Biopohjaiset älykkäät ratkaisut-yhteistyöalusta kiertotalouden alueellisena vahvistajana

Painettava elektroniikka älyn mahdollistajana

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13.9.2018

TAMPEREEN TEKNILLINEN YLIOPISTO

Kestävää kasvua ja työtä -ohjelma

Vipuvoimaa EU:lta 2014–2020

Euroopan unioni
Euroopan aluekehitysrahasto

Tampere University of Technology
Future Electronics www.tut.fi/lfe

Prof. Donald Lupo

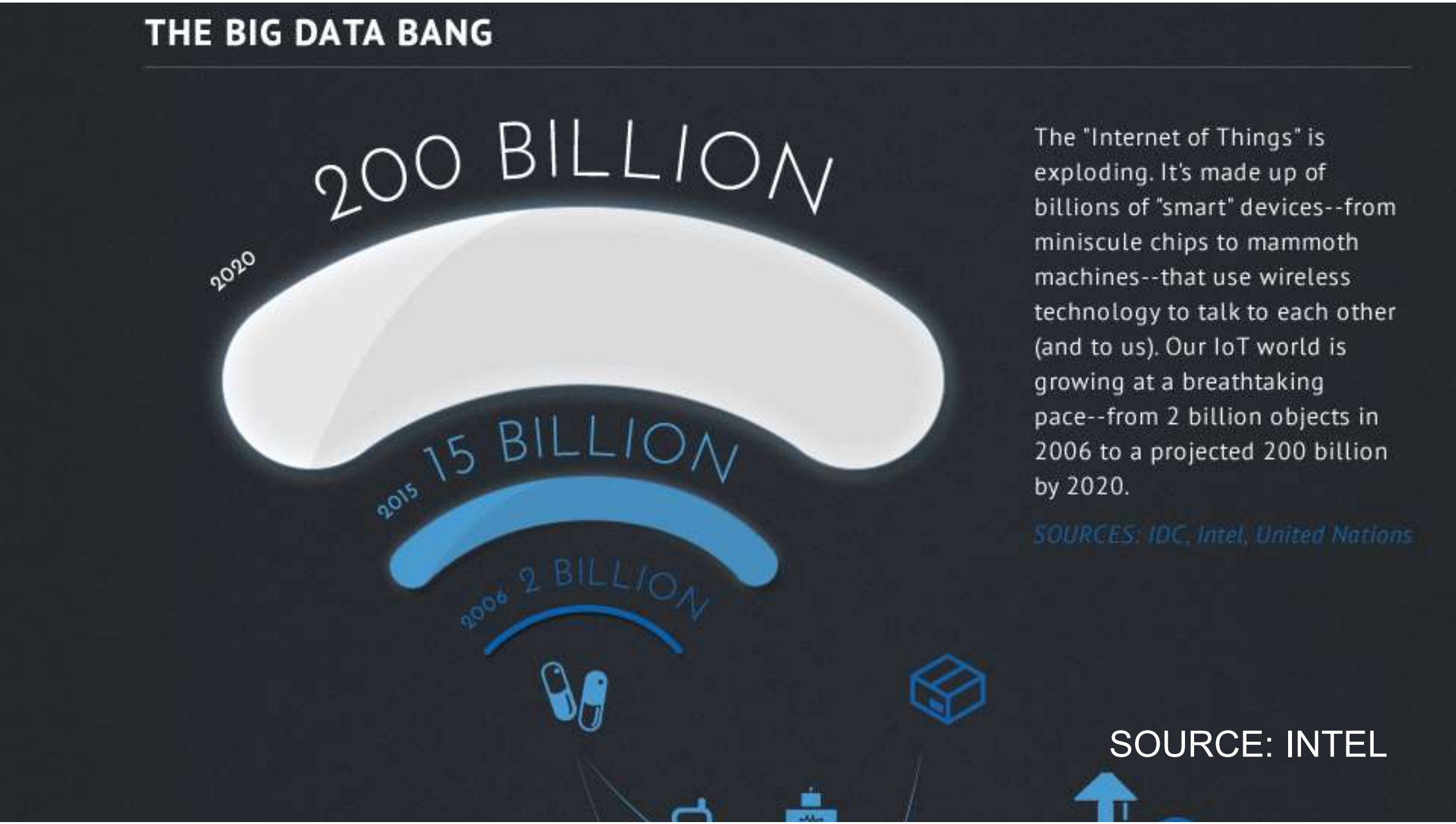
Prof. Matti Mäntysalo

Visiting Prof. Paul Berger, Ohio State

We perform research in novel materials, architectures and processes.

