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Smart Textiles and New Ways of Production

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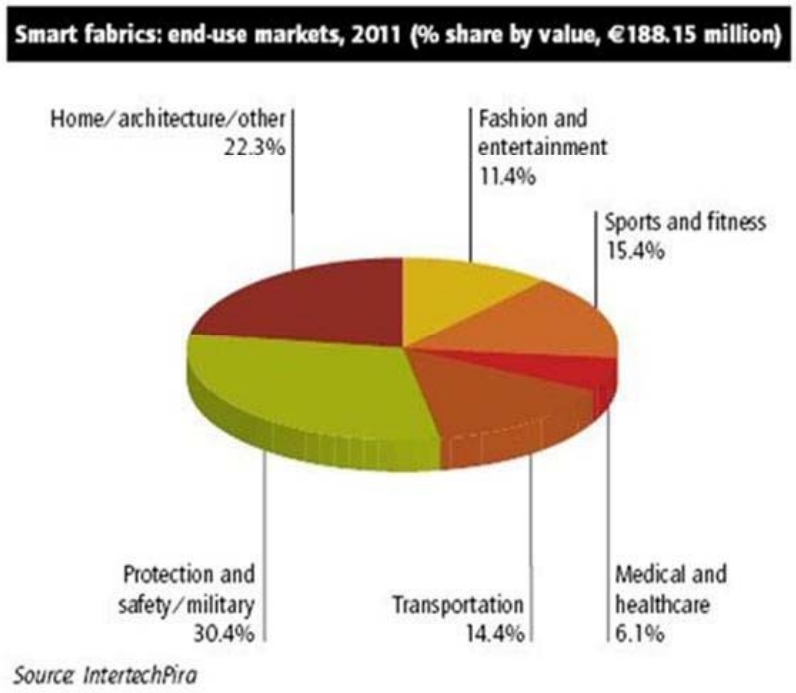
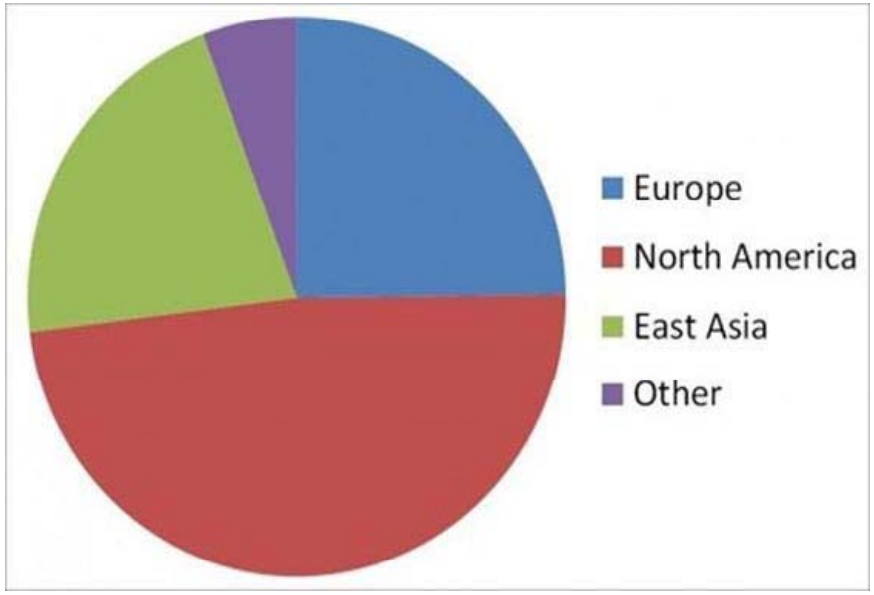
Smart Textiles for Wearable Technology



Increasing demand for wearable electronics from industries such as:

- Medical and Healthcare
- Sport and fitness
- Consumer electronics
- Defence applications

Market Value and Growth



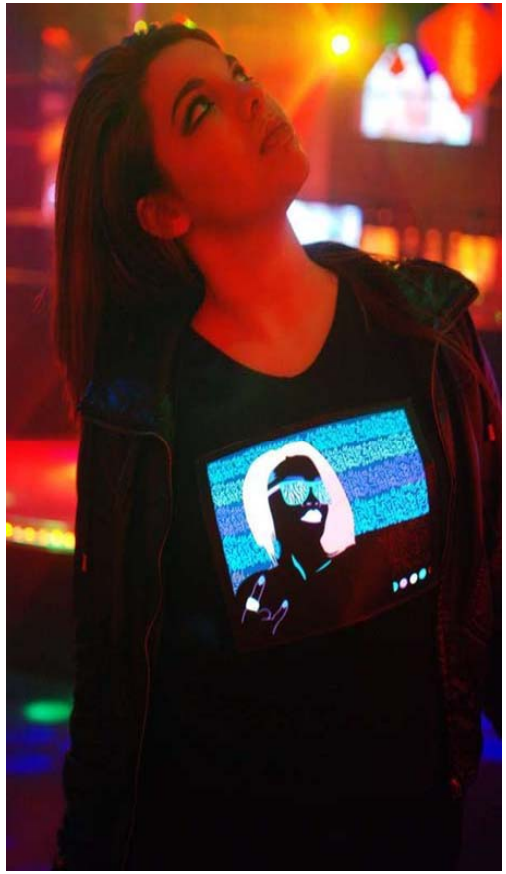
- **The wearable electronics business powers from over $14 billion in 2014 to over $70 billion in 2024. *(IDTechEx)***
- **The overall size of the global smart textile market was estimated to be USD 289.5 million in 2012 and expected to exceed USD 1,500 million by 2020 (PRWEB)**
- ***Smithers Apex* are forecasting the Compounded Annual Growth rate (CAGR) of 30% 2016-21**

