What if you could print, in just one day.....

**MULTILAYER PCBS**

Wide range of applications

**PCB & CONNECTOR**

Functional & Structural elements

**ANTENNAS**

Functional PCBs

**ELECTRO-MAGNETIC COILS**

New Mechatronic designs

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ALTIUMLIVE 2018:
You Design & You Manufacture:
Additive Manufacturing of
Complex Multilayer Circuits

Robert Even  Munich
Product Marketing  Jan.17, 2018
Manager
The 3D Printing
3D Multi-layer Printing Revolution
Why Additive / Why 3D Print?

- Accelerate time to market
- Protect IP
- Freedom to Experiment!
- Improve efficiency
Printed Electronics and the IPC

- IPC standards
  - IPC/JPCA-4921, Requirements for Printed Electronics Base Materials (2012)
  - NEW! IPC/JPCA-6901, Application Categories for Printed Electronics
  - NEW! IPC-6903, Terms and Definitions for the Design and Manufacture of Printed Electronics (Additive Circuitry)
3D Printed Electronics and the IPC

- IPC-7991

- Technologies
  - Traditional Printed Circuit Board methods
  - Inkjet
  - Extrusion
  - Aerosol Jetting, MID
Very good, Low-cost, Desktop, 2-sided*, Simple PCBs
Players – Lab

Excellent Lab Tools for Research
Very Good Single Layer Deposition on any Contour
Test multiple ideas - quickly and affordably!

- No internal Purchase Order bureaucracy
- No shipping time
- No minimum order quantity
- No more hesitation to try new concept
Change Your Workflows: New Intermediate Options

- Proofs of concept
- Design validation
- PCB Prototype
- Test fixtures
- Redistribution layers
PCB adapter within 3h
AM-Produced PCB Reduces Rework Time by 97%

- Phytec job - 24 prototypes
- Drawing error discovered 2 days before deadline
- Estimated rework – 2-5 weeks
- Actual rework – 1 day!
  - Print 30 4x4mm PCBs in 6 hours
  - Powerup & soldering ½ day
Two Main Lines of Additive Manufacturing

A- PCB & RF ANTENNAS/DEVICES

B- ELECTROMECHANICAL DEVICES (examples)

Less than 1.3dB difference up to 6GHz Vs. conventional manufacturing

Encoders

Electromagnets
How it

- 2 Printheads jet both materials simultaneously
- Both conductor & substrate are printed - fully additive process
- Build up, layer by layer
  - ✓ Silkscreen
  - ✓ Solder mask
  - ✓ Signal layers
  - ✓ Isolation layers
  - ✓ Through holes, filled vias, mills

Nano Dimension
Conductor: AgCite Silver Nanoparticle Ink

- Optimized for
  - Inkjet 3D printing
  - Compatibility with dielectric ink
  - On-the-Fly sintering (no post-process)
  - Used for surface finish (no need for gold-plating)
Materials: Dielectric Ink

- A “liquid FR-4”.
  - $D_k @ 1 \text{ GHz}: 2.9 \quad D_f @ 1 \text{ GHz}: 0.02$
- Optimized for:
  - Inkjet 3D printing
  - Compatibility with Conductive ink
  - On-the-fly curing (no post-process)
  - Used for solder masking

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• PCB Size: 20x20 cm (max)
• Min/Max PCB thickness: 0.7/ 3 mm
• Max. layer count: N/A
• Min/Max layer thickness: 10μm

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<th>Thickness</th>
<th>Trace Width</th>
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Examples of 125µm (5 mil) Space
Send to Print!

**Next Job**
- **Job Name:** test prepared job.apcb
- **Owner:** Robert
- **Added Time:** Sun Dec 10 17:01:37 201

**Printer Status**
- **Status:** WORKING
- **Slices Completed:** 148 of 3046
- **Current Action:** Printing

**Time to finish:** 00:20:50
Planar: 100% Precision 3D-Printed

6-Layer PCB (Credit Phytec)

12-Layer PCB

Hybrid: BGA Rework (Credit Phytec)

Complex (and seasonal) Routes

Capacitive Sensors

5G Balun Bow-Tie Antenna
Soldering To Printed Silver Ink
# Application Area and Users

<table>
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<th>Rapid Prototyping</th>
<th>Distributed / low volume production</th>
<th>End use parts</th>
<th>Saving weight</th>
<th>Smart parts</th>
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X-Ray & SEM of Boards and Interconnects
Additive Manufacturing of Harris RF Amplifier

- Functional RF circuits
- @4.7GHz, 1db gain difference
- @6 GHz, <1.3db gain difference

Results very close to traditional FR-4 & coaxial connector
• Temperature & humidity sensor
• Tested & works at normal temp. ranges
• 4 layer PCB with 0.5mm BGA
  • 18 x 18 mm x1.6mm
  • Line/Space – 120/120 microns
  • Blind and buried microvias
  • 5 PCBs printed in 12 hours
  • Vapor Phase soldering at 240degC

Printed & tested by Phytec New Dimensions
We have achieved basics, now we move into:

✓ Signal integrity (e.g. controlled impedance)
✓ RF performance and high-end dielectrics
✓ Power circuits
✓ Reliability and longevity

Simulation tools are not always present

EDA & CAD worlds are approaching...

- Best example, Altium & SolidWorks
3D Electronics Printing...
SOLIDWORKS Plug-In - The Mechatronics Gap
Bend-To-Fit Capability
Who says conductors have to be planar?
By pausing the print it is possible to add components within PCBs before continuing the print process.

* In development and not fully released
Thank You!

**ALTIUMLIVE 2018:**
You Design & You Manufacture: Additive Manufacturing of Complex Multilayer Circuits

**Robert Even**
Product Marketing Manager  
**Munich**  
Jan.14, 2018
About Nano Dimension

Listed on the TASE in 2014 and on the Nasdaq in 2016

Since 2014:
- Developed printer
- Developed materials
- Established manufacturing
- Built organization

Since 2016:
- Conducted comprehensive early access trials with Fortune 500 companies

Started generating revenues:
Q4 2017 - $440k
Q1 2018 - $635k
Q2 2018 - $1,088k
Q3 2018 - $1,672k

2018 Execution:
- Opened U.S. headquarters
- Opened HK Office, expanding reach in Asia Pacific

Opened 4 Customer Experience Centers
Recruited 18 value-added resellers world-wide
Worldwide Reach and Expansion

Distributors

Customers

Headquarters
Our Manufacturing Capabilities

- In-house 3D Printer production
- In-house nano inks production
- Certified ISO14001 and OHSAS18001

- Founded - 2012
- NASDAQ / TASE (NNDM)
- 100 employees
- 2/3 Engineers /Scientists
Our Technology is Breaking Design

**Chemistry**: conductive nano-metals & polymers

**Software**: recipe driven additive manufacturing, closed loop controls, PM

**Ink Jet**: heads, ink delivery system, monitoring

**Polymerization and sintering**: UV, IR, Heat