- We digitalize physical objects
- The focus is on Internet-of-Everything for **ambient intelligence** and **healthcare** application.

Research themes:
- Flexible/bendable/stretchable electronics
- Integration of printed and conventional electronics (hybrid systems)
- Energy storage and harvesting
- Printed thin-film circuits and systems



SOURCE: INTEL

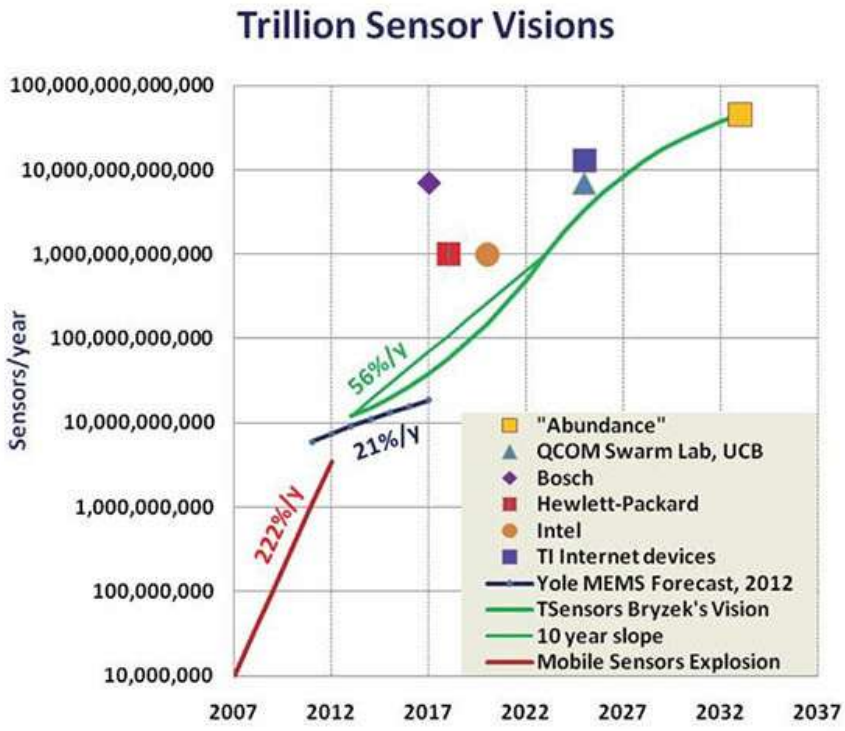
Trillion sensor vision

- Billions (and potentially trillions) of MCUs are needed every year.
- World's annual manufacturing rate of MCUs is around tens of billion pieces.

- **Paradigm shift in manufacturing is needed**

Source: Thin Film Electronics

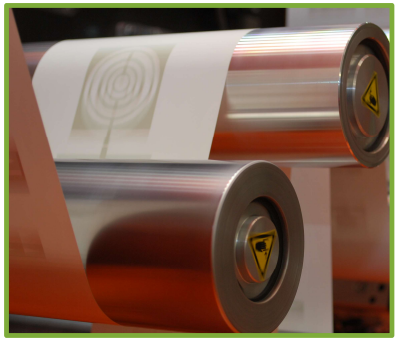
Source: FuturistSpeakers.com



Large Area Printing & Patterning Techniques

- Large-area
- Cost-effective

High volume printing processes

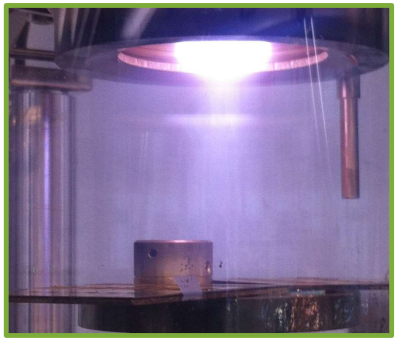


- Gravure
- Flexography
- Offset
- Lithography

Digital patterning processes

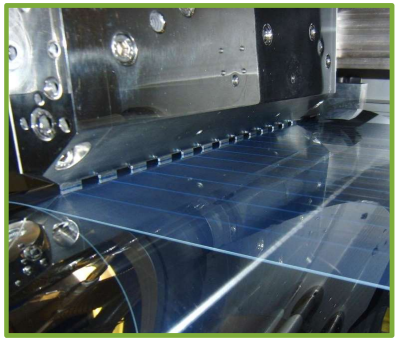
- Inkjet printing
- Aerosol jet printing
- Laser transfer & machining
- Micro-plasma printing
- Syringe deposition
- Xerography

