Printable Autonomous Sensors for Promotion in Condition Monitoring

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“Innovations for Industry”

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Autonomous machine monitoring

- Energy scavenging
- Machine monitoring: focus on acoustic monitoring --> scavenging device forms part of sensor & vice versa
- Energy buffer (battery / supercap) critical

Source: HSG-IMIT

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Business case for printable machine monitoring device?

- Low cost --> **give-away approach** to services marketing
  - → Device to be affixed to & left on consumers´ machines
  - → Consultant visit --> readout and software demos
  - → Replace printable device with industrial strength equivalent
  - → Throw away promotional monitoring device
- Other uses in monitoring
- Old and **new** "printable electronics" elements
  - Elastomer spring
  - Electrical coil
  - Ferromagnetic polymer masses

  →many potential spinoffs

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Towards printing scavengers & sensors

- **Printable electromagnetic scavengers (power ??)**
  - new, to be researched
  - recent advances in high-conductivity printed wires
  - reformulate polymer magnetic recipes
- **Add to already-existing (PV) scavenger architecture**
  - printable photovoltaics
  - printable electrochemical storage
  - print sensor
- **Validate business model**
  - push towards low cost, including lower-cost discrete-systems!
  - market for disposable/promotional scavengers
  - trials
  - synergies

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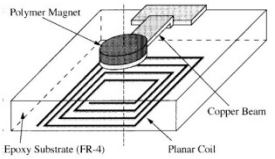
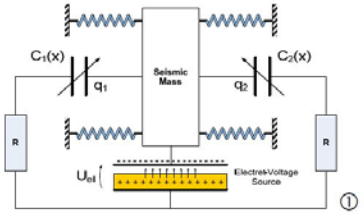
A number of architectures are “printable”

- Electromechanical cantilever:
  - follow precedent: e.g. Lagorce et al., IEEE Vol.8 #1, March 1999 with partially printed actor
    - partially printing, partially etching
    - software simulations
    - scavenger and sensor combined
  - solve **coil conductivity + inductance** challenge
  - print thicker polymer permanent magnet
  - increase power
- Piezo solutions
  - print electrodes on piezo foil is known
  - printing piezo material itself possible
- Capacitive scavenger
  - seismic mass printable
  - electret printable
- Printing elastomers
  - porous
  - solid



Source: IEEE 1999



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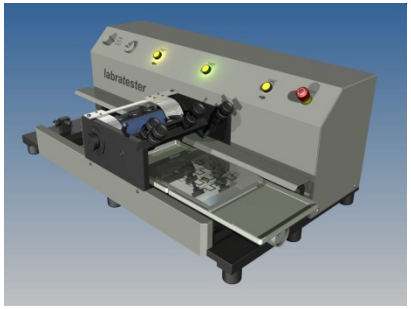
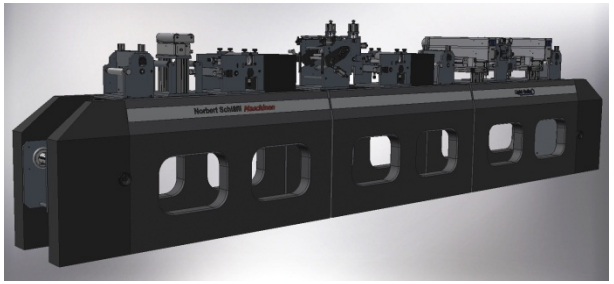
State of the printing art...

- Printing variants
  - “analog”: screen, flexo, gravure
  - “digital”: inkjet, valvejet, exotic variants
  - established processes: lamination, coating
- Printing challenges to be tackled
  - robust elastomers
  - ultrahigh conductivity tracks, coils / antennas, plates etc.
  - high coercivity polymer magnets
  - some printable semiconductors (e.g. PV)
  - compatible printable secondary battery / supercap
  - discrete signal processing in all cases
- General functional printing issues
  - Exotic inks (“beyond printable electronics”): multiphase, high-viscosity, curing, many other issues
  - Registration is key
  - Trapping & ink-to-ink wetting
  - Robustness (“at least 4 week lifetime”)
- Need for <u>new generation of laboratory printers</u>
  - Handle widest variety of inks
  - Mix processes



Single-Unit Single-Sheet Lab Printer



Multi-Unit Prototype Printer, Roll to Roll

Source: NSMZ, www.nsmz.com

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Proposal for printed autonomous noise monitor

- Elements
  - Printing feasibility to be shown for all elements
  - Discrete / printing: a cost issue
- Approach
  - Focus on business case
  - Participation to national and EU FP6, FP7 projects
  - Modify existing printing hardware platforms
  - Synergies

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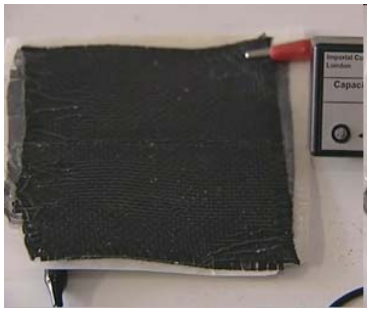
Printable (secondary!) batteries & supercaps

- Know-how includes EU project exploitation:
  - EU FP7 FACESS: Photovoltaic device & battery printed on same line, in progress
  - EU FP7 GREENBAT: towards environment friendly printed LiIon batteries, in progress
- Academic / industrial state of the art
  - Printable supercaps still under investigation, e.g. @ Imperial College
  - Discrete electronics for power management
- Industrial interest

Source: VTT, FACESS site

Source: VARTA, Greenbat site



Imperial College London, The Composites Centre

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GREENBAT workshop

- Printable secondary battery characteristics
- Electrochemical storage requirements incl. Scavenging
- GREENBAT workshop May 4-5th, 2011 Vellberg / Schwäbisch Hall, Germany

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Thank you

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