Sports & Healthcare

Philips Blue Touch Pain Relief Patch

Talktomyshirt.com

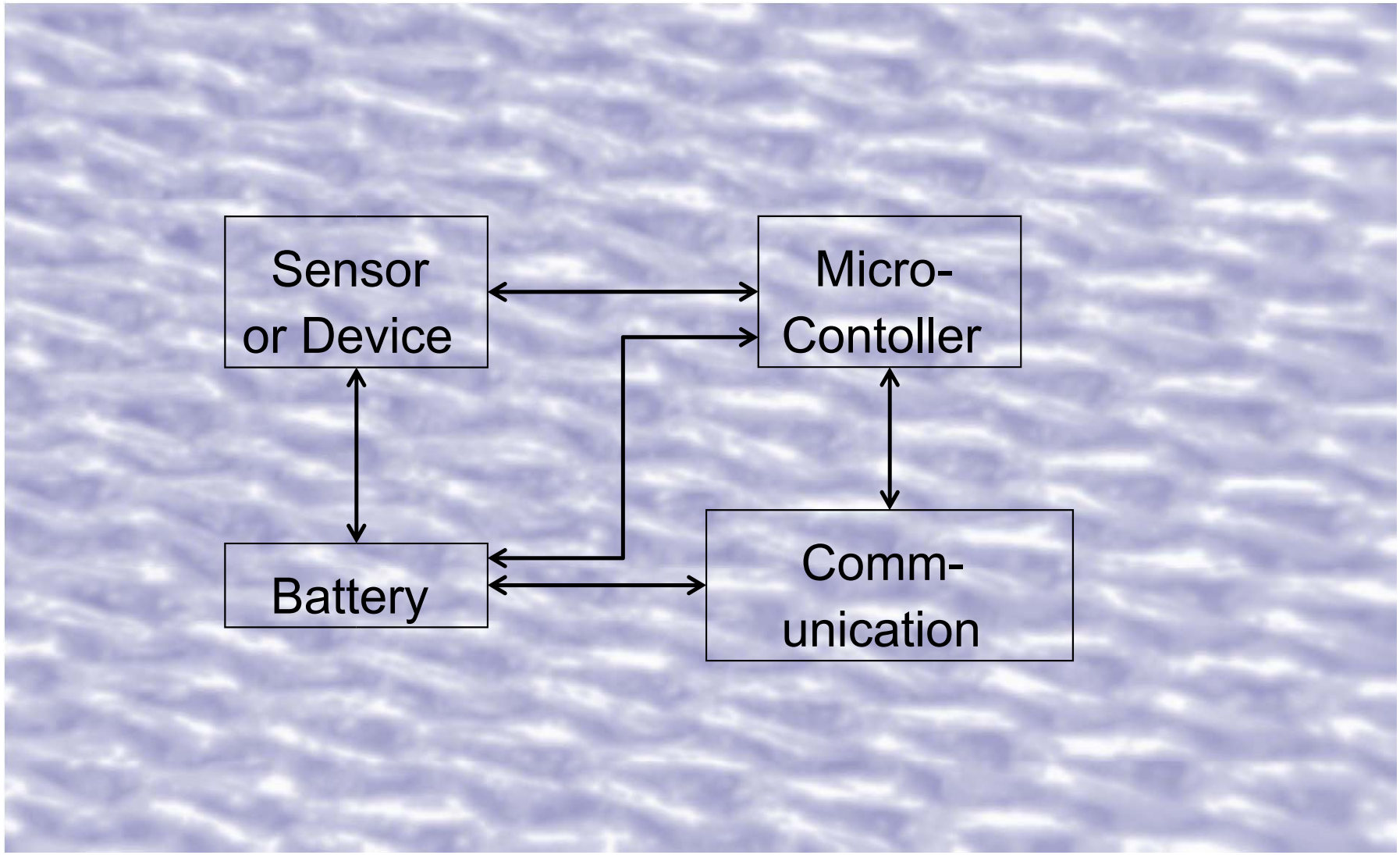
Fashion



Sound reactive Thunderstorm dress
Amy Winters

Photo by Reuters

Interconnect solution

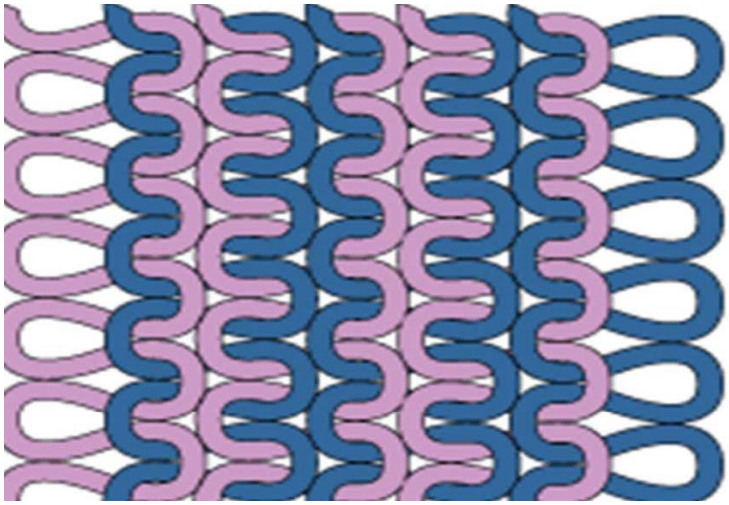


Conductive Fabrics

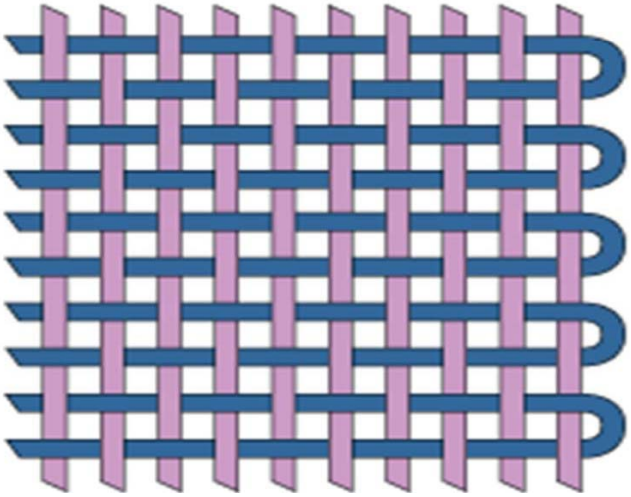
Current technologies used for conductive textiles include:

- **Weaving of separate metal threads into the textile.**
- **Printing/deposition of conductive polymers.**
- **Printing metallic inks on to the surface.**
- **Plasma deposition on the threads**
- **Electroless plating**

Fabric Types



Knitted

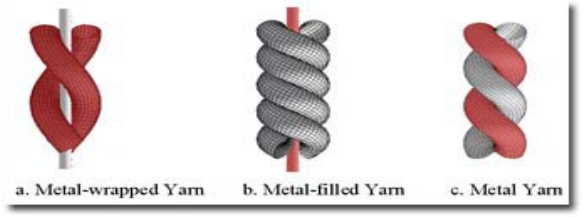


Woven

And non-woven !

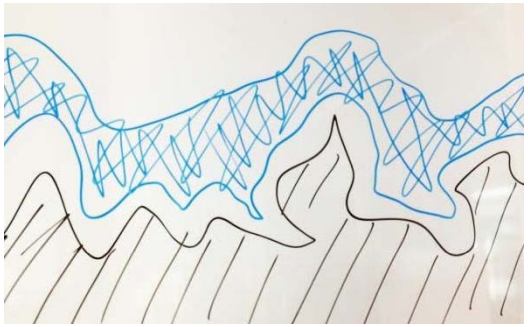
Attachment

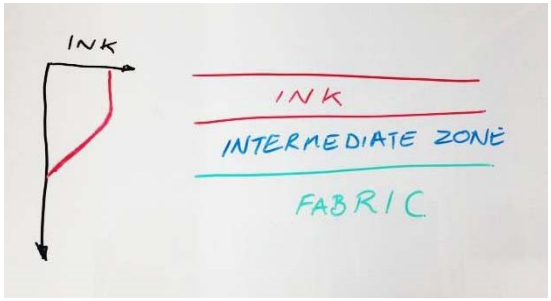
- Conductive Yarn



These systems perform poorly when the underlying fabric is stretched, bent or twisted

- Printing
- Physical Attach
- Hydrogen Bonded





What is needed is a conductive medium that can follow the fibres, ideally without affecting their ability to deform

- Penetrating System

Available Technologies

1. Weaving or knitting metal wires into the textile

- **E.g. Plug&Wear, 100% metal knitted fabrics. Either tin/ copper or silver/copper**

- **However, metal wires can break easily during the manufacturing and during use**
- **Limited elasticity, adds weight to garment**