Further patterning & deposition processes



- Vapor phase deposition
- Soft & large area lithography
- Nano-imprint lithography
- Pad printing
- Wetting/dewetting
- Hot stamping

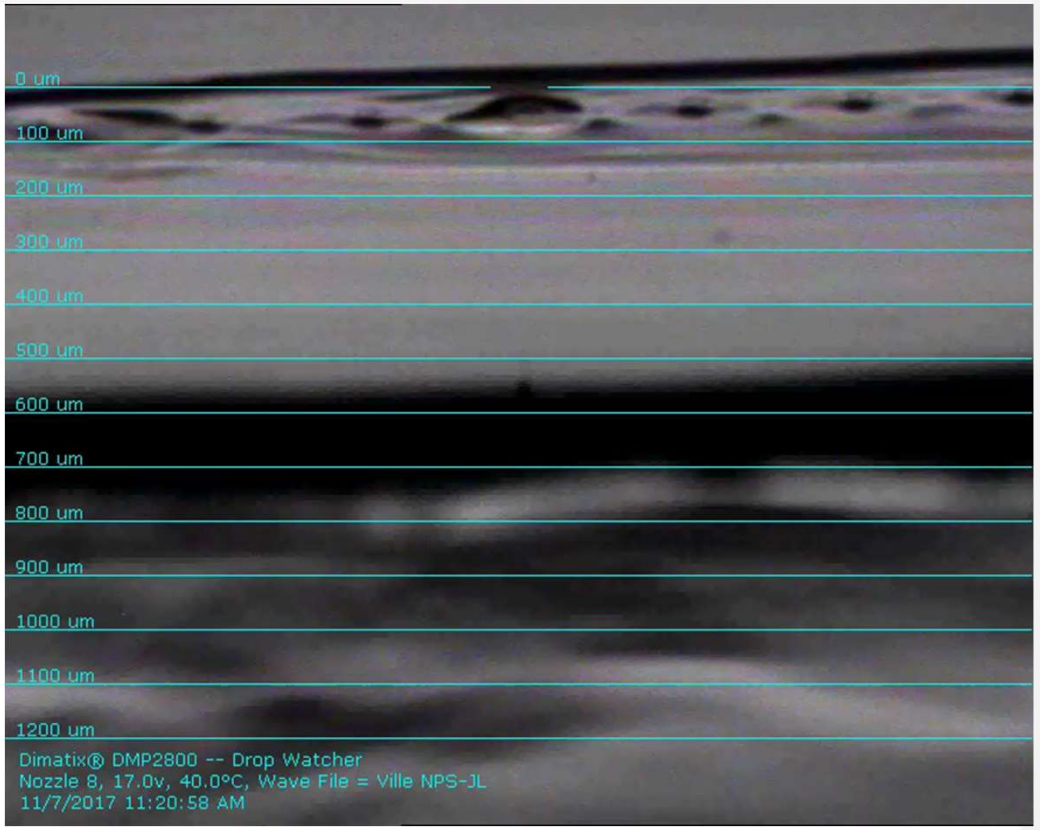
Solution coating processes

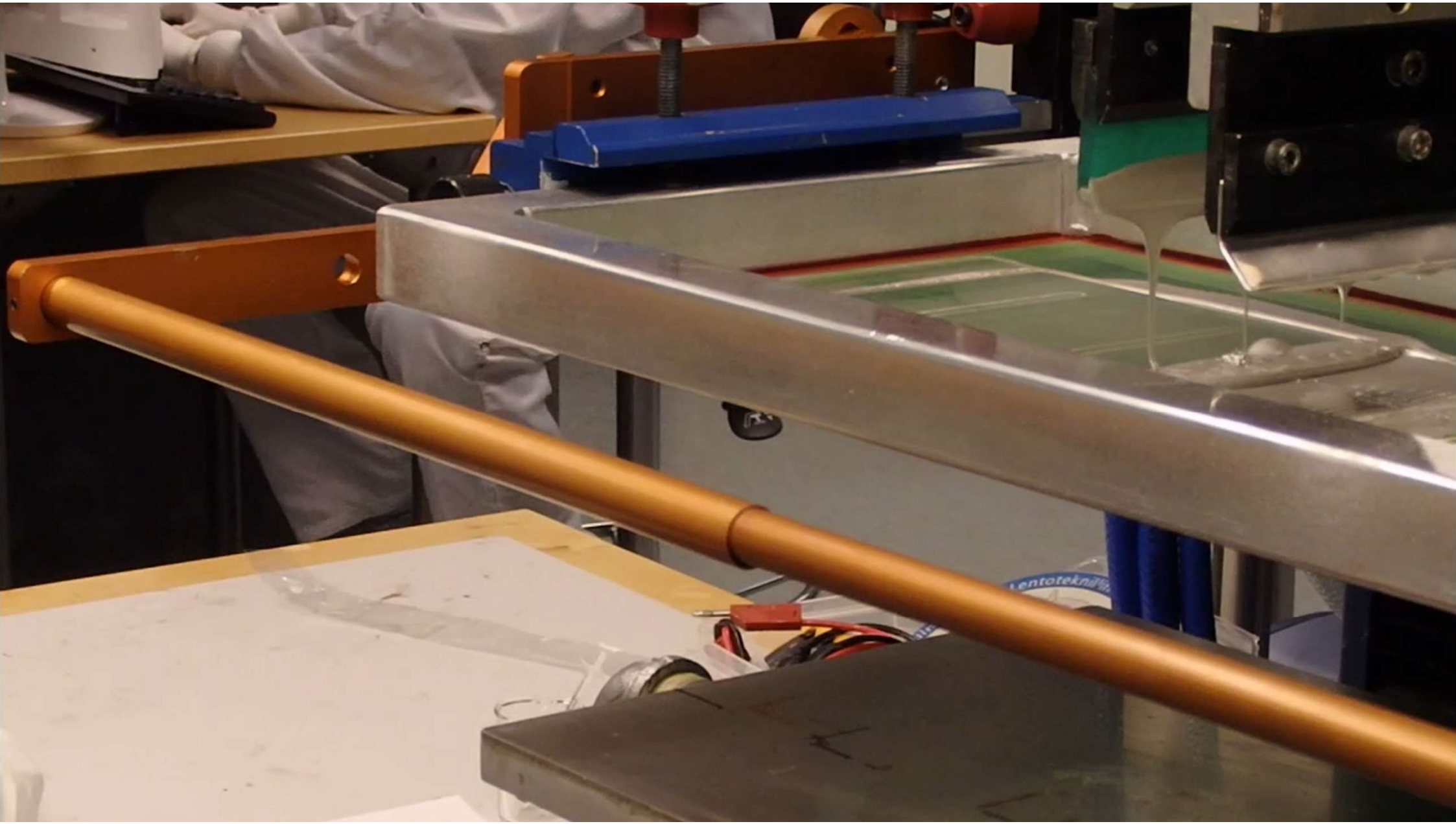


- Slot-die coating
- Wire bar coating
- Curtain coating

Ink

- Functional
  - Ag-flakes,
  - Nanowires,
  - Conductive polymers
  - Carbon nanotubes
  - Graphene, …
