
Professor David Zeitun - BIU

Sicrys™
Cu - a majority of Single crystals particles

- SEM, EBSD (electron back scattered diffraction) & XRD



Example of diffraction pattern from Cu sample ("kikuchi lines"), and solution for the diffraction pattern



HRSEM and EBSD - IEC, Materials Lab, Dr. Shmuel Ariely

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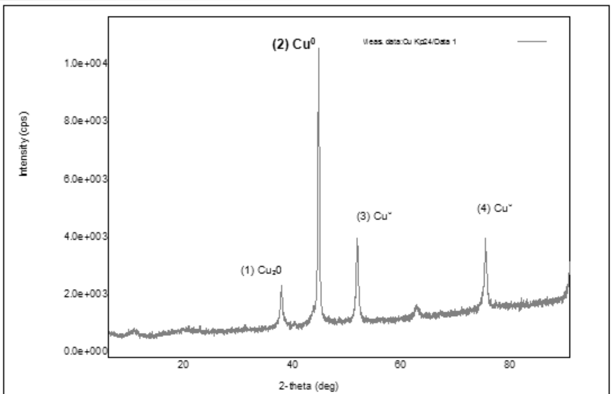
Sicrys™
Cu - a majority of Single crystals particles

- TEM, SEM, EBSD (electron back scattered diffraction) & XRD



Peak list

No peak	2-theta(deg)	Height(cps)	FWHM(deg)
1	36.803(18)	929(48)	0.48(2)
2 (*)	**43.703**	7318	**0.240**
3	50.803	1951(70)	0.447
4	74.453	1653(64)	0.42

Fig. 5. Diffraction pattern of Cu nano powder and selected data of main peaks

Average grain size D (nm) was calculated using *Debye-Scherrer* equation:

D=0.9xλ/FWHM(rad) x cos(theta)

Where: λ is wave length of X-ray radiation=0.1541nm (instrument data);
FWHM is full width at half maximum of the peak (in rad)= FWHM(deg)x3.14:180;
"Theta" is the diffraction angle.

The grain size D(nm) of Cu nano particles was calculated based on data for strongest Cu peak #2:

D=0.9x0.1541/[(0.24x3.14:180) x cos(43.702:2)]=**~ 36 nm.**

The good agreement between this value, average particle size measured by PSD d(50)=35 nm

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Sicrys™ Cu ink oxidation stability

- Oxidation stability: >1 year (at least)

- Ink should be stored under argon, but some contact with air during handling is not "forbidden"
- Ink may be printed under ambient conditions (air)

Sample	Amount of Cu_2O (%w/w) after time interval**	
KP24 (in EG*)	As prepared	After 1 month
	13.3%	**13.8%**
KP26 (in EG)	As prepared	After 1 month
	7.4%	**6.3%**
KP27 (in TPM*)	As prepared	After 3 months
	8.3%	**8.5%**
KP39 (in EG)	As prepared	After 2 months
	-	**3.2%**
KM305 (in EG)	As prepared	After ~12 months
	5.5%	**5.8%**

** Only Cu_2O was detected in addition to metal Cu

Usual ways to achieve oxidation stability for Cu inks:

1) Big amount of dispersant ("encapsulation")

2) Cu oxide or Cu precursors (not Cu metal)

Intellectual Property

PVN IP **Sicrys™** inks:

- Copper WO PCT/1B2015/051536 (WO2015132719) – National phase.
- Silver WO PCT/US2011/063459 (WO2012078590) – National phase.
- Patents **granted** in USA (9,556,350), Russia (RU 2593311), China (CN 103282969) and Japan (JP 6067573).
- Patents submitted (Silver and copper):
  - UK (1020556.5 & 1403731.1).
  - Europe (11846848.7 & 15758302.2).
  - Brazil (112013013885.5 & 11 2016020056 0).
  - India (5064/CHENP/2013 & 201647031956).
  - South Korea (10-2013-7015635 & 10-2016-7026792)
  - Japan (2016-554873).
  - China (2015800145501).
  - Israel (226665 & 247528).
  - Russia (2016137018).
  - USA (15/122,185).

- PVN joint patent submitted with TAU: IP Nano wires for thin solar cells metallization: WO 2013/128458; US 9,373,515 B2 Conductive Nanowires Films.
- PVN IP general (sono chemistry – nano materials – owned by subsidiary NZE): USA 7,157,058; USA 7,504,075; IL 144638; IL 149932.

