

Flexible piezoelectric materials for smart textile application

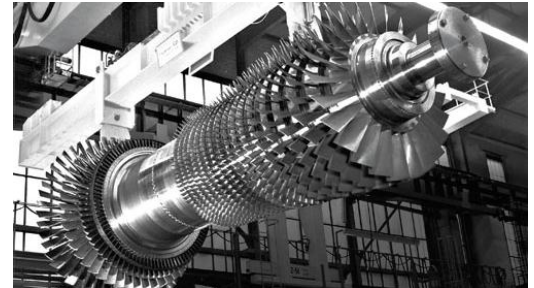
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MEGGITT A/S, MSS, Denmark

Outline

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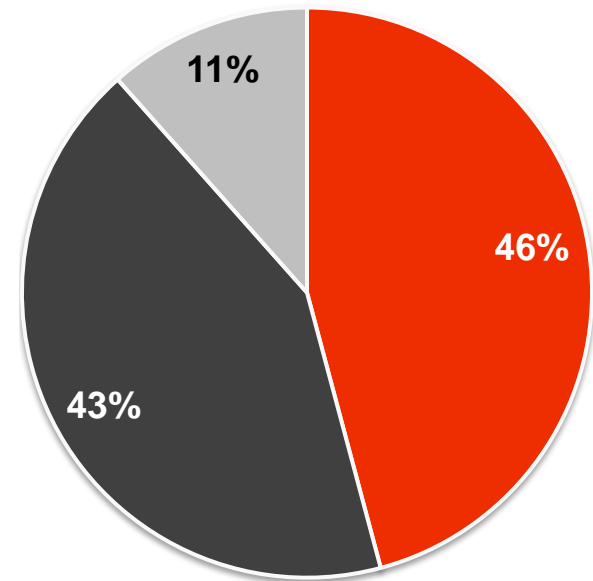
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Company introduction



Meggitt - 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)

