New emerging technologies for smart textile application

Konstantin Astafiev, Tomasz Zawada, and Erling Ringgaard
CTS | Ferroperm, Denmark

Outline

1 | Company introduction

2 | Microflex project

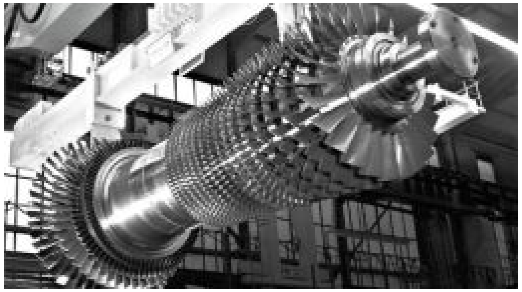
3 | Smart Workwear

4 | Ultra low temperature piezoelectric materials

5 | Conclusions

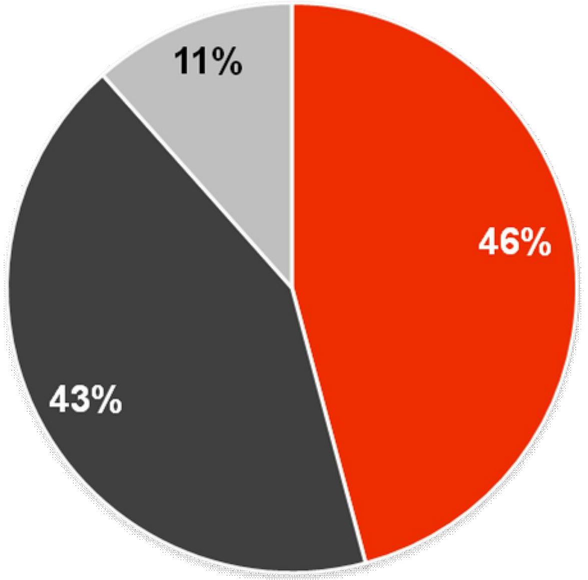
1 Company introduction





Overview

- Provides high technology products and systems for the aerospace, defence and other specialist markets, including: medical, industrial, energy, test and automotive
- 60 years experience in extreme environment engineering
- Broad geographic footprint
- Annual sales, $2.17B *[£1.41B]*
- Listed on London Stock Exchange (MGGT)

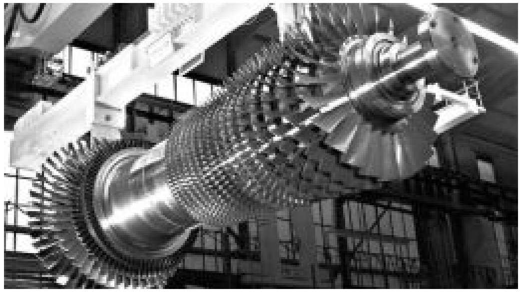


OE 52% / Aftermarket 48%

CTS | Ferroperm Denmark

- We are a manufacturer of piezoelectric materials, components, devices
- 2-3 million units produced annually
- Major markets
  - Medical ultrasound
  - Underwater acoustics
  - Acceleration sensors
  - Flow meters
  - Energy Harvesting
  - NDT

2 Microflex Project



MicroFlex Project

- Micro fabrication production technology for MEMS on new emerging smart textiles/flexibles,
- The MicroFlex Project is a EU FP7 funded integrated project, 7.7 M€ Budget, 5.4 M€ funding,
- 4 Year project, end date 30th October 2012,
- 13 Partners, 7 industrial, 9 countries.

