Harnessing Circuit Board Technology to Revolutionise the E-Textile Technology and Wearables Market

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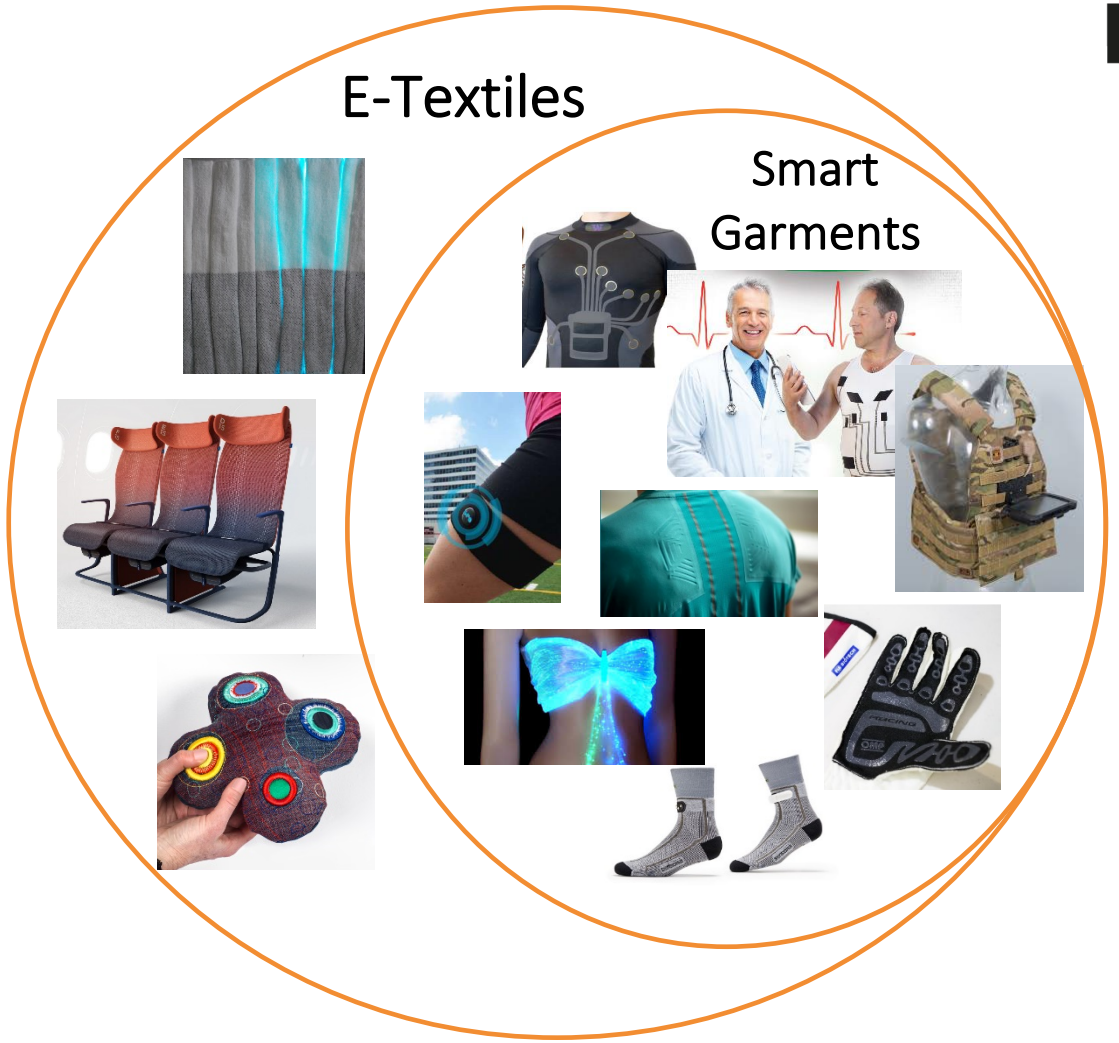
We enable smart garments and e-textiles by

creating printed circuits directly on textiles

without affecting handle, drape, stretch or breathability.