- Carrier fluid
  - Water, alcohol, …





Stick-it-on-Devices
”sticker computer”

Turn ”**old world**” objects to ***smart devices***

Sticker computer

Mass manufacturable

billions of components and devices will be needed in the future (i.e.”trillion sensor visions”)

Form factor

easy embedding into old world objects

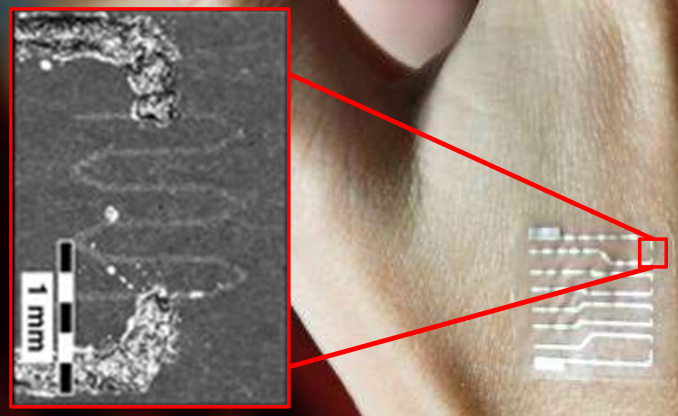
Energy autonomy

Harvesting and storing

Function

sensing, actuating, computing..