Resources:
Copper - https://patentscope.wipo.int/search/en/detail.jsf?docId=WO2015132719
Silver - https://patentscope.wipo.int/search/en/detail.jsf?docId=WO2012078590; http://bit.ly/2lsNEnl

Sicrys™ Silver Inks - Properties

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Product Shortlist - Silver Digital Conductive Inks

	Sicrys™ product name	I30EG-1	I50T-11	I50T-13	I40DM-106	I50DM-106	I50DB-114	I50TM-115	I60PM-116	I50TM-119
Solvents	Solvent	EG	TPM	TPM	DGME	DGME	DGBE	TGME	PM/DGME	TGME
	Viscosity@25°C (cP)	17.1	5.5	5.5	3.5	3.5	4.9	6.2	1.7/3.5	6.2
	Surface tension (dyne/cm)	48	30	30	34.6	34.6	30	36.4	27.7/34.6	36.4
	Evap. rate@25°C (nBuAc=1)	0.01	0.0026	0.0026	0.019	0.019	0.004	<0.01	0.62/0.019	<0.01
Inks	Solids (metal content, %)	30%	50%	50%	40%	50%	50%	50%	60%	50%
	Viscosity@25°C (cP)	28	24	26	11	21	28	37	26	34
	Surface tension (dyne/cm)*	47	28	28	31	31	28	33	26	30**
	Evap. rate@50°C (mg/min) (per area, mg/min/mm^2)		0.3 (0.009)			2.4 (0.07)		0.2 (0.006)		
	Sedimentation rate (T=10%; Lumisizer®)	0.25	0.32	0.27	0.66	0.37	0.26	0.2		0.24
	Open time (min) (jetting temperature,°C)		>60min (35°C)	>60min (35°C)	10min (30°C)	1.5min (40°C) 10min (30°C)		>60min (40°C)		10min (35°C)
	Resistivity (µΩcm) (thermal sintering, °C, min)	≤ 27 (150,30) ≤ 10 (180,30)	≤14 (200,60) ≤ 9 (230,60) ≤9 (100ms)[#]	≤ 11 (180,30)	≤ 10 (150,30) ≤ 12 (130,30)	≤ 10 (150,30) ≤ 12 (130,30)	≤ 10 (150,30)	≤ 10 (150,30) ≤ 12 (130,30)	≤ 10 (130,60)	≤ 10 (150,30) ≤ 12 (130,30)
	Sheet resistance (mΩ/□) (thickness, µm)	500 (1µm) 100 (4µm)	100 (1µm) 22 (5 µm)	100 (1µm) 25 (4µm)	9 (10µm)	9 (10µm) 102 (1.5µm)[##]		100 (1µm) 20 (4µm)		30 (3.5µm) 15 (8µm)
	Adhesion (tape test - 5B)	PC, PI, PEN, LCP	PC, PA	PC, PEN, PET	Glass, ITO, PET	Glass, ITO, PET	Glass	Glass, ITO, PET, PC	glass, PC/ABS, Kapton, PC	ITO, Kapton, PET
	Printheads tested	KM, DMC-11610-10pl, RICOH	KM, DMC-11610-10pl, RICOH	KM, RICOH, DMC-11610-10pl, Dimatix Sapphire QS-10pl	Samba, RICOH	KM, Dimatix Sapphire QS-10pl, RICOH	RICOH	KM, RICOH	Air Brush	KM, RICOH

Notes: *- ST measured with Du Noüy Ring method; **- ST measured with Pendant Drop method; # - Photonic sintering; ## - Laser sintering.
Solvents: EG - ethylene glycol, TPM - tripropylene glycol monomethyl ether, DGME - diethylene glycol monomethyl ether,
DGBE- diethylene glycol monobutyl ether, TGME - triethylene glycol monomethyl ether, PM - propylene glycol monomethyl ether.

Rev-3

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Sicrys™ Copper Inks - Properties

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Product Shortlist - Copper Digital Conductive Inks

Sicrys™ product name	Solvents				Inks								
	Solvent	Viscosity @25°C (cP)	Surface tension (dyn/cm)	Evap. rate @25°C (nBuAc=1)	Solids (Cu^0 metal content, %)	% Cu^0 in Cu nano-particles	Viscosity @25°C (cP)	Surface tension** (dyn/cm)	Open time (min)(jetting temp.,°C)	Resistivity (µΩcm) (thermal sintering - °C, min, Argon)	Adhesion (tape test 4B-5B)	Printheads tested	Storage
I25EG-1	EG	17.1	48.0	0.01	25%	>90%	26-32	47	5min (35°C)	≤ 5 [##] ≤ 32 [#] ≤ 90 (300,30,Ar)	Glass	KM, Dimatix, RICOH	Room temperature under Argon
I50TM-8	TGME	6.2	36.4	<0.01	50%	>95%	26-32	31	20min (40°C)	≤ 5 [##] ≤ 120 (300,30,Ar)	Glass, ITO, FR4, Kapton	KM, Dimatix, RICOH	Room temperature under Argon

Notes: **- ST measured with Pendant Drop method; # - Photonic sintering; ## - Laser sintering.
Solvents: EG - ethylene glycol, TGME - triethylene glycol monomethyl ether.