Available Technologies

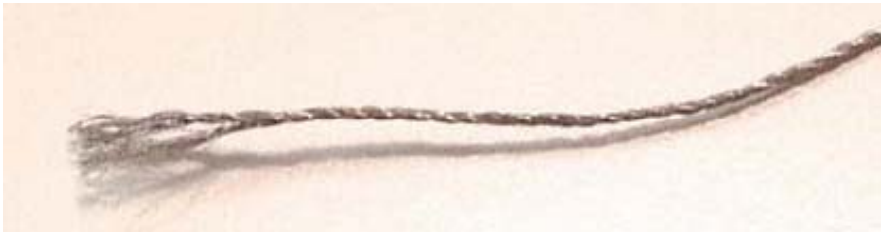
2. Weaving or knitting conductive threads into the textile

- Most threads are metallised with an alloy of metals, such as silver, copper, tin, nickel
- The core is normally cotton or polyester
- Examples include Shieldex (nylon/silver)
- Swicofil (aluminium metallized polyester)
- Karl Grimm (threads have thin flattened wires wrapped around them, stiffer than metallised yarns)
- ARACON® brand metal clad fibres, outer metal coating on Kevlar fibres

Available Technologies

2. Weaving or knitting conductive threads into the textile (cont)

- Significant differences in conductivity/resistivity
- Commonly sold as 2-ply or 4-ply (4-ply contains twice as much metal as 2-ply)
- Issues with robustness, e.g. can't always withstand elongation stresses during textile manufacturing or use
- Possible stress cracks in metal plated yarns
- Conductive thread tends to fray and the stitches can become loose



Available Technologies

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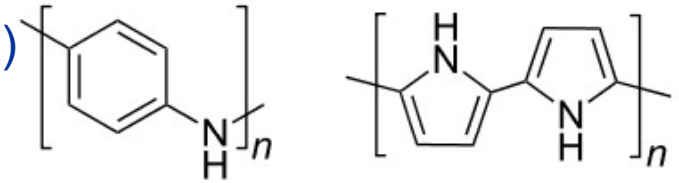
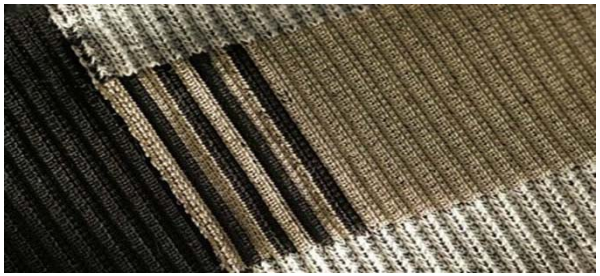
3. Deposition/coating of conductive polymers

- E.g. polyaniline (L), polypyrrole (R)



- Either purchased as solids or disperse solutions. Can be applied via polymer coating, or polymerisation of monomer on the textile surface also possible
- E.g. Textronics, “Textro-Polymers”, which can take the form of a fibre, a film, or a coating, provide a predictable conductivity change with stretch



Available Technologies

3. Deposition/coating of conductive polymers (cont)

E.g. EeonTex™ conductive textiles from Eeonyx. A propriety coating system suitable for a range of substrates (e.g. wovens, non-woven, polyester, nylon, glass, spandex, aramids)

- Fibres coated with doped polypyrrole
- Controllable surface resistivity between 10 and 106Ω/sq

Bomb suit made with EeonTex™, eliminates static

Available Technologies

4.Printing conductive inks

Conductive component can be copper, silver, carbon (ink, paint, pastes, pens)

Application methods include screen printing, inkjet printing, flexography

Suppliers include Dupont, Henkel, GEM

Available Technologies

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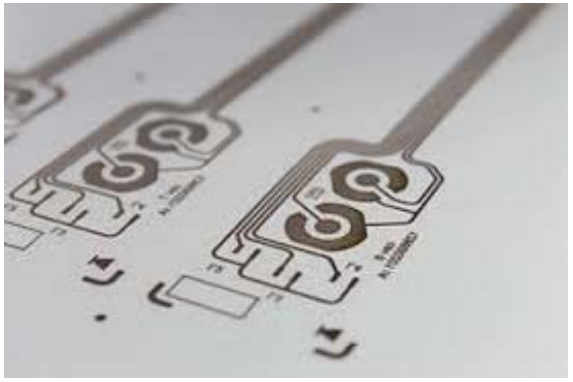
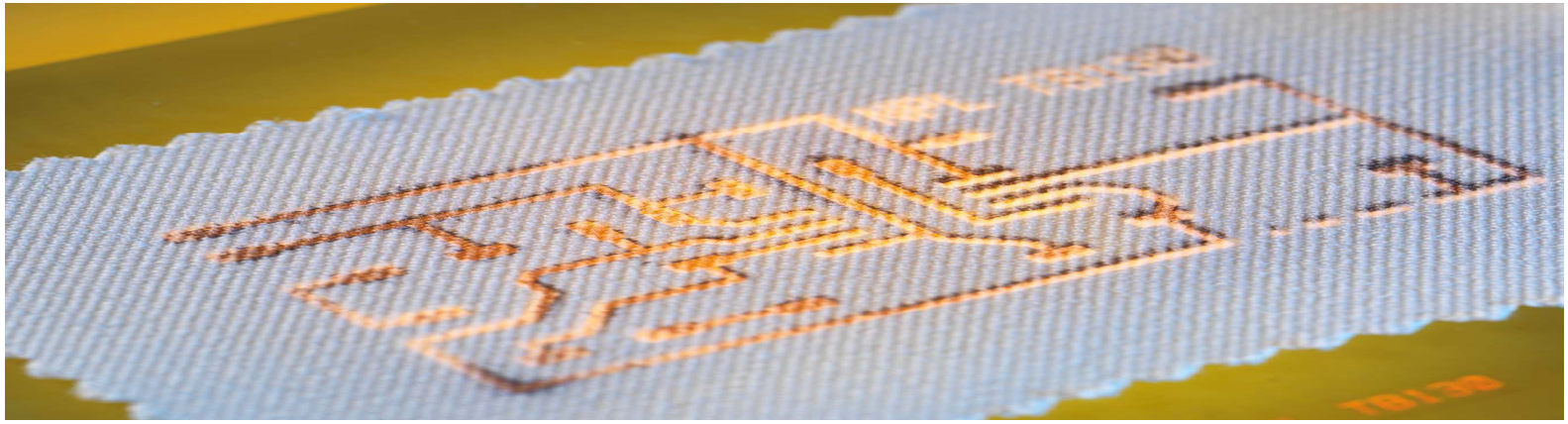
4.Printing conductive inks (cont)

- Good conducting ability, e.g. DuPont CB200 copper conductor for screen printing, sheet resistivity is 20-30 mΩ/sq
- The main issue with inks is cracking on the uneven fabric surface → loss of conductivity
- Also processing, some need heat/UV curing