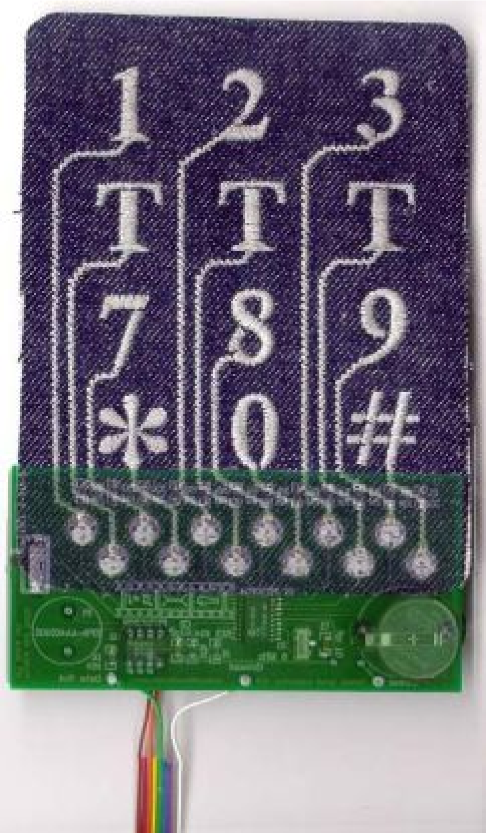
MicroFlex Project Goals

- To develop MEMS (Micro Electro-Mechanical Systems) processing capability for the production of flexible smart fabrics. Based on screen and inkjet printing,
- Process relevant aspects: cheap, high volume production, clean, reliable, flexible,
- To develop new functional inks and pastes, that are compatible with the variety of textiles,
- To produce industrial prototypes demonstrating the functionality of the new inks.

http://microflex.ecs.soton.ac.uk

Smart Textile

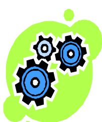
- Smart textile materials become more and more popular nowadays and are widely used in various areas, allowing incorporation of built-in technological elements into everyday textiles and clothes.
- Most of the commercially available smart textiles are limited to **passive elements**, such as printed conductive elements (wires) or simple switches (buttons).
- Development of new materials may open a new opportunity for smart textiles by incorporating **active devices** such as buzzing elements or motion sensors into the garments.



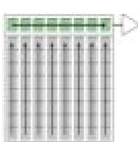
MIT Media Laboratory, Cambridge

Examples of Functions and Applications

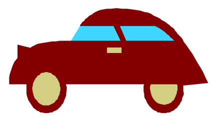

Drug delivery


Mechanical action

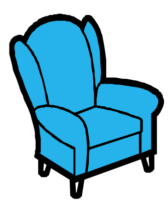

Lighting


Sensor

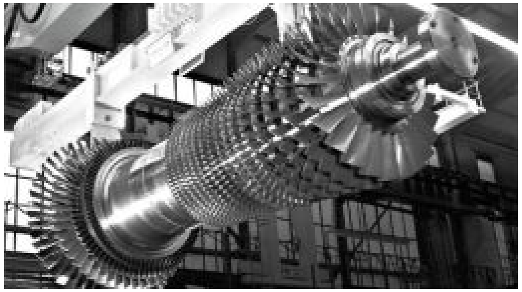

Medical: Smart bandage, auto sterilization uniform, active monitoring underwear


Transport: Luminous cabin, smart driver seat, auto clean filters


Workwear: Danger warning workwear (heating suite, high visibility, gas sensing, temperature sensing, movement sensing, alarm sounder


Consumer: Massage and cooling/heating armchair, surroundings customisation

3 | Smart Workwear



Smart Workwear

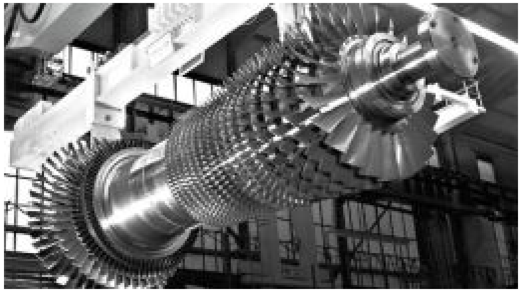
Intelligent clothing or smart clothing represents a combination of **active electronic components** that are embedded into the textile fibre and connected to classical electronic devices or components.

- 1 – Piezoelectric vibrator,
- 2 – Motion sensor,
- 3 – CO Sensor,
- 4 – Piezoelectric buzzer,
- 5 – Electroluminescent lights,
- 6 – Temperature Sensor.