Rev-1

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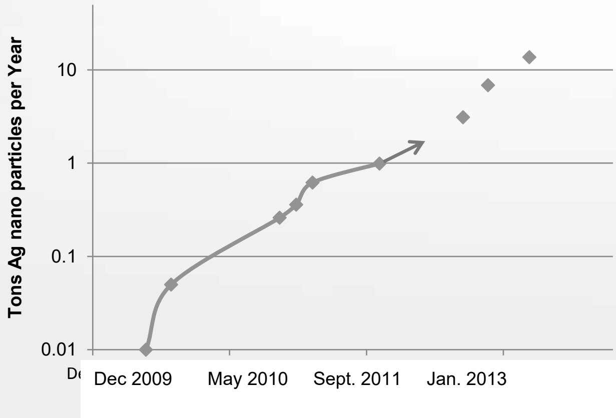
PVN Production Process and Capabilities

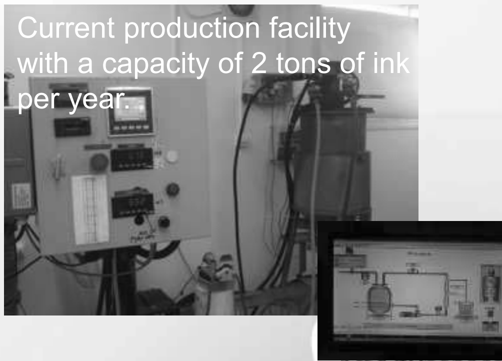
Cost efficient production process.

Production capabilities upgraded, automatic control.

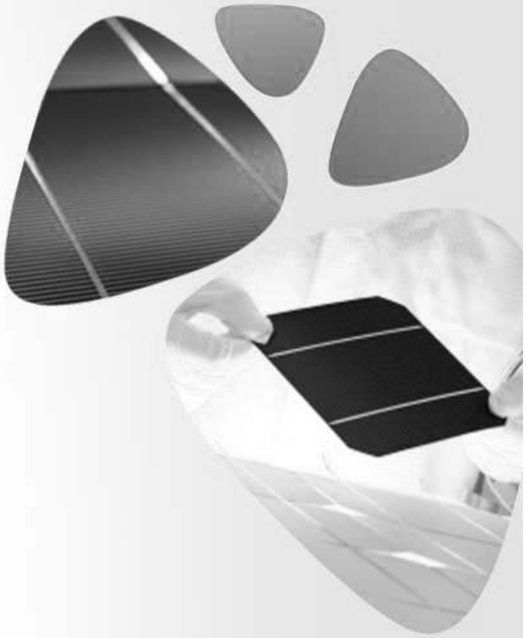
Current capacity ~ 2 tons ink/year.

Following is the history of our scale up process:





Current production facility with a capacity of 2 tons of ink per year.



Business

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PV Nano Cell Vision

Sicrys™ Additive Digital <u>Mass Production Printing Processes</u>

- Sicrys™ inks, silver and copper:
  - Additive digital manufacturing (inkjet, airbrush…).
  - Mass production compatible inks.
  - High quality.
  - Competitive pricing.
- **<u>Unique Products</u>** solar cell metallization and **<u>copper</u>** inkjet inks.
- **<u>Enables</u>** Additive Digital Manufacturing for:
  - Flexible, customized, thin & light weight electronics.
  - Flexible production process, quick set up, shorter production time, less manpower, easy to make adjustments.
  - New electronics.
- **<u>Clean technology</u>**, no hazardous wastes (through the whole production chain, inks to products).
- **<u>Lower costs</u>** – operational and capex.

Additive Digital Manufacturing Challenges

- Until now **<u>Inks, equipment</u>** and processes (printers and post treatments) are **not compatible with Additive Digital Mass Production manufacturing**
- **Key Problems Identified:**
  - Conductive inks
    - Inks are <u>not</u> compatible with mass production process (stability or throughput).
    - Inks are only compatible for prototyping.
    - Inks are expensive.
    - No commercially viable copper ink available.
  - No mass production printers and processes.

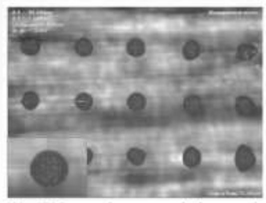



Additive Digital Manufacturing <u>Not Yet</u> in Mass Production!

Beta sites qualifying today supported by Sicrys™ inks

Study on Sicrys™ Silver Inks: Fujifilm

Jet-ability and Drop Formation tuning:
The waveform was based on the Dimatix Model Fluid and modified to optimize drop speed and formation. A cancellation pulse was used to keep the ligaments straight while exiting the nozzle. Drop speed was adjusted to 5 meters per second to match the print head to substrate distance. The nozzles jetted the fluid consistently and reliably with a long open time. Leaving the print head in the printer over the weekend was able to jet after a 0.8 second purge and all 16 nozzles fired. This is very good for reliability in a production environment.