E-textiles and Smart Garments

- A form of structural electronics
- Textile plus:
  - Sensors / indicators
  - Controller
  - Power source
  - External interface (typically)
  - Interconnects (connections between separate electronic devices)
- Applications across multiple sectors
- Wearables and other e-textiles
- $2bn market in 2028 (IDTechEx)



The Problem?

Current Wearables

Truly wearables

How can electronics be integrated into smart garments that are truly wearable?

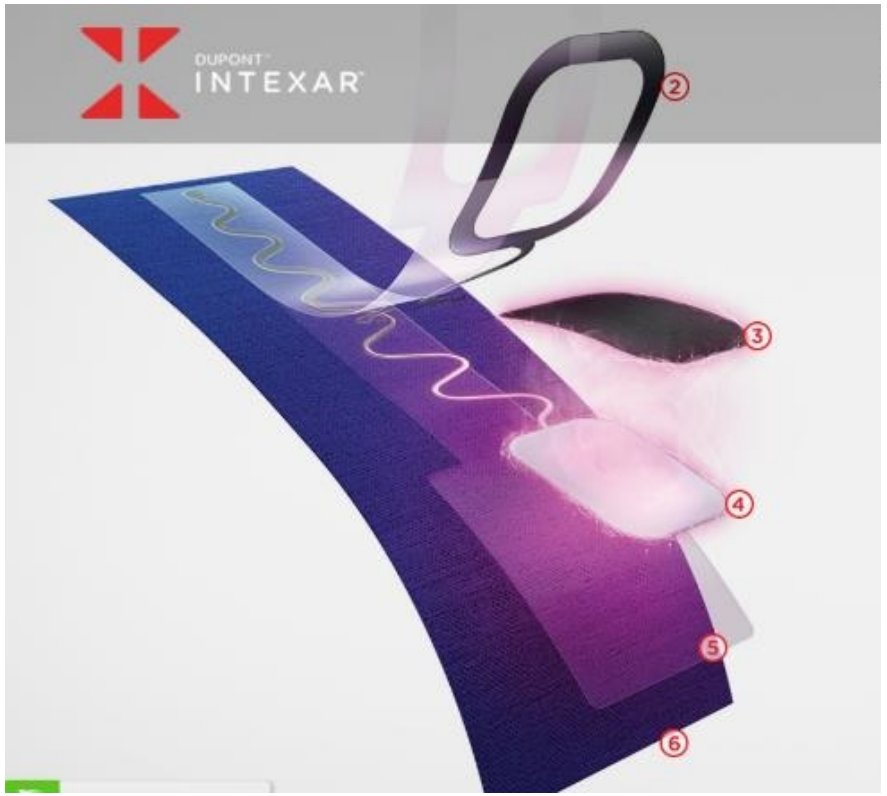
So what is the E-textile interconnect challenge?

- Huge variety of substrates (woven, knitted, non-woven, natural, synthetic, etc.).
- Highly conformal and stretchable nature of textiles
- May be worn next to the skin – comfort essential
- May need to be washed
- Differing manufacturing processes
- Textile/garment industries are old, established and entrenched

"interconnects may seem like simple elements, but they are crucial in enabling truly wearable textile-based applications".
IDTechEx, Nov 2017