Challenges

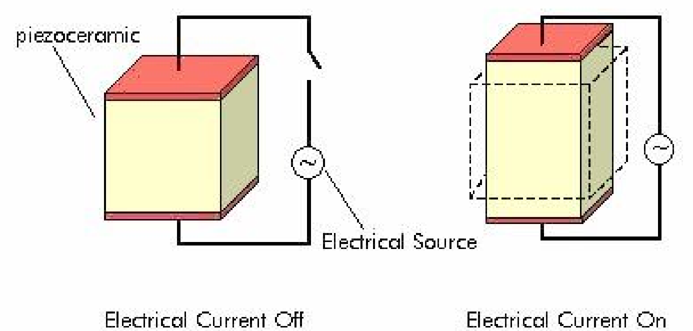
- Compatibility with flexible materials/fabrics,
- Compatibility with commercial printing techniques (e.g. pad-, screen-, or ink-jet printing),
- Low processing temperature,
- Reliability and ability to “survive” repeated washing,
- Low manufacturing cost,
- Suitability for large scale production.

4 | Flexible piezoelectric materials – PiezoPaint™



Piezoelectric materials

- Piezoelectric materials expand when subject to an electrical field, similarly they produce an electrical charge when strained,
- Ideal material for sensing and actuating applications.



http://www.piezomaterials.com

Typically, piezoelectrics are characterized by the **piezoelectric charge coefficient *d***, which is the ratio of electric charge generated to an applied force.

- However, most of the piezoelectric materials are manufactured at very high temperatures (around 900 – 1200 °C) and therefore are not compatible with textile.

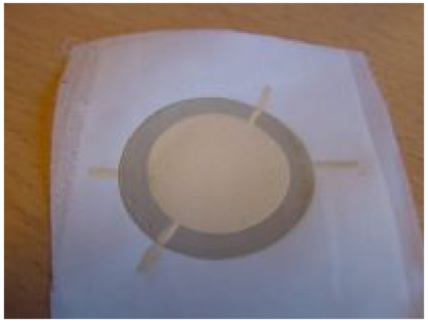
Flexible piezoelectric film - PiezoPaint™

Target goals for the development:

- Ultra low processing temperature (< 150 °C),
- Electrically active material which converts an electrical signal into mechanical excitation or vice versa,
- High piezoelectric activity (d_{33} > 15 pC/N),
- Flexibility and compatibility with screen- and pad-printing techniques,
- Reliability and low production cost.

Flexible piezoelectric film - PiezoPaint™

Low temperature flexible piezoelectric materials has been developed on the basis of commercially available piezoelectric PZT based ceramics and polymer materials.

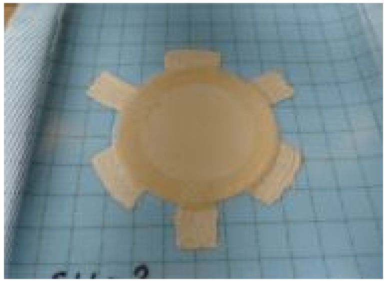


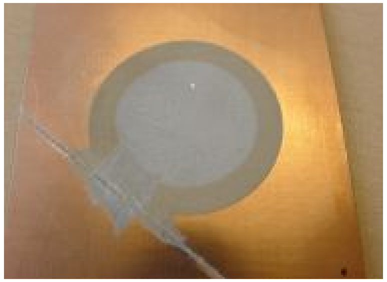
- Ultra low processing temperature (only 100 °C),
- High piezoelectric activity (d_{33} > 40 pC/N) and low dielectric losses (no power dissipation – no unnecessary heating),
- Flexibility and compatibility with screen- and pad-printing techniques,
- Low manufacturing cost and suitability for the large scale production,
- Ability to adjust the properties, depending on the final application.

PiezoPaint™ - The substrates

- Fabrics
- Textiles
- Composites
- Metals
- Plastics/polymers
- Laminates
- Ceramics
- Paper
- PCB
- Etc.