Summary of Results:
The PV Nanocell I50T-1 Silver Nanoparticle fluid jets well. The waveform was based from the Dimatix Model Fluid waveform with minor modifications. A single pulse waveform was created for this test. Test patterns were jetted onto standard glass slides. On initial inspection the typical "coffee ring" effect was not noticed. The coffee ring effect is where the fluid has a tendency to pool at the outer edges leaving a lower depression in the center of the pattern. This is the first silver fluid we have seen which does not exhibit this phenomenon. The jetting was consistent and all nozzles jetted even after leaving the print head and cartridge in the printer over night.

Print Results:
Using plain glass slides as a test substrate, the drop diameter was measured at an average of 52 microns. When using UV Ozone to treat the glass slide surface, an average drop diameter was measured at 80 microns. For large fills, the fluid cured flat and did not show typical coffee ring effects. With our standard 25 mm long line with a width of 1mm test print, we measured conductivity on 1.5 Ohms. This is very good and the lowest we have seen with silvers on glass with this image file. Typical measurements fall between 25 to 30 Ohms for other silvers.

FUJIFILM Dimatix

Study on Sicrys™ Silver Inks: M-SOLV

Print stability testing of Sicrys 150TM-119 silver nanoparticle ink

Phase 1: waveform optimisation.

Phase 2: longevity testing, vibration testing and weekend idle time testing.

The printing stability of PV Nano Cell Sicrys™ I50TM-119 silver nanoparticle ink was determined by printing continuously for 17 hours a day for a total period of 4 days and checking test prints at regular intervals. Also a "vibration test" was performed using repeated X stage movements to investigate whether printing is affected by air bubble formation and/or nozzle drying at air flow. Printing was performed with KM1024SHB print head, frequency was set up to 15kHz with one print every 6 seconds. Head maintenance every 30 minutes.

Summary

- Overall, results are very good for all tests performed: longevity testing (printing test and weekend idle test) and vibration testing. Collected data indicated that in all cases jetting straightness was stable. Nozzle plate for printing test and vibration test stayed dry for all the time.
- Wave form and maintenance cycles were optimized.

M-SOLV

Integrated Business Model

- PVN provides a comprehensive Complete Solution Approach

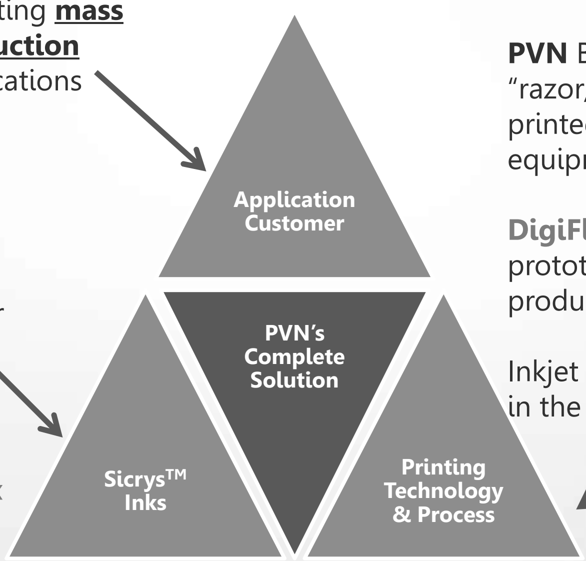
Targeting **mass production** applications

Selling Inks:

Single crystal conductive **low cost & high quality** nano inks Silver & Copper – **PVN Sicrys™ inks**

Polymer based inks – insulators and dielectric functions – **with DigiFlex**

Graphic applications, inks for printing plates.



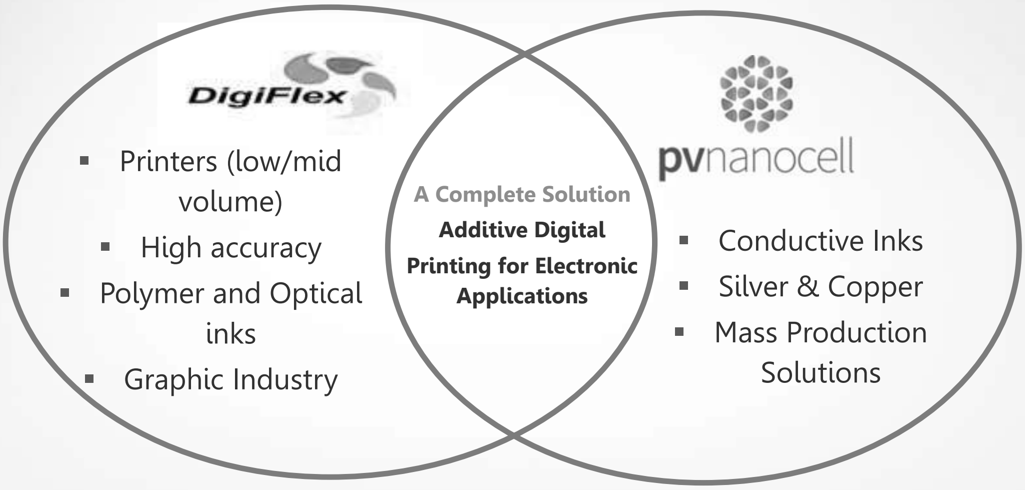
PVN cooperates and/or cell inks with/to > 12 printer producers.