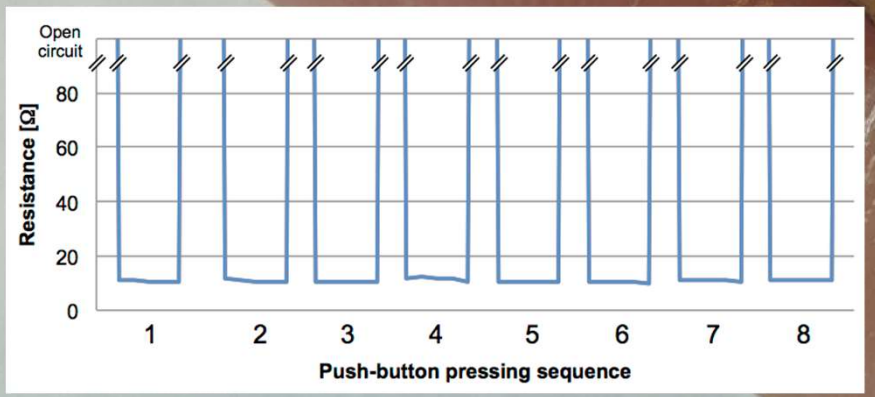
Temperature sensor



T. Vuorinen, DOI: 10.1038/srep35289

T. Vuorinen et al, Printing future days 2015

Pressure sensor

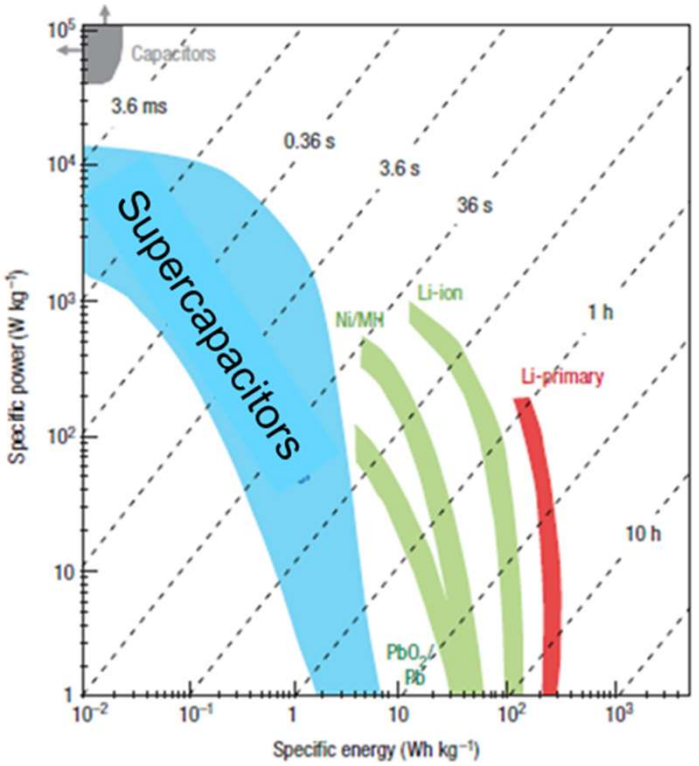


BUSINESS INSIDER NORDIC

Finland invests in printing the Internet of Things - to avoid a global environmental nightmare

Margarita Khartanovich | 27 Sep 2016 2:29 PM | 1057

FiDiPro Professor Paul Berger, Professor Donald Lupo and doctoral student Suvi Lehtimäki are developing printed electronic components for the Internet of Things.