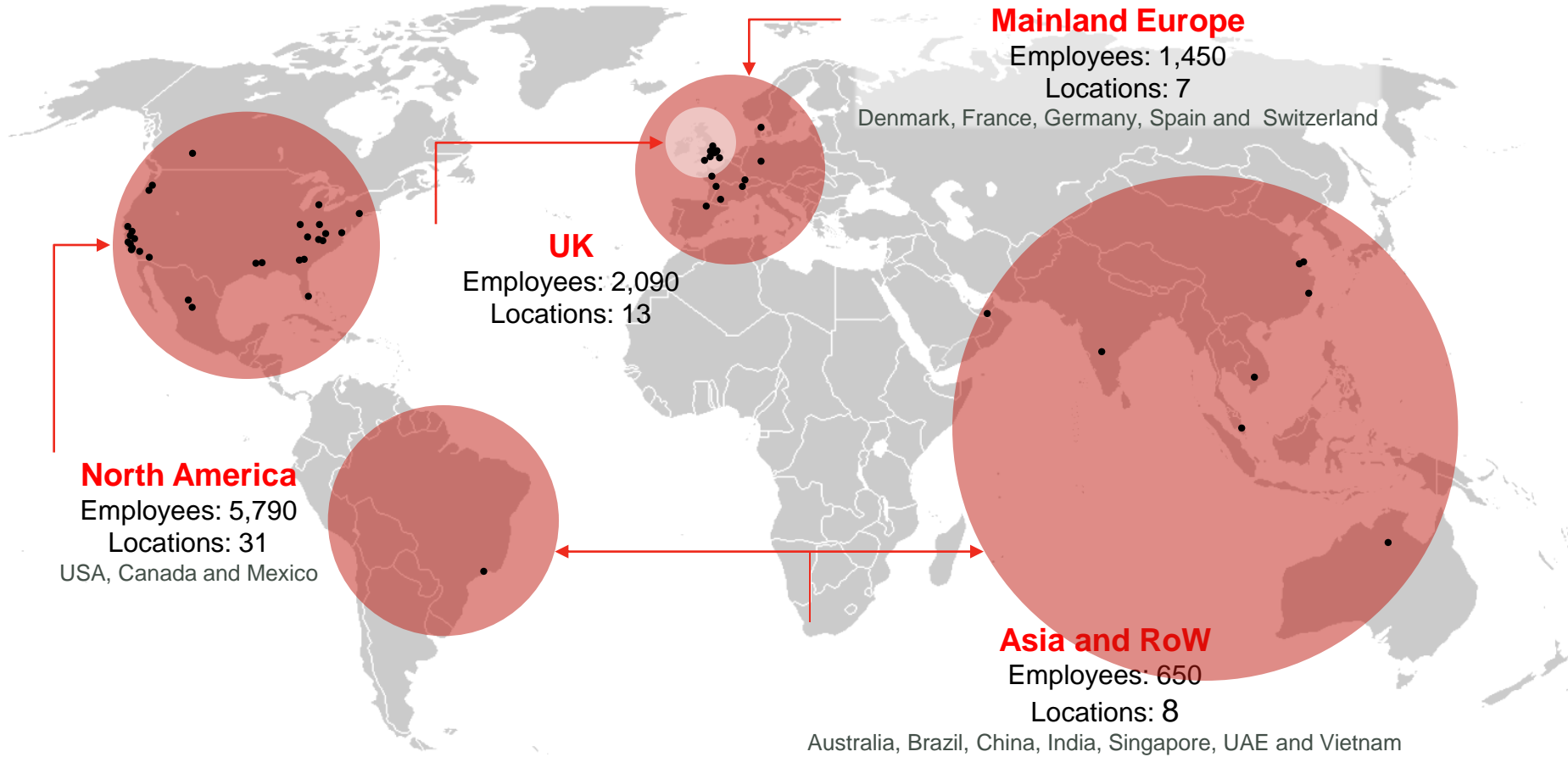


OE 52% / Aftermarket 48%

- Civil aerospace
- Military
- Energy and other

A global presence

9,980
employees worldwide



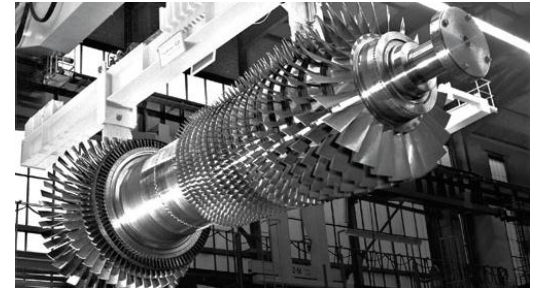
Meggitt Sensing Systems Denmark

- » Meggitt A/S is 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



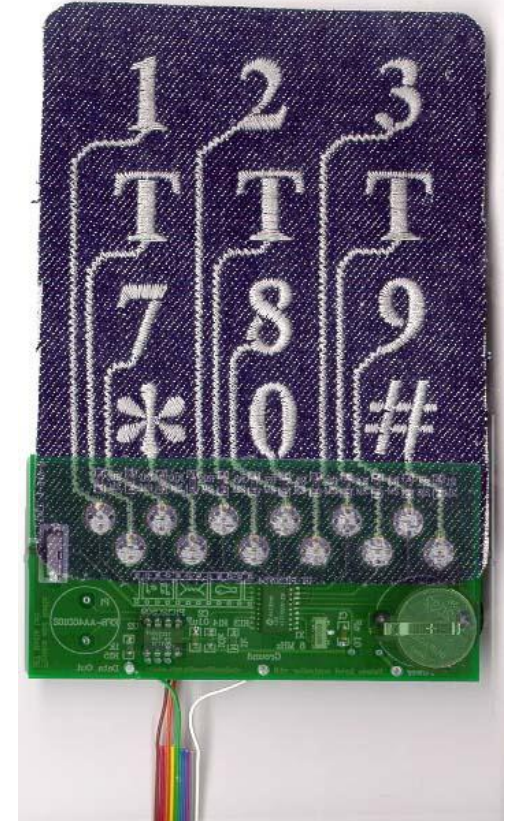
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Smart Workwear



