Conductive Textiles: Towards True Wearable Technology

Chris Hunt, Roya Ashayer-Soltani, Kathryn Wills
National Physical Laboratory
Who we are….And what we do…. 

- The UK’s national standards laboratory 
- Founded in 1900 
- World leading National Measurement Institute 
- ~700 staff; 500+ specialists in Measurement Science 
- State-of-the-art laboratory facilities 
- The heart of the UK’s National Measurement System to support business and society 
- Experts in Knowledge Transfer 
- Multidisciplinary R&D and technical services for public and private sector
Conductive Fabrics

• Novel printable technology
• Works with different types of textiles
• Provides flexibility of design
• Comfortable to wear
Why Wearable Technology?

Increasing demand for wearable electronics from industries such as:

- Medical and Healthcare
- Sport and fitness
- Consumer electronics
- Fashion and entertainment
- Protection and Safety
- Transportation
Market Value and Growth

• The overall size of the global smart textile market is expected to grow at a CAGR of 24.1% from 2013 to 2020. *(IDTechEx)*

• The wearable electronics business powers from over $14 billion in 2014 to over $70 billion in 2024. *(IDTechEx)*

• **Smithers Apex** are forecasting the Compounded Annual Growth rate (CAGR) of 30% 2016-21

• The overall size of the global smart textile market is expected to grow at a CAGR of 24.1% from 2013 to 2020. *(PRWEB)*
Europe smart textile market by end-use, 2012 – 2020 (USD Million)

http://www.grandviewresearch.com
Sports & Healthcare

Image courtesy of Philips Blue Touch Pain Relief Patch

Image courtesy of Edema ApS

Image courtesy of Zegna Urban

Image courtesy of LEO fitness wearable
Fashion and Entertainment

Image courtesy of Sound reactive Thunderstorm dress Amy Winters

Image courtesy of t-shirtv.com

Image courtesy of Reuters
The Future of Wearables

Wearable
Visible

True wearable
Hidden
Fabric Manufacturing Types

Knitted Fabric  Woven Fabric  Non-Woven Fabric
Interconnect Solution

Sensor or Device

Micro-Controller

Battery

Communication
Available Technologies:

• Adding metal wires or threads into the textile.

• Printing/deposition of conductive polymers.

• Printing metallic inks on to the surface.

• Plasma deposition on the threads.
Current Challenges

- To run a connection in any direction on any textile.
- Weaving and knitting present severe limitations in this regard.
- Textiles should feel comfortable to wear.
- Additive processes are more flexible, and in principle will work with all textiles.
NPL: Patent Technology

Conductive Fabrics

- Novel printable technology
- Works with different types of textiles
- Provides flexibility of design
- Comfortable to wear
NPL Conductive Fabric

- Unique patent-pending technique, developed at NPL.
- All individual fibres coated with nano-metal (typical thickness = 20nm).
- Additive deposition is throughout the fabric with excellent adhesion, that allows the fabric to stretch and does not effect the drape and handle.
Conductive fabric Process

1. Alkaline Treatment

2. Linker ~ cationic polyelectrolyte

3. Immersion in Electroless Cu solution

4. Fibre encapsulated with Cu

5. Nano metal
Nano-metal coated Cotton fabric
Nano-metal coated silk fabric
Additive Metallic Layer Thickening

SEM images of electroless plating

Electroless plating to bring conductor layer 1 µm
Resistivity $R = 0.2\Omega/□$(Cotton)
Woven Fabric
Knitted Fabric

http://www.youtube.com/watch?v=skgGYFpT1Vc
Coating a Wide Range of Fabrics

- Jersey Cotton Tubular (R=0.2 Ω/□)
- Polyester (R=0.1 Ω/□)
- Linen (R=0.06 Ω/□)
- Non Woven (R=0.006 Ω/□)
Conductive Thread

Fibres before Cu plating of threads

Cu plated thread

Conductive thread used in a circuit to light an LED
Sprayed

Conductive

Not Conductive
Inkjet Printed

DMP Printer
Dyed Fabric
Conductive Fabric With Thermochromic Ink

a) Without Current

b) Using current
Antimicrobial Effect (Nonwoven)
AATCC 147_2004 method

Nanosilver stage

Staphylococcus aureus (ATCC 25723)
Klebsiella pneumoniae (NCTC 5055)
Escherichia coli (K12)
Bare Sample
Wash Test

To evaluate the robustness of the adhesion of the nano metal layer attachment to textiles fibers

- Wash test was devised based on what would be expected from potential end users of conductive textiles. Therefore a washing machine and commercially available detergent used (Fairy Non-Bio)

- Effluent water was collected and tested using ICP-OES

- Measured values of the change in resistance with following successive wash cycles
Wash Cycles (Cotton Jersey)
Stretch versus Resistance

Knitted fabric
Key Advantages of NPL Process

- Suitable for woven, knitted and non-woven.
- Comfortable to wear, no effect on drape and handle
- An aqueous process
- Can be inkjet printed
- Free form tracks
- Can be dyed
- Can be antimicrobial
- Can be stored prior to plating
Looking for partners to help us:

• integrate the NPL technology into commercial products for specific applications.

• manufacture the NPL conductive fabric on a large scale.
Thank you