PVN Building and implementing "razor/razorblade" model in printed electronics; printers, equipment and process

DigiFlex printers for design, prototyping and mid-volume production

Inkjet Printers for printing plates in the graphic industry.

Combined Business



PV Nano Cell Sicrys™ inks / DigiFlex printers:

- Unique "one shop" provider of printers for multi layer/multi ink high accuracy digital printing electronics – prototyping and mass production.
- Over 60 printers in the market.
- Dielectric and insulator inks.
- Competitive affordable prices.

Integrated Business Model: Printers
Mass Production

- PVN in contact with a wide network of OEMs in the digital printing field including printer and printer head producers.
- In partnership with printer manufacturers, PVN is working to deliver a "complete solution approach" to customers in the following fields:
  - Printed Circuit Boards (PCB).
  - Antennas for mobile phones.
  - Solar cells (photovoltaics).
  - 3D printers.
- PVN in contact or currently selling to the following printer producers:

M-SOLV, MGI ceradrop, NOTION SYSTEMS, FUJIFILM Dimatix, stratasys, PiXDRO, ardeje, UniJet, kateeva, durst, SCHMID Expect Solutions, orbotech Be Sure, STi, OPTOMEC, MEYER BURGER

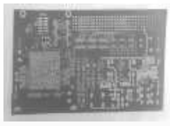
Sicrys™ Ink Applications

Sicrys™ inks are currently used for the following mass production applications (beta sites):

IoT / IoE
Printing for mobile phones
- Antenna – **approx. $0.5 B ink market**
- Touch screens

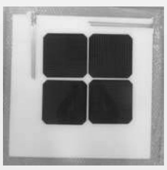

Printers from OPTOMEC

Printed Electronics
- Flexible and customized electronics – **approx. $2.0 B ink market**
- Printed Circuit Boards (PCB) – **approx. $6.0 B ink market**



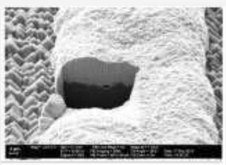
Printers from

CleanTech
Photovoltaic (PV) metallization **– approx. $1.8 B ink market**

Printers from MEYER BURGER, PiXDRO

3D Printing



stratasys

Sicrys™ Enabled Printing Process
Airbrush Systems M3D Optomec

- Antenna samples printed with Sicrys™.

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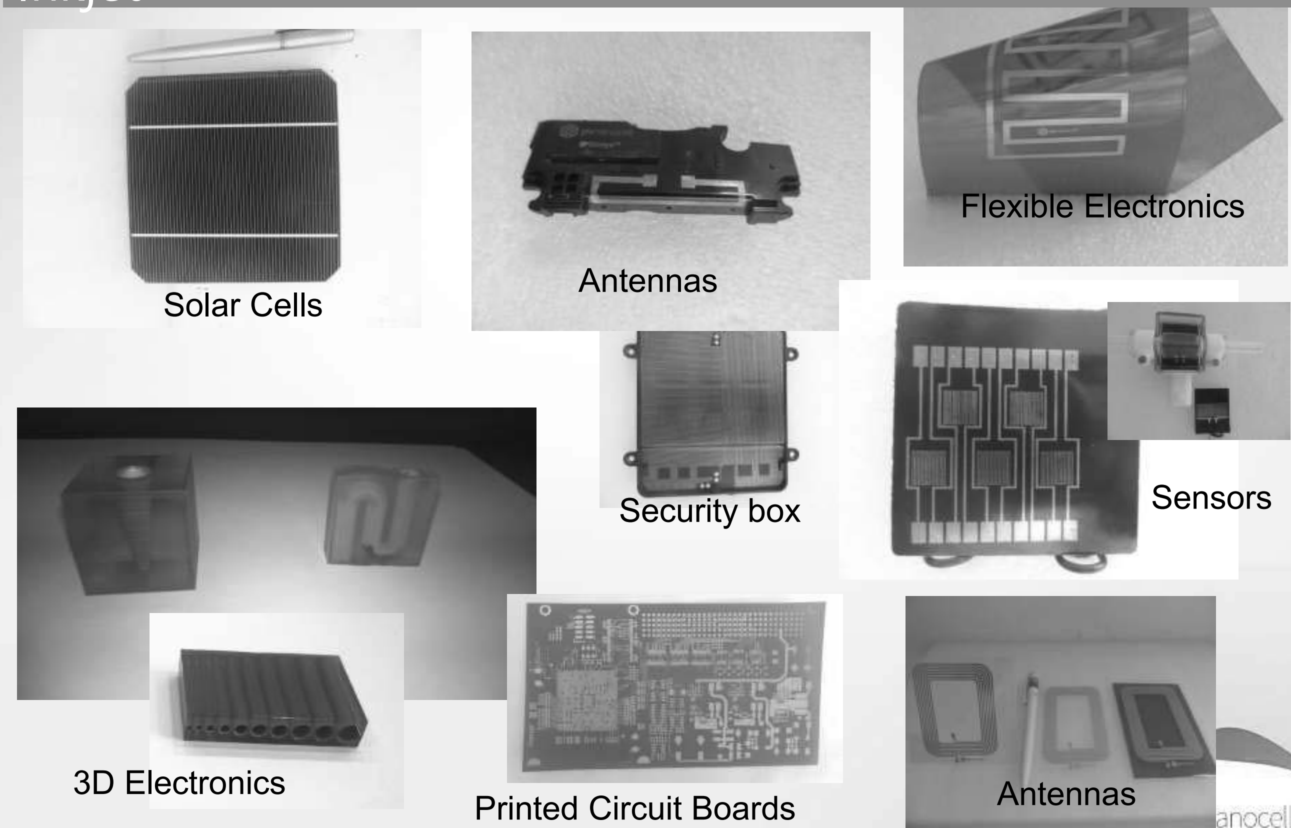
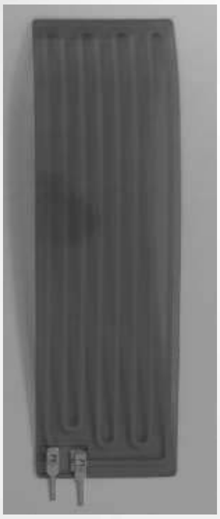
Sicrys™ Enabled Printing Process
Inkjet