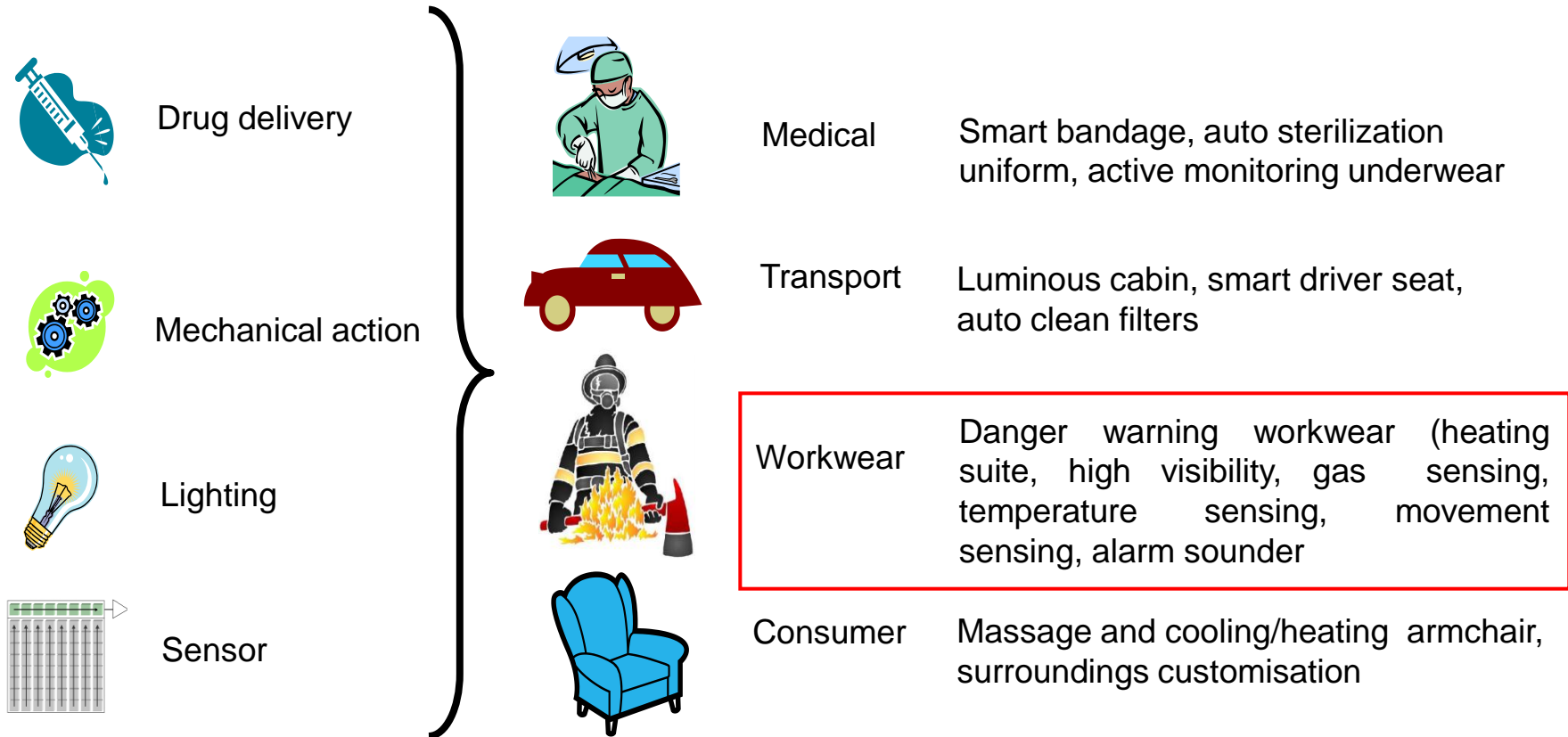
Smart Textile

- » 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



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.

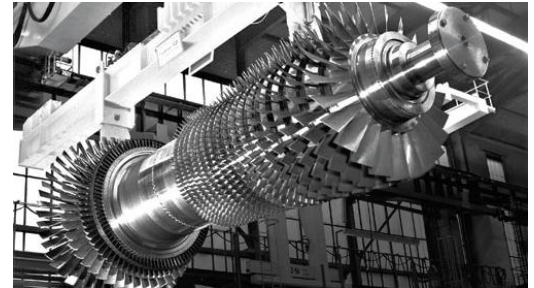


Challenges

- » 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 and suitability for large scale production.

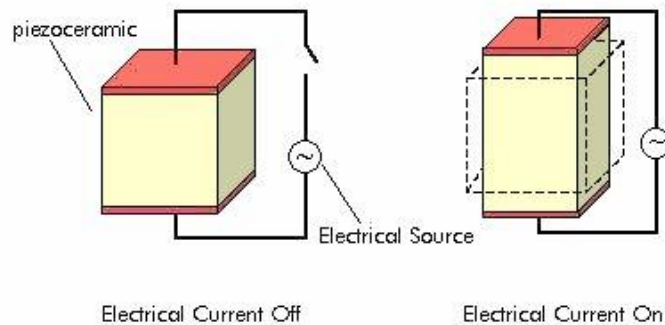
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Flexible piezoelectric materials – PiezoPaint™



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.