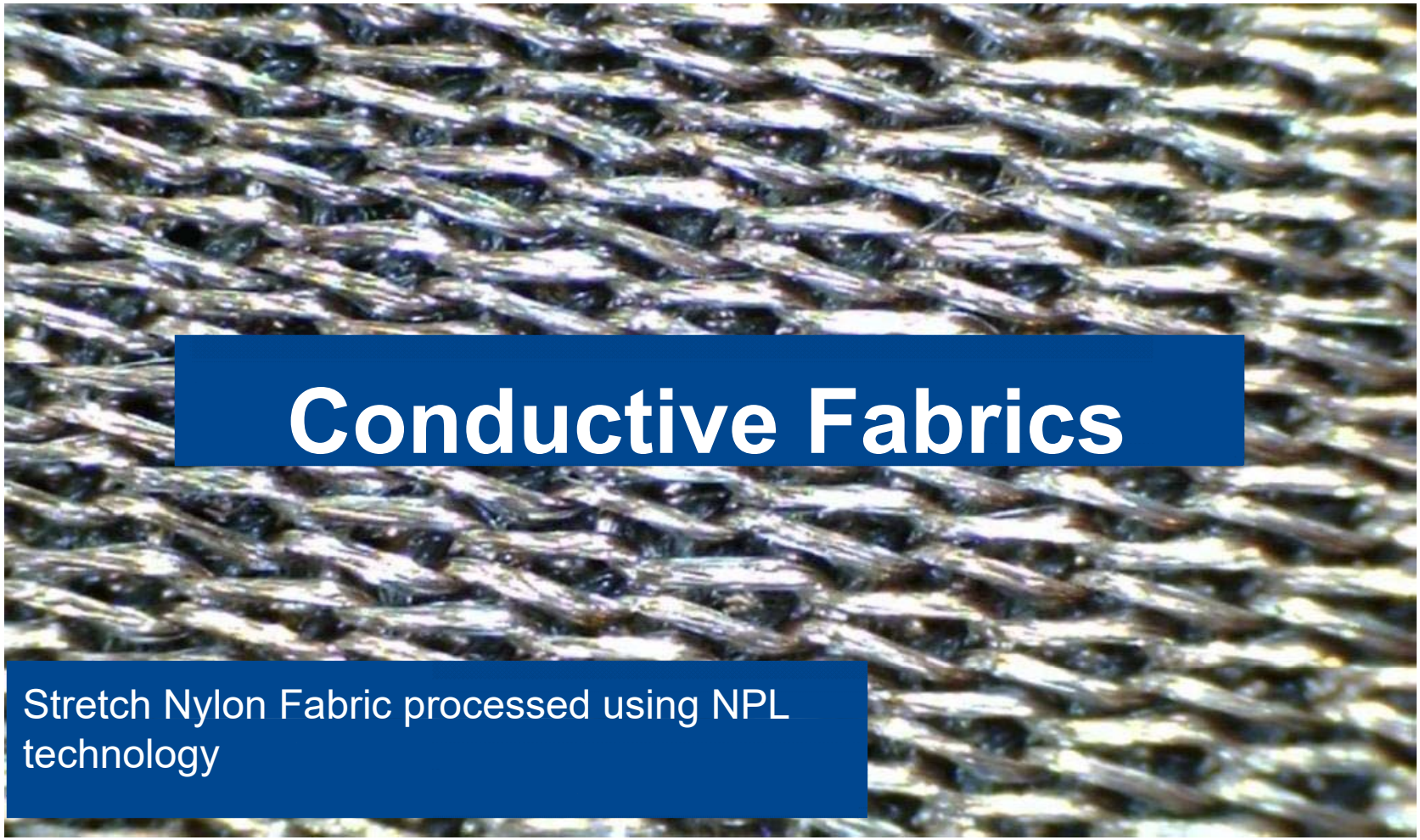


Patterning

- Future requirements will be to run a connection in any direction on any textile.
- Weaving and knitting present severe limitations in this regard
- Additive processes are more flexible, and in principle will work with all textiles

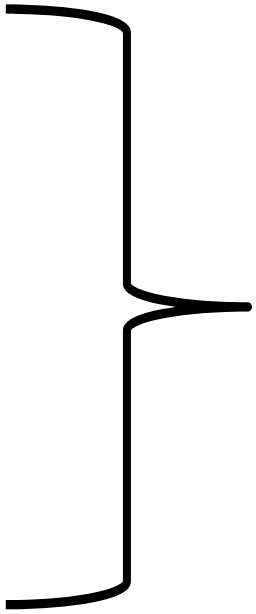


Invented by National Physical Laboratory UK



Conductive fabrics

- Processes
  - Fabric surface pre-treatment
  - Fabric surface charge modification stage
  - Metal seed layer deposition
  - Electroless plating to thicken metal layer
  - Surface passivation

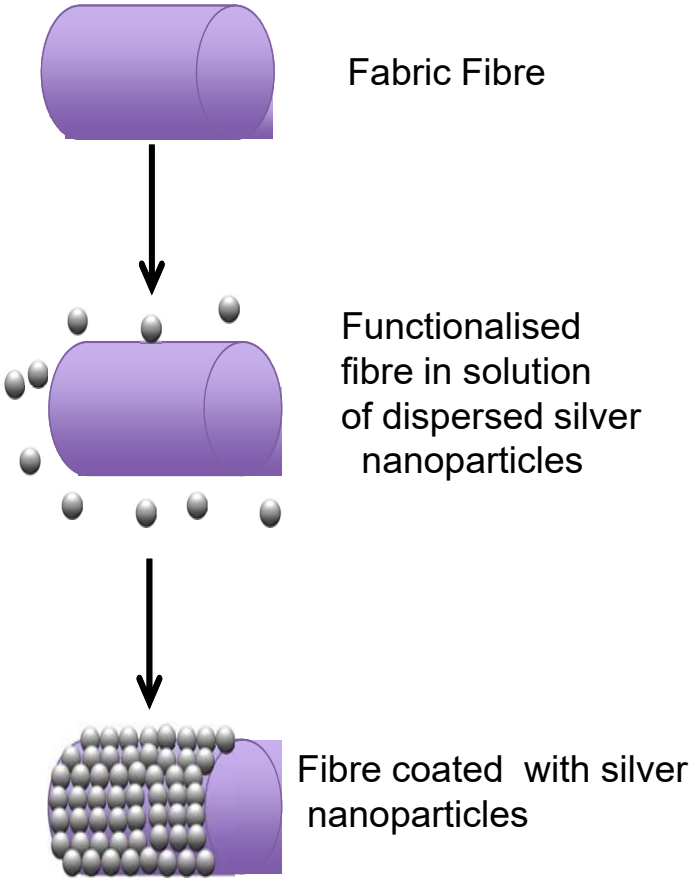


NPL Technology

- **Alternatives:**
  - Conductive polymers, printing inks, conductive yarns

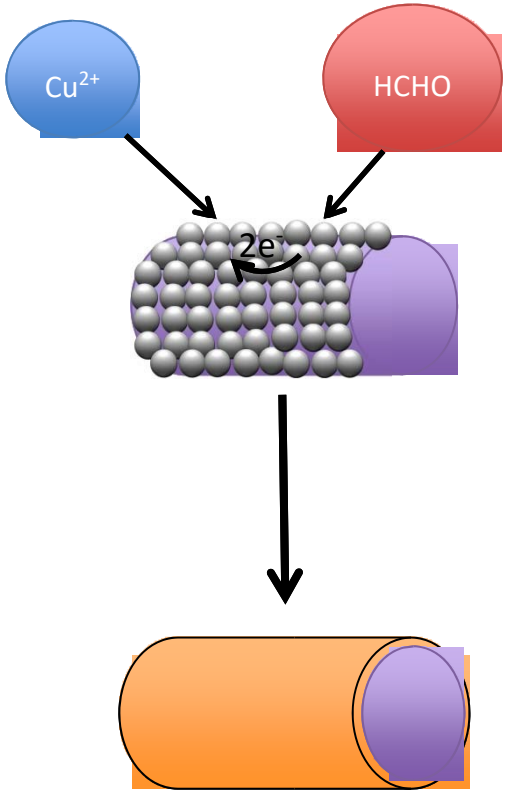
Stage 1 – Nano-Silver Coating of Fibres

- Fibres within textile are chemically functionalised
- Functionalised fabric is immersed in solution containing dispersed silver nanoparticles
- Silver nanoparticles attach to functionalised fibre
- Functional groups attract silver nanoparticles
- Fibre is coated with silver nanoparticles