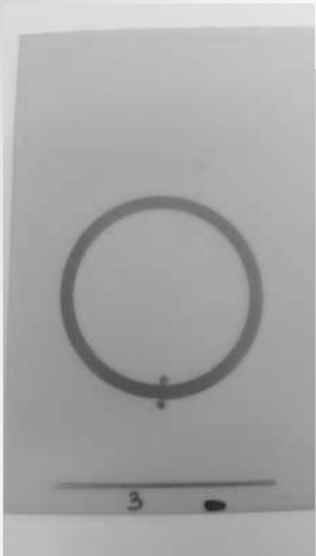
First Mass Production Inkjet Printer
Installed in CPC

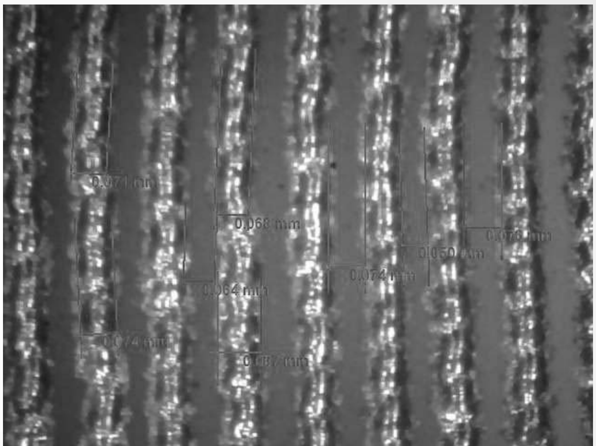


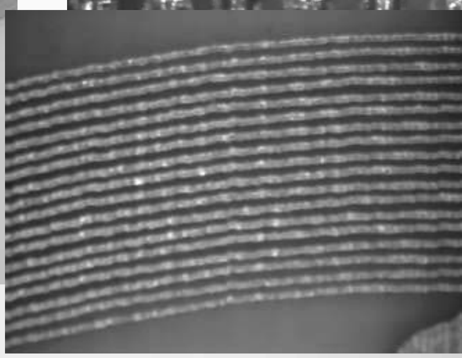
CPC Solutions
Your HMI & Turnkey Partner