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.

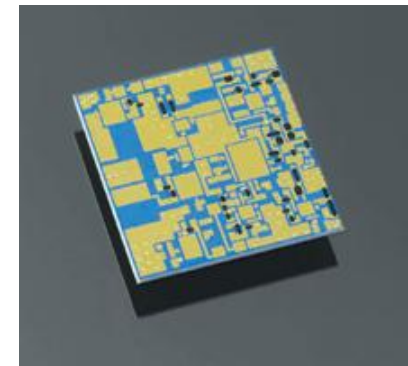
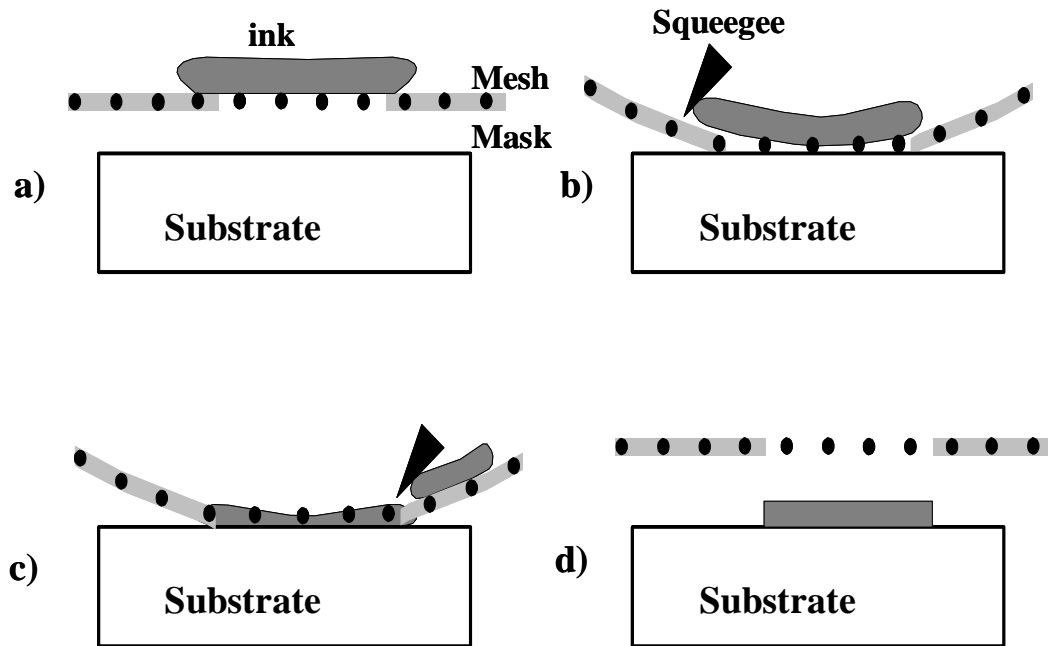
Flexible piezoelectric film - PiezoPaint™

Target goals for the development:

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

Screen printing

Also known as thick-film printing, this is normally used in the fabrication of hybrid circuits and in the manufacture of semiconductor packages.

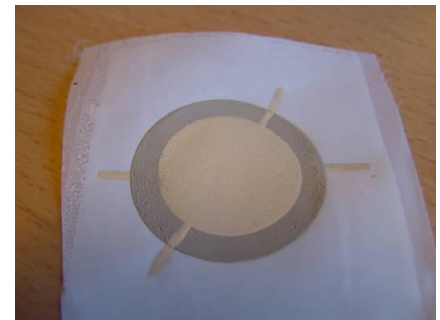


Courtesy of University of Southampton, UK

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.

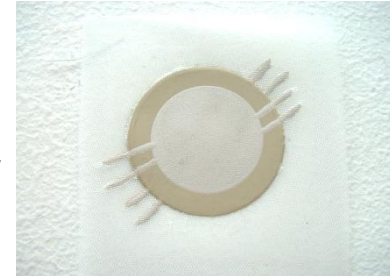
- » Ultra low processing temperature (only 100 °C),
- » High piezoelectric activity ($d_{33} > 40$ pC/N) and low dielectric losses (no power dissipation – no unnecessary heating),
- » Flexibility and compatibility with screen- and pad-printing techniques,
- » Low manufacturing cost and suitability for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