Stage 2 – Electroless plating

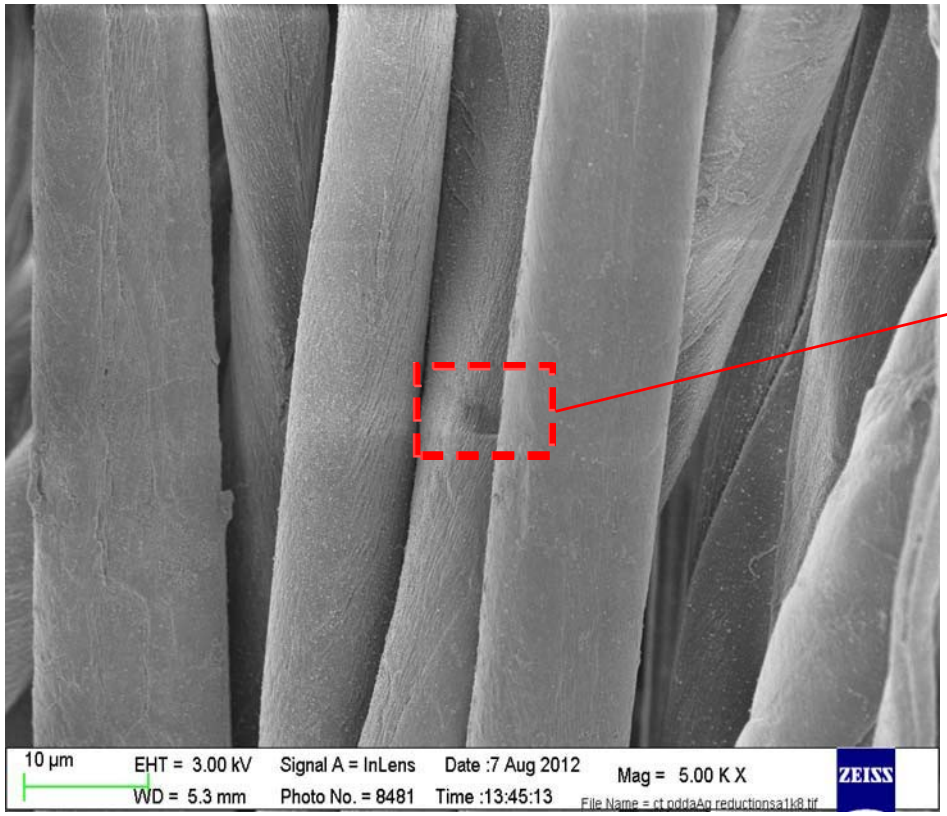
- Nano-silver coating is catalytic to electroless Cu plating
- Electroless copper plate fibres to 0.5-2.0 µm
- Final finish –Immersion silver or other anti-oxidative coating

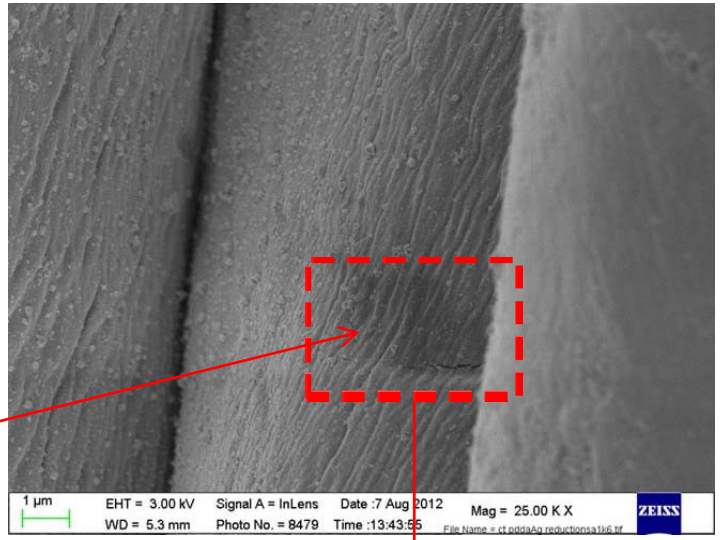


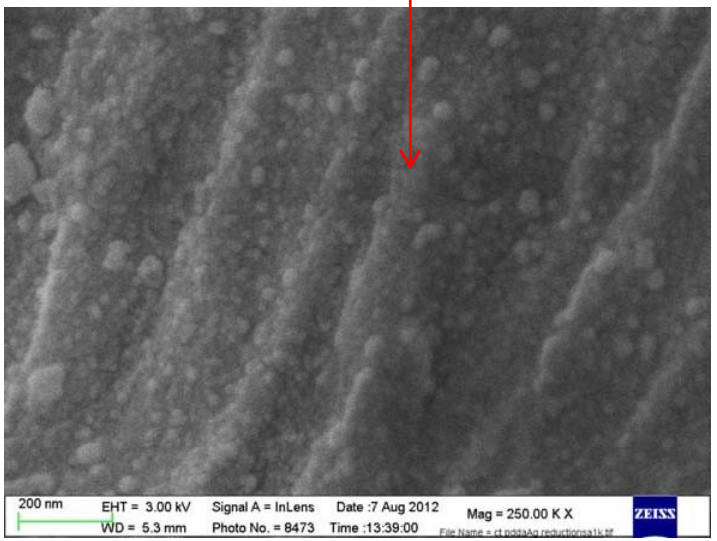
Fibre coated with silver nanoparticles Immersed in Electroless Cu solution