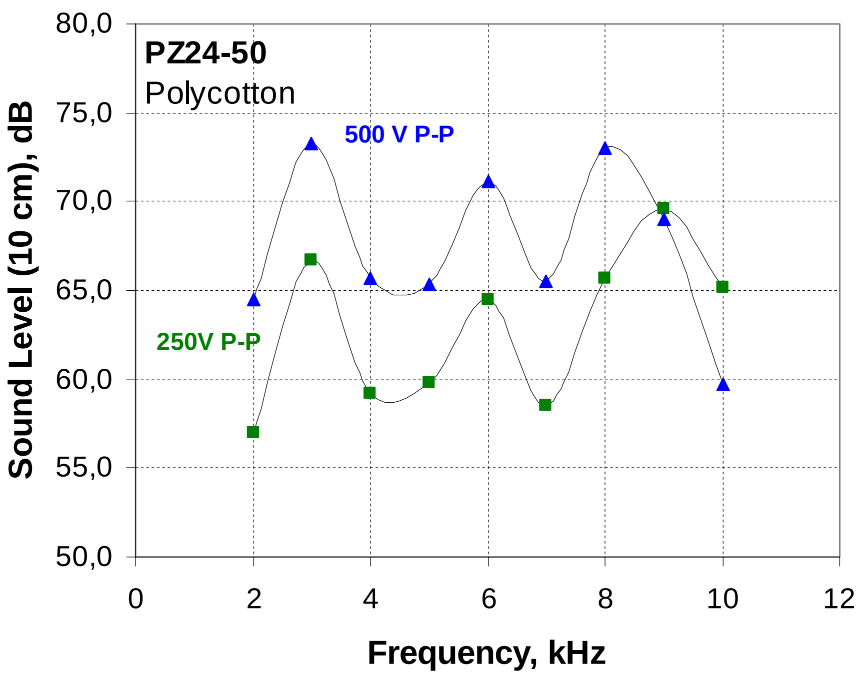

PiezoPaint™ on polymer

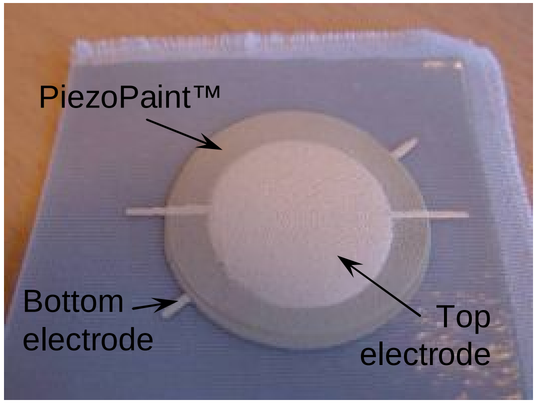

PiezoPaint™ on fabric


PiezoPaint™ on PCB

PiezoPaint™ - Examples

Piezoelectric buzzer on textile:

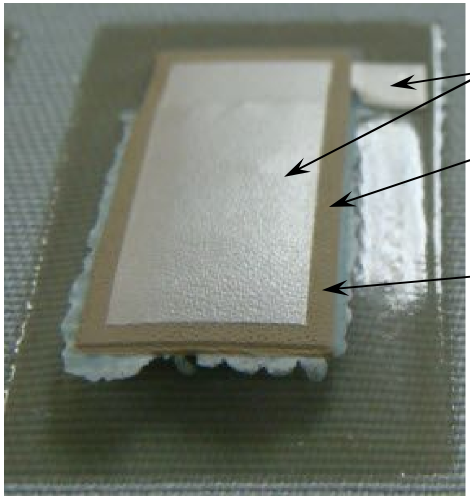


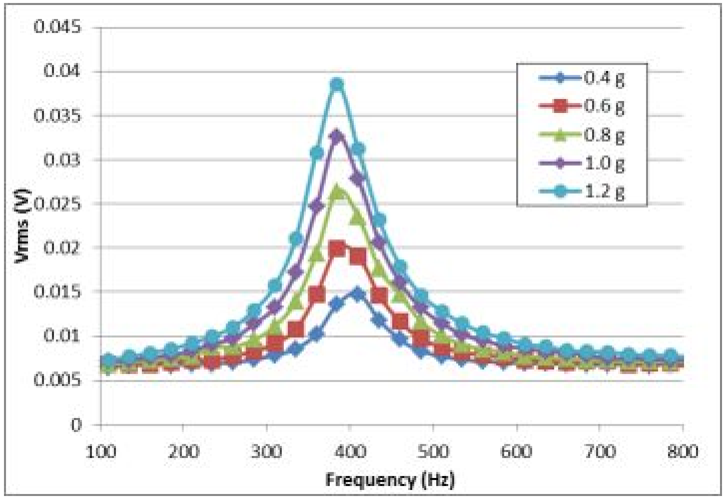


- » Up to 75 dB of sound pressure,
- » Flexible and can be applied on any structures, including the lab coats or workwear.

PiezoPaint™ - Examples

Piezoelectric accelerometer / energy harvester:



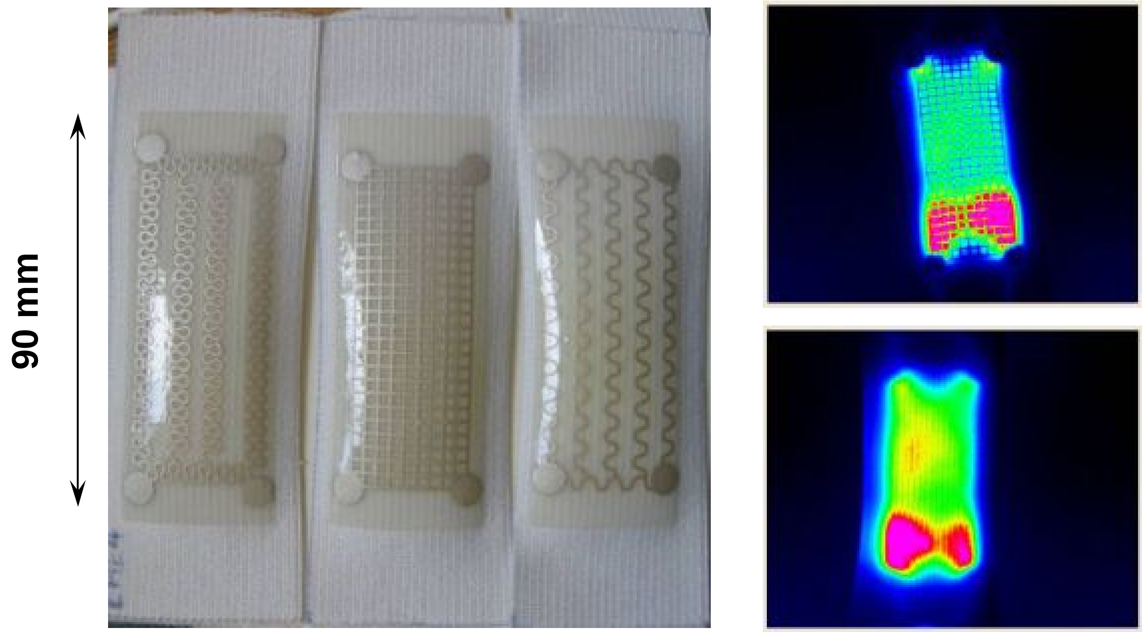


Courtesy of University of Southampton

» The sensor has good linearity and produces a peak output of nearly 60 mV which would be sufficient for a motion sensor detection system.