orbotech
Be Sure

First Mass Production Inkjet Printer
Products



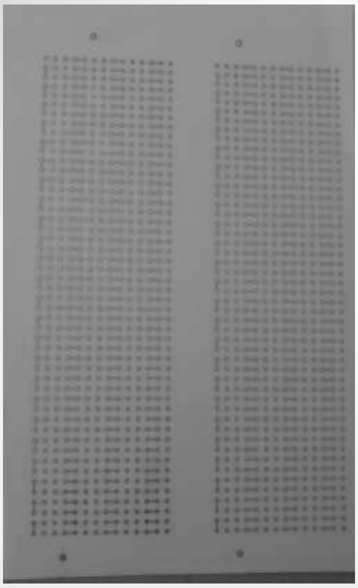


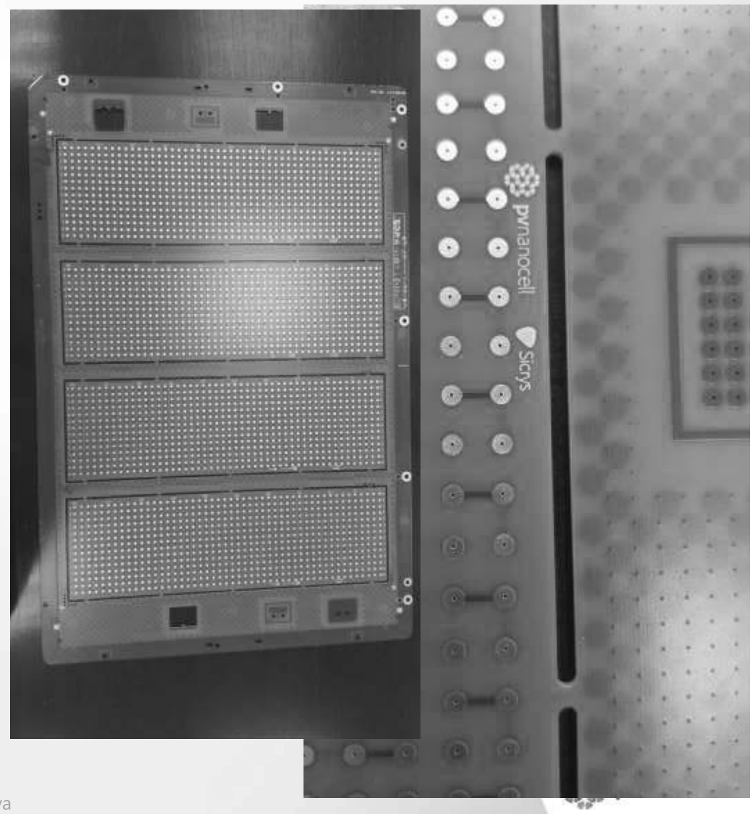


Antennas

Sicrys™ enabled printing process

Inkjet Inner layers inkjet printed (PVN and Eltek)





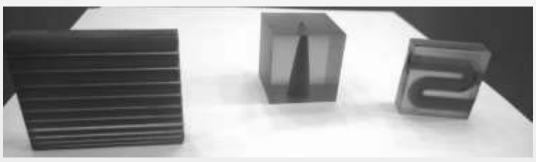
Printed Circuit Boards – 4 layers, inner layers inkjet printed

Integrated Business Model: 3D

3D Printing

- Established the consortium "Printel" which is developing broad 2.5D and 3D printed electronics generic technologies (started July 1, 2014):
  - 3 year initiative with approx. $ 5-6 million yearly budget.
  - 60% financing by the Israeli OCS.
  - First Sicrys™ ink developed and selling in small volumes to Stratasys (SSYS).

- EC Horizon 2020 3D Printing Project – PV Nano Cell developing framework with leading partners Profactor, Stratasys, KIT, Borealis, Tiger, Festo, Phillips, JKU, Soreq, Cirp, Tecnan (started October 2015).
  - DIMAP www.dimap-project.eu



DIMAP DIGITAL MATERIALS FOR 3D PRINTING

stratasys (NASDAQ: SSYS)

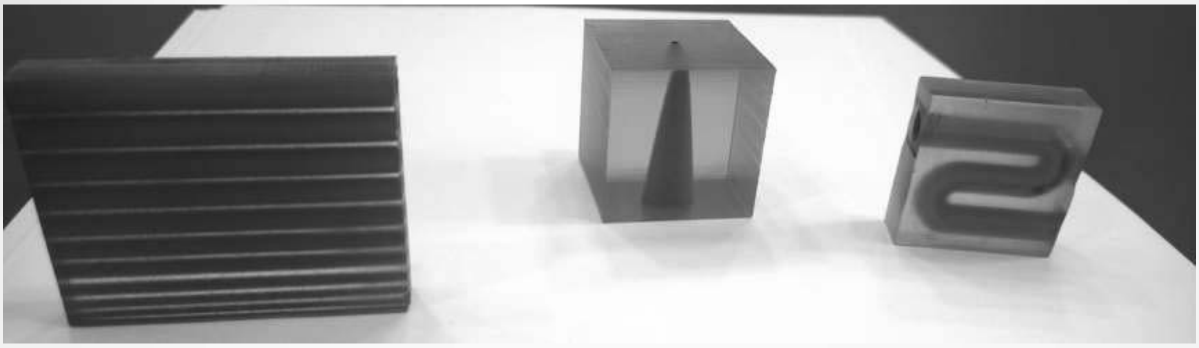
BOREALIS Keep Discovering net profit € 313 M Q12017

orbotech Be Sure (NASDAQ: ORBK)

PHILIPS AMS: PHIA

Stratasys Printed 3D Models: PVN Particles

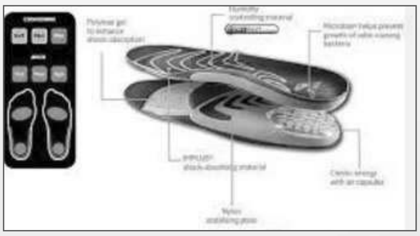
- Stratasys printed 3D models with conductive pattern (using PVN particles).