Fibre encapsulated with Cu

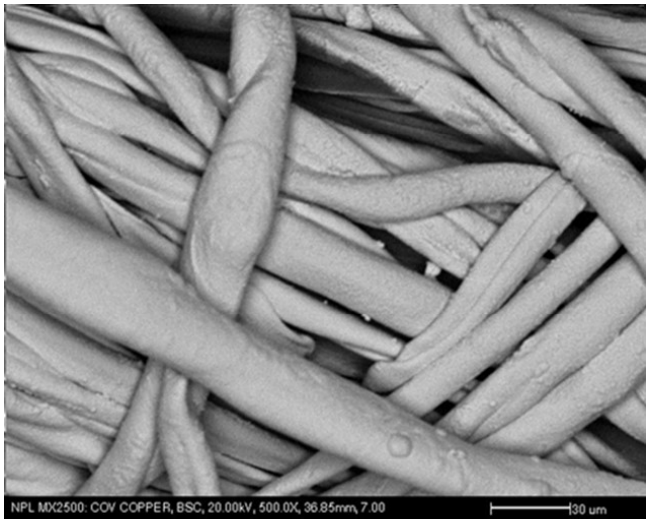
Nano-silver coated fabric

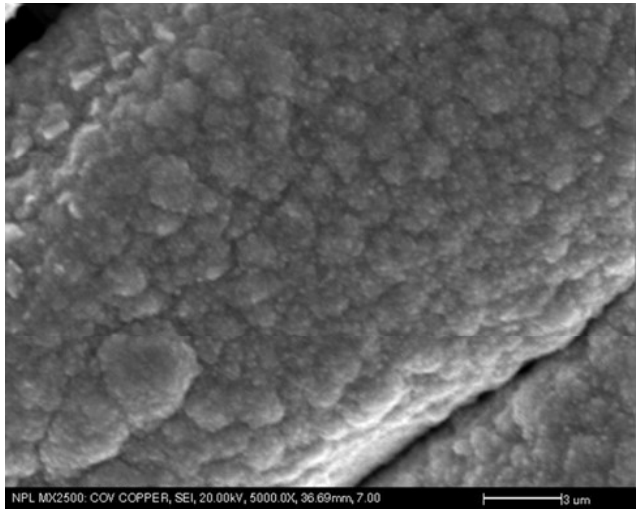






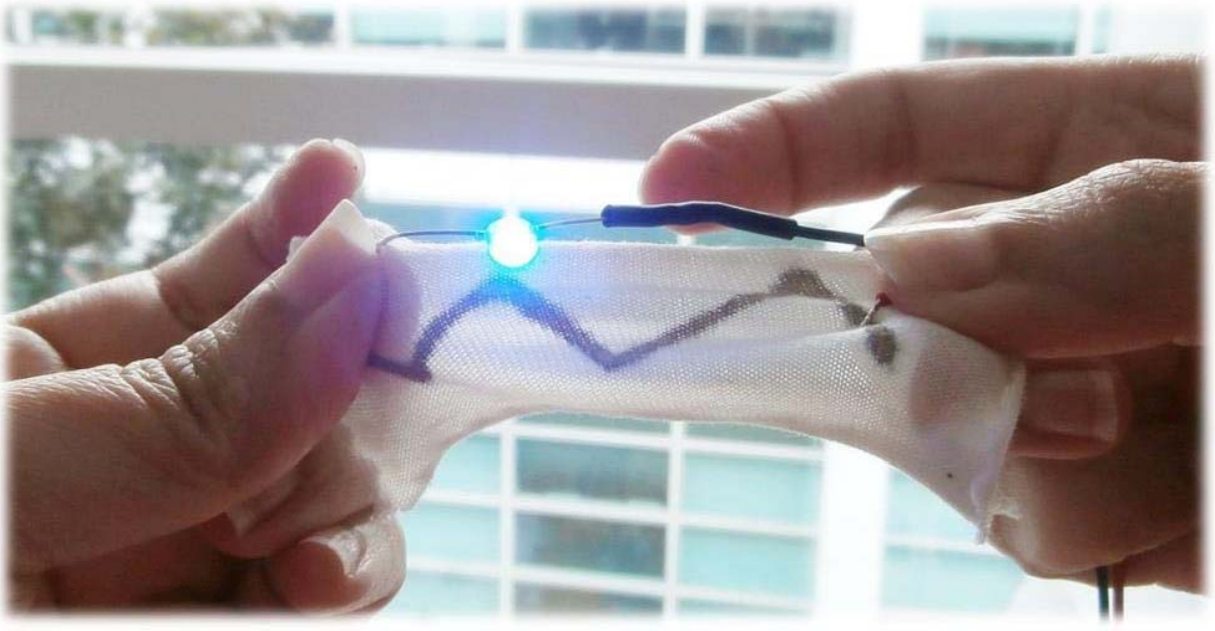
Additive metallic layer thickening





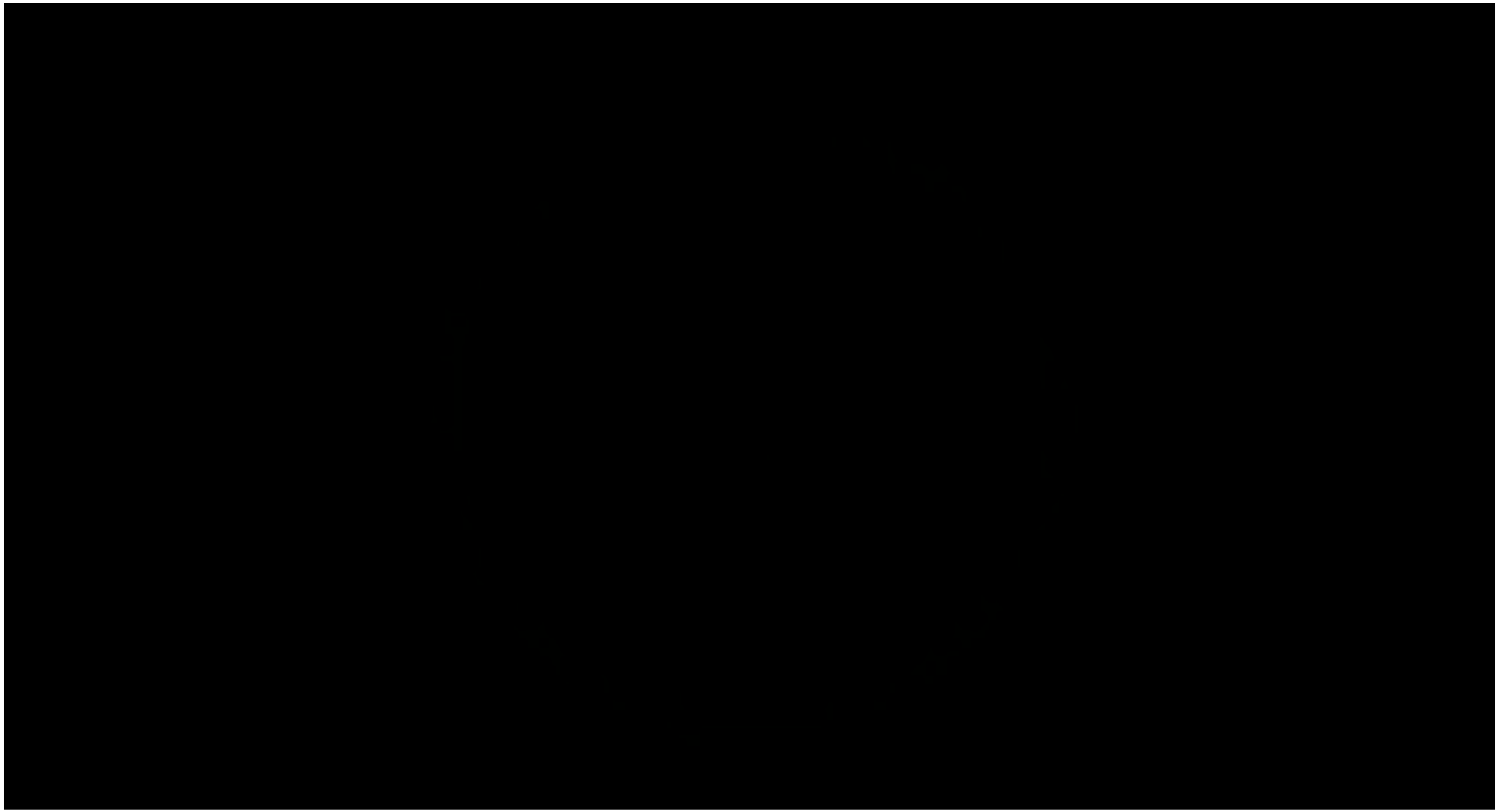
- Electroless plating to bring conductor layer to >1µm
  Resistivity R= <0.2Ω/sq
- Additive deposition is throughout the fabric with excellent adhesion, that allows the fabric to stretch and not effect the drape and handle