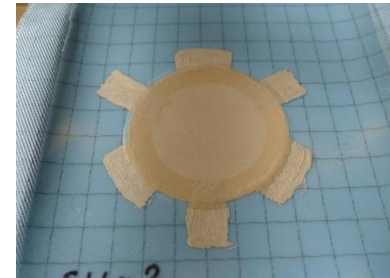
PiezoPaint™ - The substrates

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

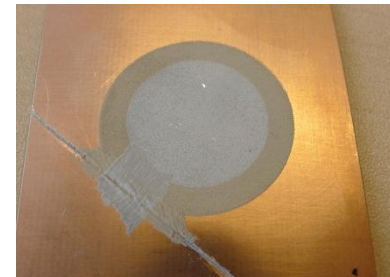
PiezoPaint™ on polymer



PiezoPaint™ on fabric

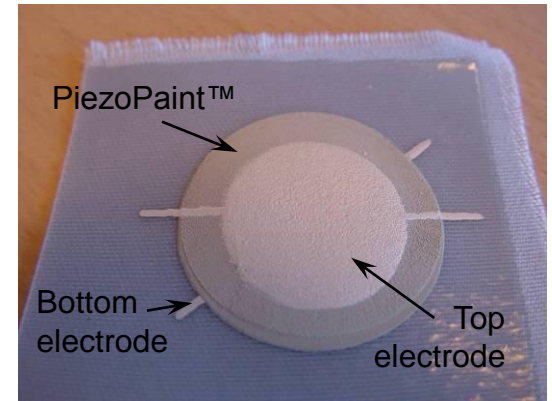
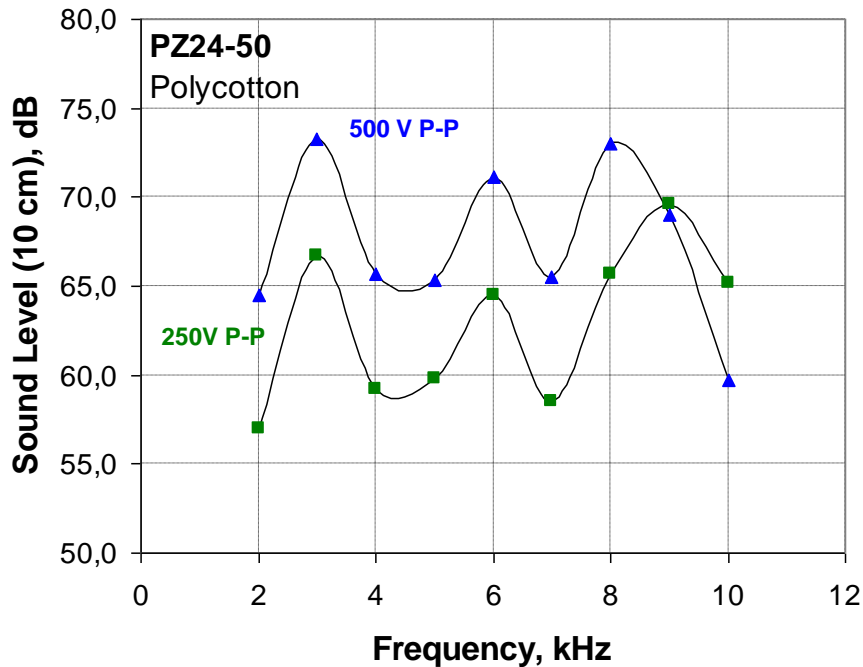


PiezoPaint™ on PCB



PiezoPaint™ - Examples

Piezoelectric buzzer on textile:

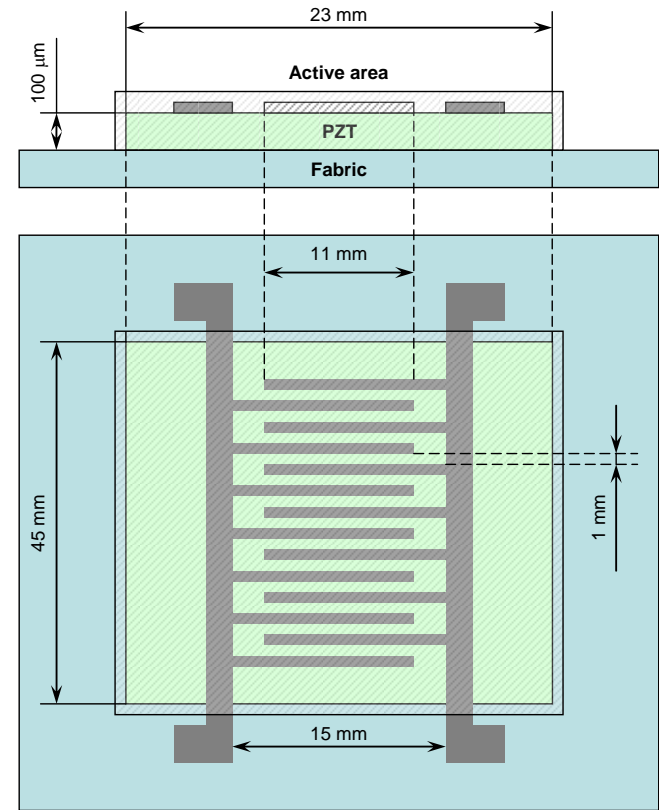
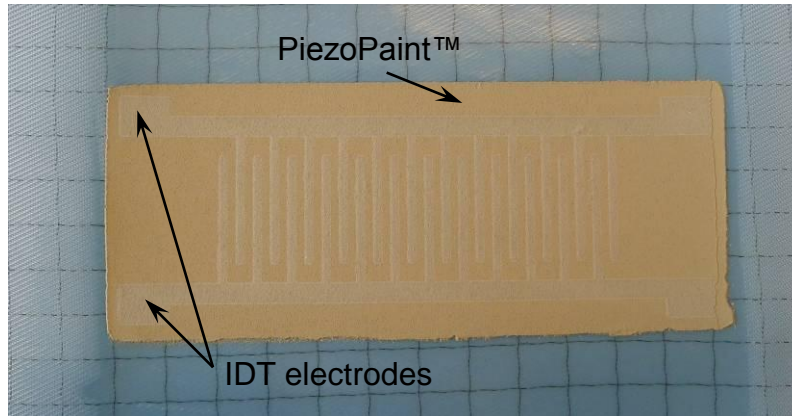


- » Up to 75 dB of sound pressure,
- » Flexible and can be applied on any structures, including the lab coats or workwear.

PiezoPaint™ - Examples

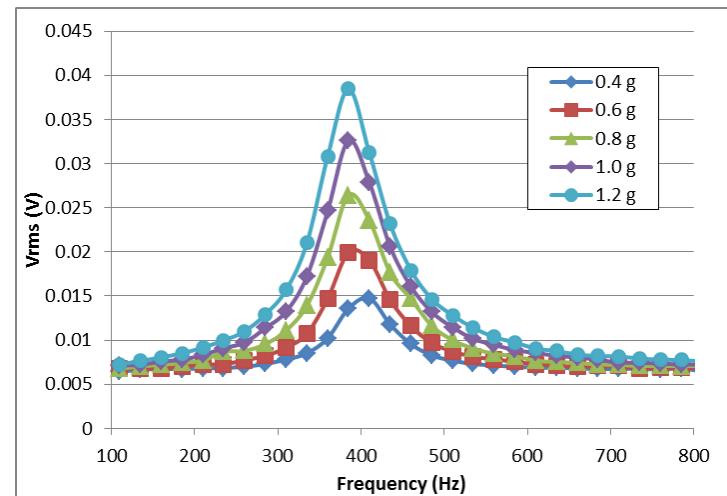
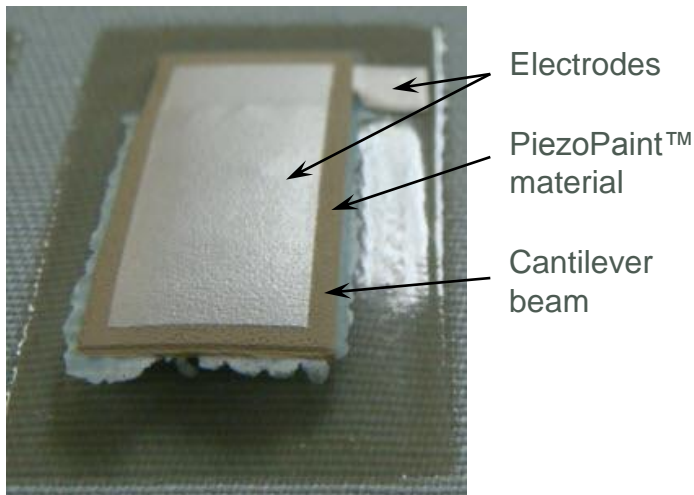
Piezoelectric motion sensor:

- » Printed on lab coat's sleeve,
- » The sensor is connected to the workwear's control system and sensing the bending of the sleeves.
- » The level of output signal is about 100mV,



PiezoPaint™ - Examples

Piezoelectric accelerometer / energy harvester:



Courtesy of University of Southampton, UK

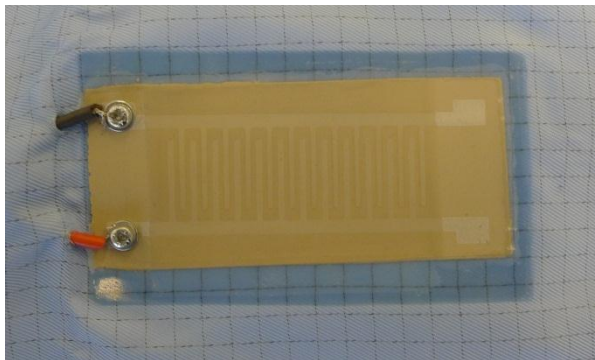
- » The sensor has good linearity and produces a peak output of nearly 60 mV which would be sufficient for a motion sensor detection system.

PiezoPaint™ - Lab coat prototype

Piezoelectric buzzer

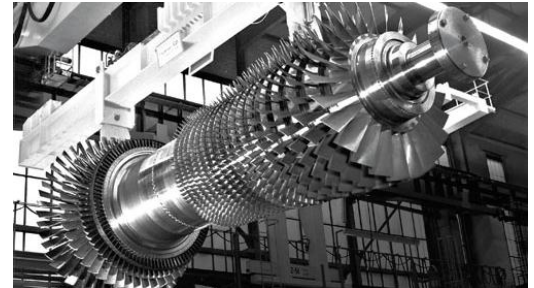


Piezoelectric motion sensor



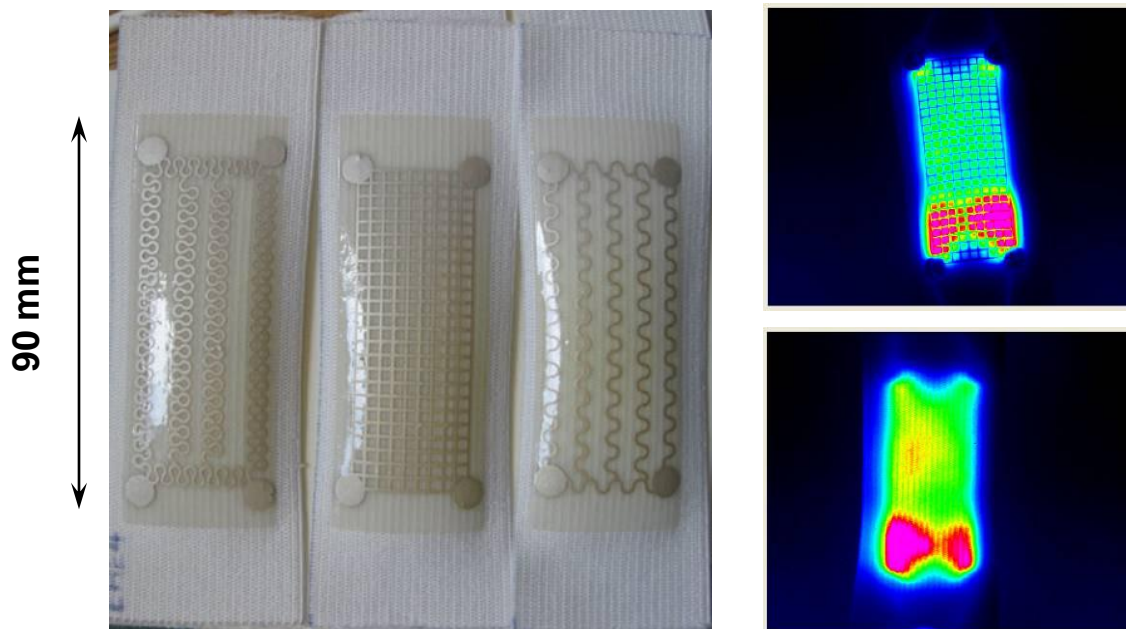
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Examples of smart textiles