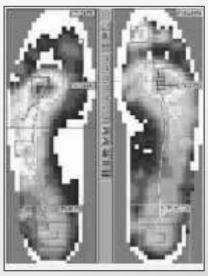


Future of 3D Digital Printed Electronics

- Currently: 3D printed foot orthotics/insoles.
- Future: 3D printed functional foot orthotics with pressure embedded sensors and antenna enabled by Sicrys™ inks.

Illustrative example of what can be done

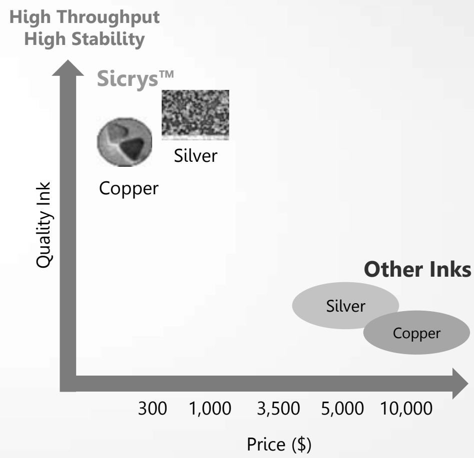




Competitive Landscape

Sicrys™ inks compared to other silver and copper inks:

- Better price – competitive with screen printing pastes
(silver ~ $1,200 /kg for high volumes).
- Robust high throughput, 24/7 printing.
- Low viscosity at 50% (and higher) metal loading.
- Greater stability – over 1 year.
- Proven narrow pattern printing < 50 µm.
- Low resistivity: ρ < 2.5 x bulk.
- Low sintering temperature (< 150 °C).
- Unique products – Silver environmental resistance, copper and solar cell metallization inks.
- Sicrys™ production process – 2 t/year (20 t/year):
  - Scaled up.
  - Efficient and green.
  - Low cost equipment & process.



PV Nano Cell Sicrys™ inks / DigiFlex printers:

- Unique "one shop" provider of printers for multi layer/multi ink digital printing electronics.
- Over 60 printers in the market
- Silver and **copper** inks.
- Dielectric and insulator inks.
- Competitive affordable prices.

Benchmark:

Nanodimension (NASDAQ:NNDM; market cap $ 66M – 20/5/17)

- A few beta sites printers.
- Silver ink~ $10,000 /kg – no copper ink.
- Expensive printer, low throughput

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Summary of Competitors

Summary of Selected Competitors' Nano Silver Inkjet Inks vs. PVN's Sicrys™

- Competitors price range: >$5,000 per kg silver ink (<50% metal).
- PVN price range: approx. $3,500 per kg silver ink (50% metal), down to approx. $1,200 per kg silver ink for high volumes.

Company	Metal	Resistivity (sintering conditions)	Remarks
PVN Sicrys™	50%	2, 7 -30 µΩ·cm (240°C ; 150°C; 180°C; laser & photonic)	Solvent based, thick 3D patterns, Best robust printing, low prices
Novacentric (USA)	15-35%	2.8 – 18 µΩ·cm (< 125°C & photonic)	Less than 0.5 µm thick, water precursors chemistry
ANP (Korea)	30-35%	5 – 11 µΩ·cm (100°C - 200°C)	PSD < 10 nm, expensive
InkTec (Korea)	15 – 40%	2.8 – 4.8 µΩ·cm (130°C - 350°C)	Precursor chemistry (low thickness), expensive
Intrinsiq (UK)	20%	<10 µΩ·cm	Very expensive

- Nano Silver solar cell metallization inkjet inks (No known competitor).

Competitors of PVN's Sicrys Copper inkjet inks

- Most competitors (Novacentric, App Nano) produce copper oxide inks not copper inks.
- Intrinsiq offers a very expensive Nano Copper ink, approx. $ 10/gr.

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PVN Timeline

Investment in PVN (cumulative):

Seed $300k	$ 2 M (Terra)		$ 4.2 M (IPB & IEC)		$ 5 M	$ 7.2 M	~$ 9 M

In addition, received EC Horizon 2020 and Israel OCS R&D grants ~ $2M

2009 – Seed

2010 – Silver patent application

2012 – Copper patent application; Glass Frit (GF) license

Fraunhofer IKTS

Narrow printing

2014
- 2 t/y capacity production
- Printed Electronics, Low temperature sintering inks
- 25% Copper ink
- Solar metallization ink

OPTOMEC, SCHMID, PiXDRO, ROTH & RAU

2015 – 3D inks, PCB ink

2016-7 – 50% Copper ink for Mass production printers; Purchasing DigiFlex

DigiFlex

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Thank you!

Join us to make a difference in the world!

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