Patterning



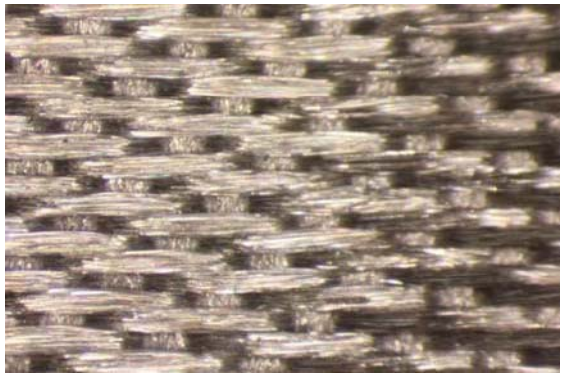
Additive process is successful on most fabrics

Stretch Fabric



Coating a wide range of fabrics

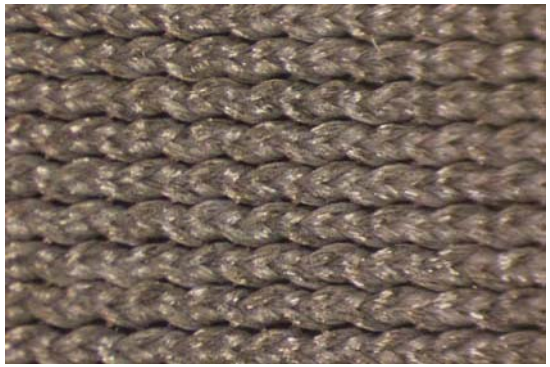
Polyester Satin (R=0.5Ω)



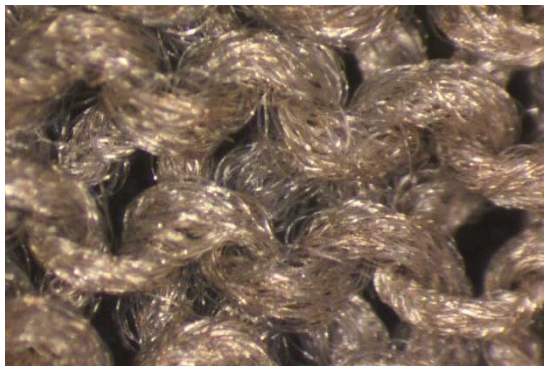
Jersey Cotton Tubular (R=0.2 Ω)

Linen(R=0.06 Ω)

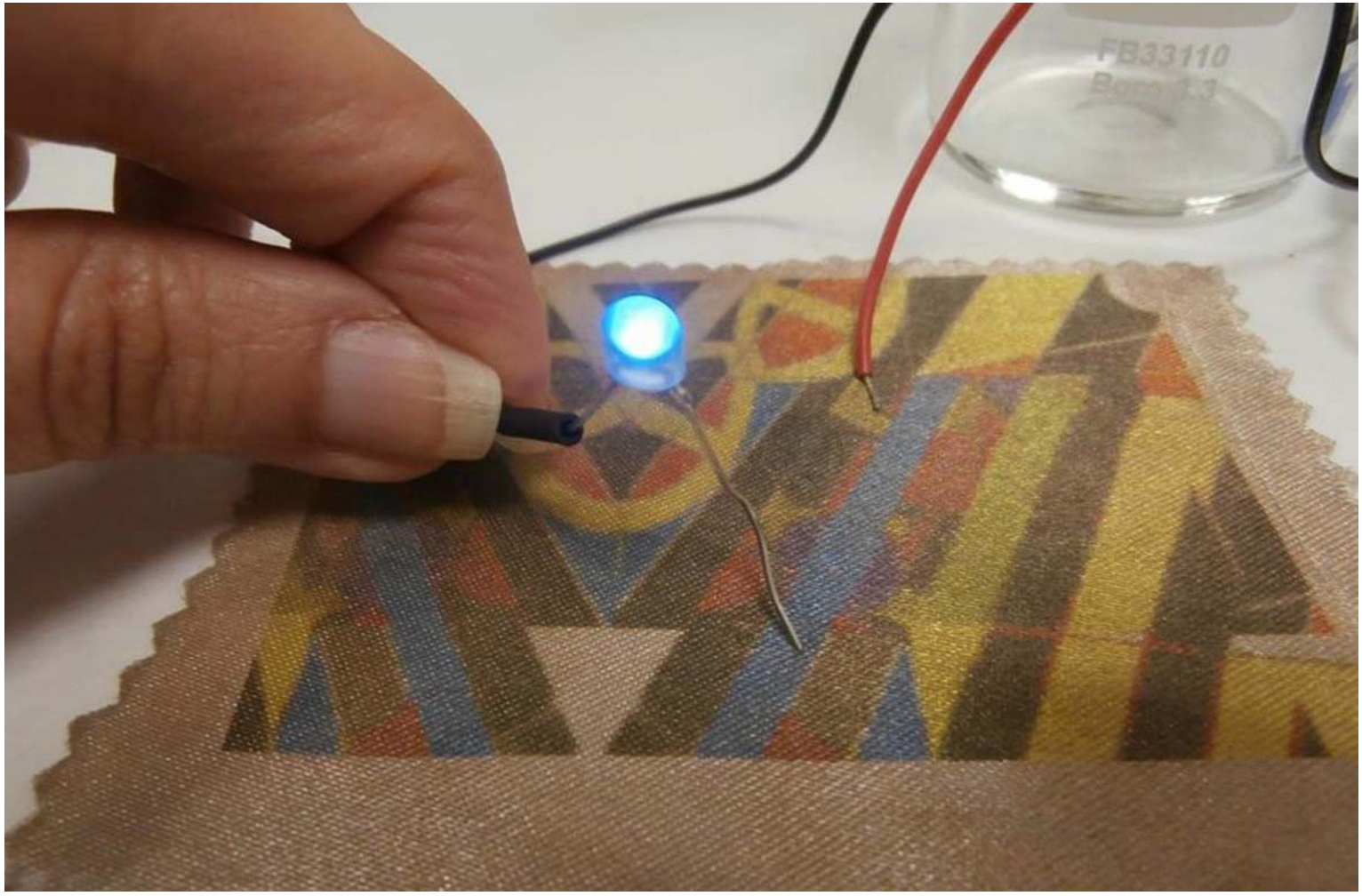
Lycra(R=2.0 Ω)