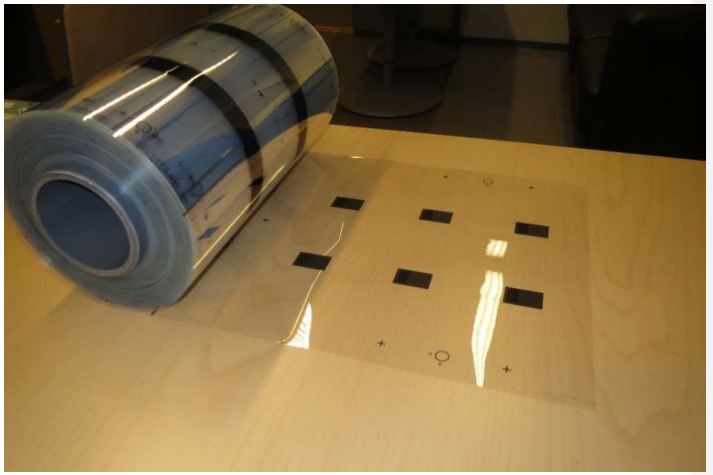


http://nordic.businessinsider.com/finland-invests-in-printing-the-internet-of-things---to-avoid-an-global-environmental-nightmare-2016-9/

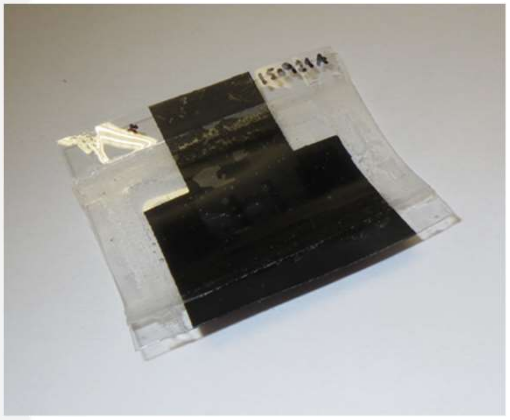
Disposable supercapacitors energy everywhere

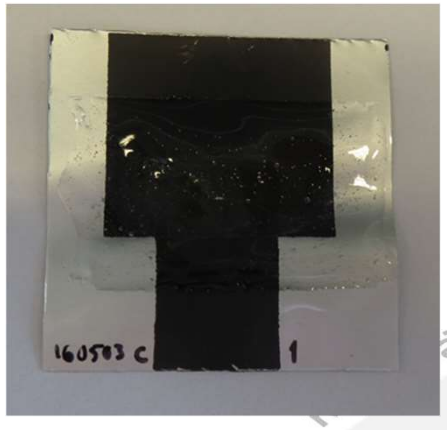
J. Keskinen et al. J. Energy Storage **16,** 243 (2018)

- Layers applied **on top of each other** on PET or PET/Al
- Only non-toxic printable materials applied on each other
- Various architectures tested



Carbon + water + salt





- Capacitance 0.2-0.4 F
- ESR 25-40 Ω
- Leakage current ~ 20 µA

Example: Energy autonomous temperature sensor

Energy storage in supercaps

ASIC with power management,
T sensor and Eink display driver

E-Ink temperature display

Energy harvesting – OPV module and
printed RF (13.56 MHz) harvester

Shown at LOPEC 2016. Participants: TUT, Store-Enso, Aalto Univ., Walki

LFE Infrastructure

- **Lab-space**: over 250 m2 lab space, with 60 m2 cleanroom close to ISO 14644-1 class 5 (non certified).
- **Printing equipment**: Most major relevant printing processes on lab scale: screen, flexo, gravure, inlk jet, bar and spin coating, including Superfine Inkjet (fl droplets)
- Major printing upgrade in 2018: state of the art inkjet and high registration/precision flexo, gravure, offset gravure and rotary screen (delivery autumn 2018)
- **Integrated inert processing and characterization facility:** coating, inkjet printing, evaporation, electrical and optical characterization, encapsulation without leaving inert environment
- **Wide range of characterization equipment:** including, among others, source measure units, state of art semiconductor analyser including C-V, potentiostat, Maccor energy storage characterization interface

Thank You! Kiitos!

Project's Principal investigators:

Johanna Lahti, Sampo Tuukkanen, Tero Juuti,
Tomas Björkqvist, ***Matti Mäntysalo***

Project staff:

Jari Keskinen*, Jarkko Pakkanen, Sanna Siljander,*
Juuso Toriseva, ***Hanna Christophliemk****, Arno Pammo*

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Kestävää kasvua ja työtä -ohjelma

Vipuvoimaa EU:lta 2014–2020

Euroopan unioni
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