Other examples

Screen printed heating elements on fabric

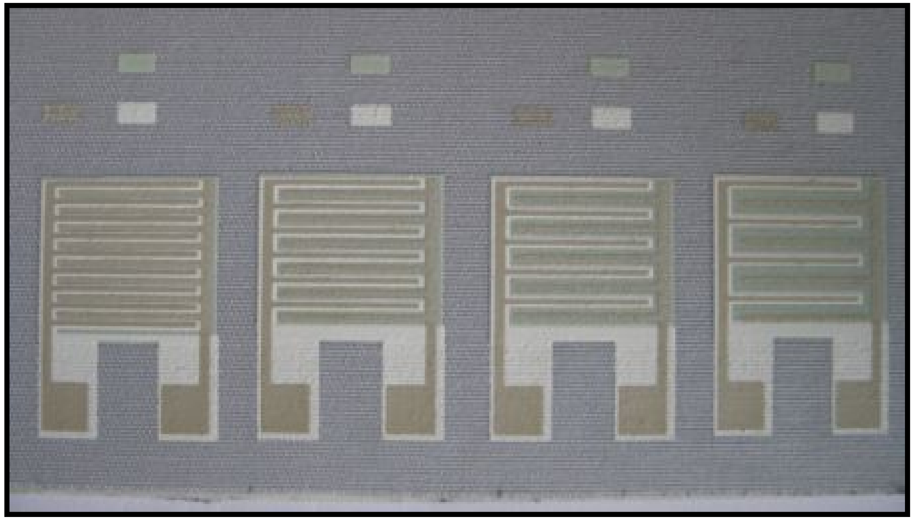


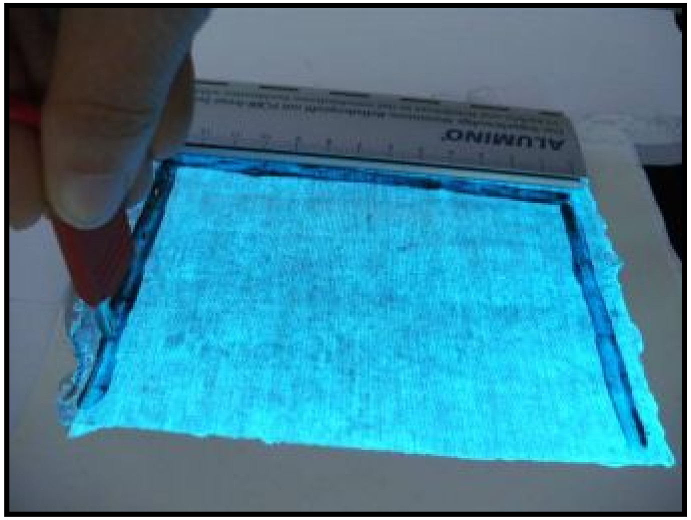
Courtesy of University of Southampton, UK and Elasta, Belgium

- Can be printed on a number of different fabrics,
- The heater provides a temperature range of 25 - 120 °C over an area of 100 cm^2.

Other examples

Screen printed electro-luminescent lamp on fabric

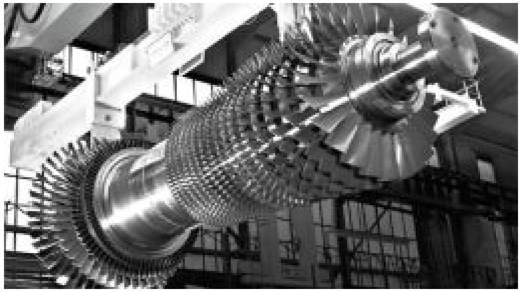




Courtesy of University of Southampton and IFTH (Institut Français du Textile er de L’Habillement)

- Printed on lab workwear, possibly on relatively large areas,
- Extremely robust and can be applied to any type of fabric.

5 Conclusions



Conclusions

- Smart textile materials become more and more popular nowadays and are widely used in various areas, allowing incorporation of built-in technological elements into everyday textiles and clothes.
- The Microflex project opens new prospects in terms of developing intelligent clothing and smart garments by incorporating **active devices** such as light emitting elements or motion sensors into the garments.
- This brings additional benefits for small- and medium size companies, creating opportunities for entering market of higher added value products.
- As CTS | Ferroperm we see a number of potential benefits for the company from being in the project, such as development of new products for different markets (Structural Health Monitoring in aerospace, Energy Harvesting etc), entering new markets with higher added value products, and establishing cutting edge background technologies in the field of e.g. piezoelectric materials and devices.

Acknowledgments

7th Framework Programme: Micro fabrication production technology for MEMS on new emerging smart textiles/flexibles - MICROFLEX

Special thanks to all Microflex partners and CTS | Ferroperm Denmark Team :

- Dr Tomasz Zawada,
- Dr Erling Ringgaard,
- Karsten Hansen,
- Lise Nielsen.

Thank you