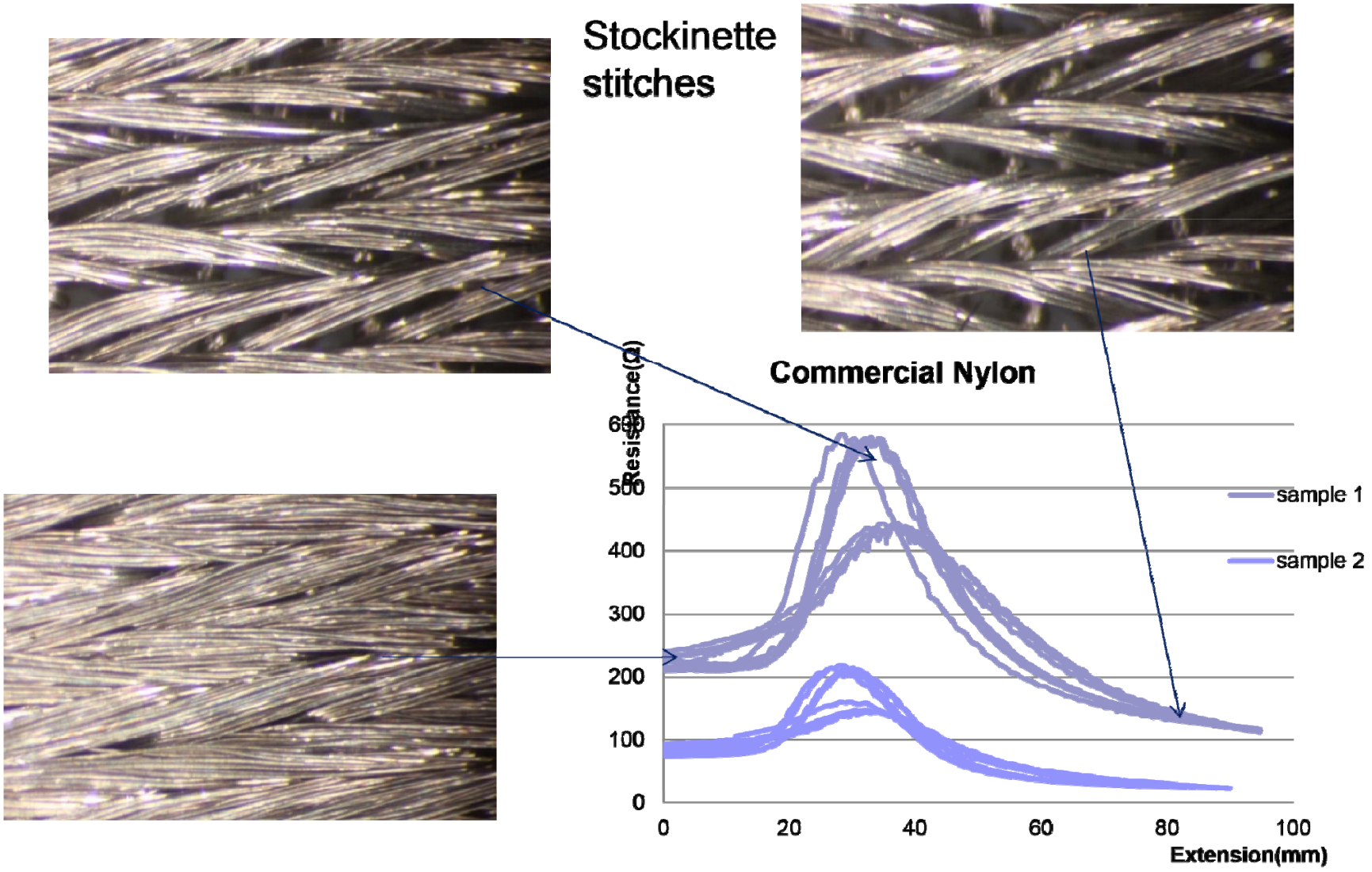
Polyester (R=0.1 Ω)



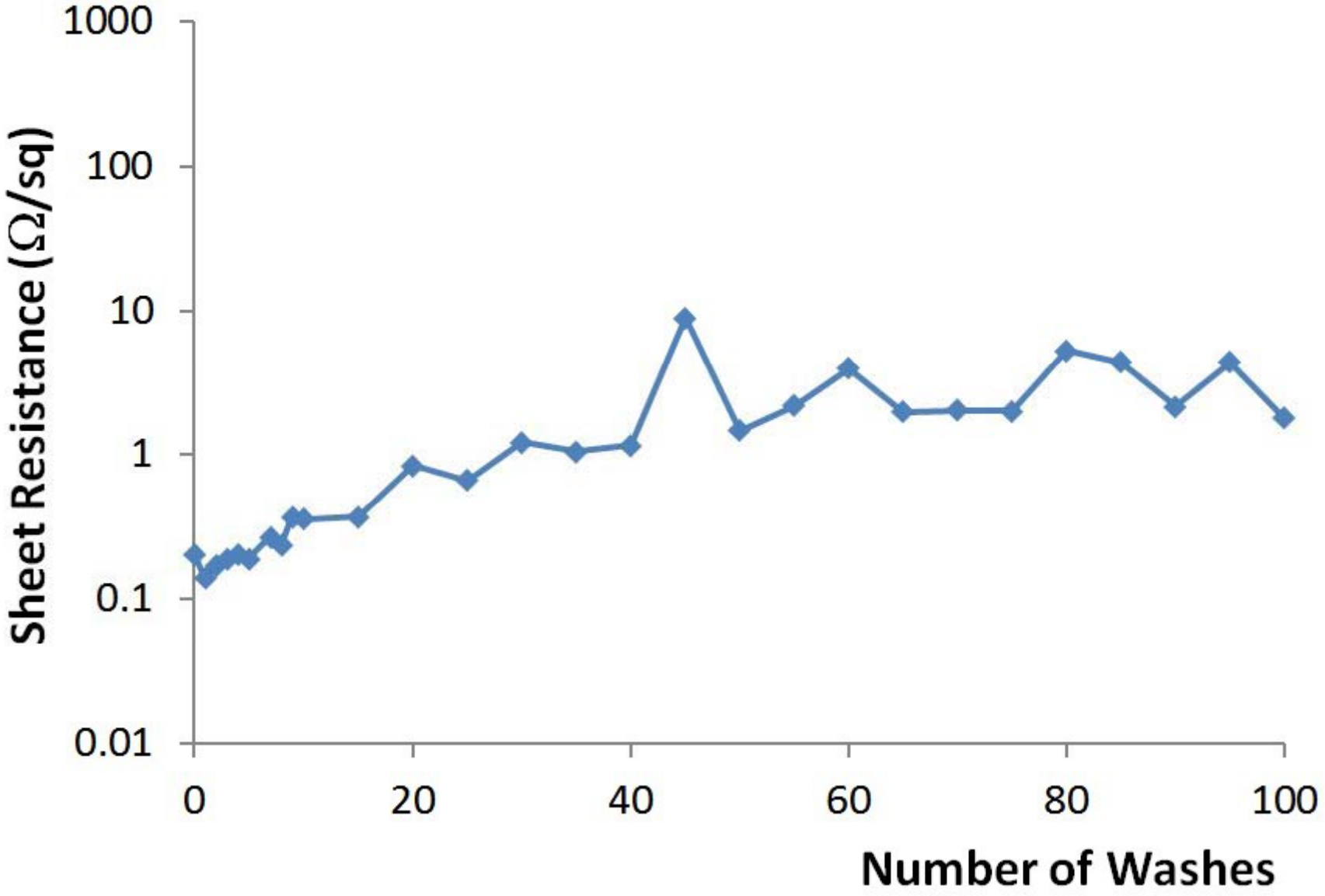
Dyed fabrics are conducting



Stretch tests



Wash Cycles (Cotton Jersey)



Summary

- Smart textiles for wearables is in its infancy.
- Many potential material solutions exist
- Applications are proliferating
- NPL solution offers highly conductive fabric, with excellent flexibility
- Can be used on large areas, or patterned
- Good washability100 cycles with acceptable change in resistance.
- Stretchable fabrics retains conductivity
- Different metals can be used

Further Contact Details

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Thank you!

Questions welcome

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