Other examples

Screen printed heating elements on fabric

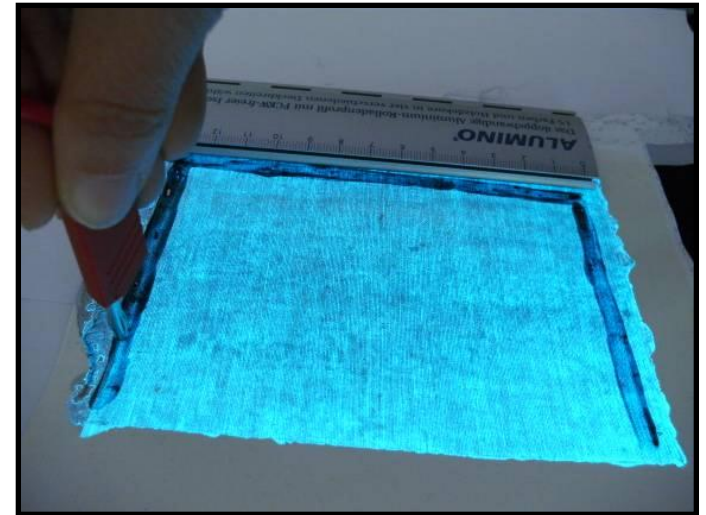
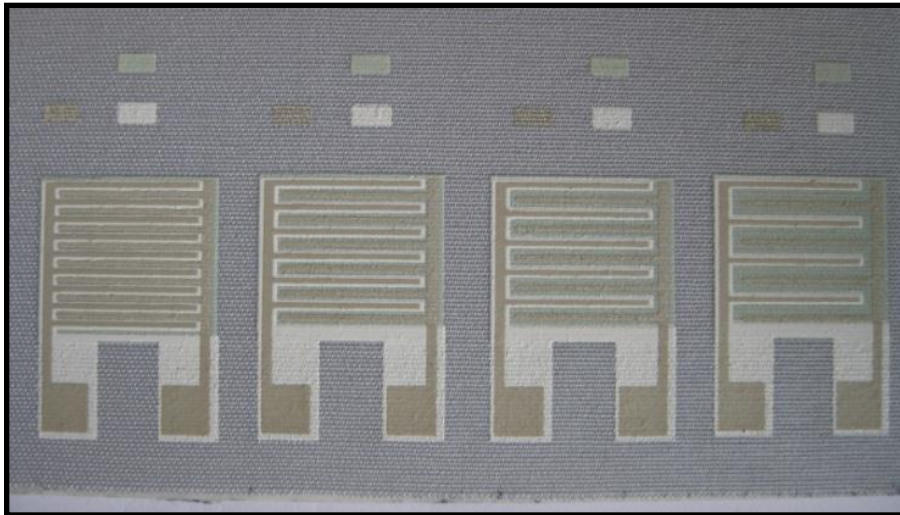


- » Can be printed on a number of different fabrics,
- » The heater provides a temperature range of 25 - 120 °C over an area of 100 cm².

Courtesy of University of Southampton, UK and Elasta, Belgium

Other examples

Screen printed electro-luminescent lamp on fabric

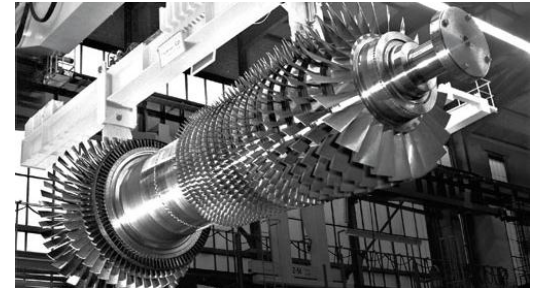


Courtesy of University of Southampton, UK and IFTH (Institut Français du Textile et de L'Habillement)

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

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Conclusions



Conclusions

- » The development of intelligent clothing and smart garments by incorporating **active devices** such as light emitting elements or motion sensors into the garments brings additional benefits for textile industry, creating opportunities for entering markets of higher added value products.
- » PiezoPaint™ printable piezoelectric material enables design and manufacturing of sensors, actuators and transducers on a variety of flexible substrates, including textiles and polymers.
- » As Meggitt Sensing Systems we see a number of potential benefits for the company from entering this research field, 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 EU Framework Programme: Micro fabrication production technology for MEMS on new emerging smart textiles/flexibles - MICROFLEX



Special thanks to all Microflex partners and Meggitt Sensing Systems Denmark Team :

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

Thank you