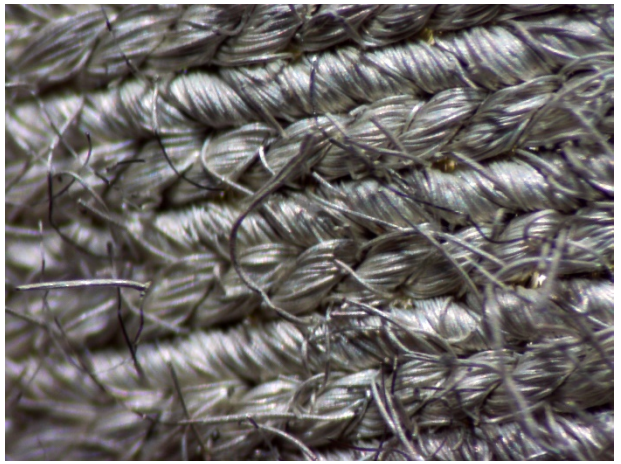
Conductive Inks are Sub-Optimal

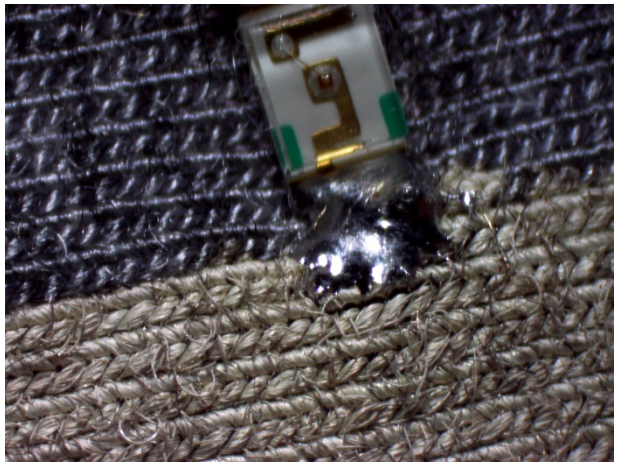
- Current technology alternative is printed conductive inks (e.g. Intexar™)
- These inks require a TPU base layer (5)
- TPU layer causes stiffness and creates a moisture barrier
- Very limited stretch-ability
- Not suitable for soldered connections



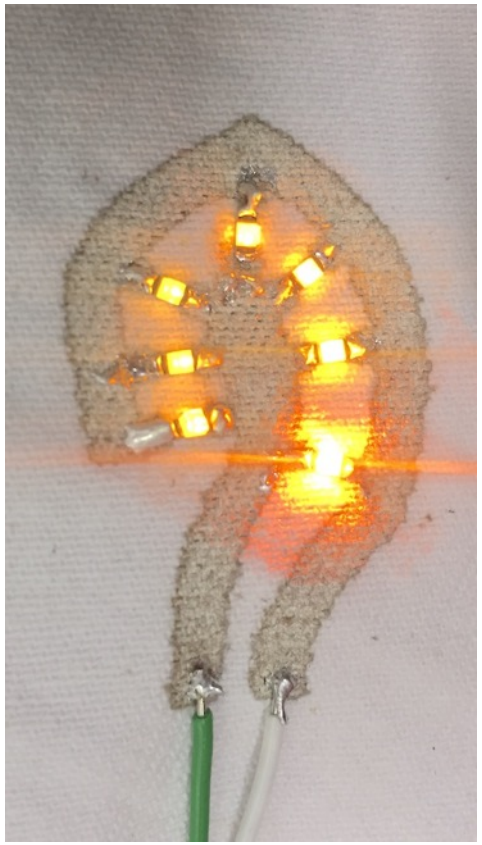
Pireta Technology

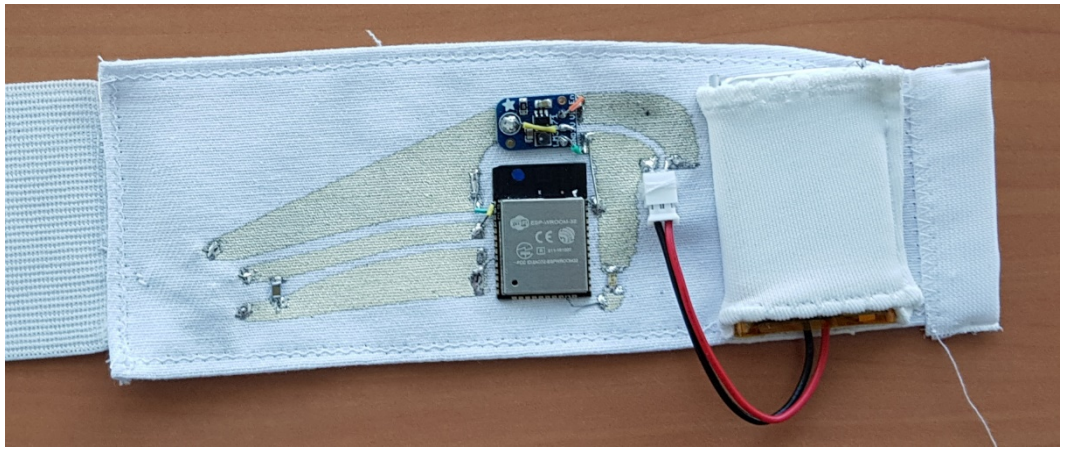
- Copper is applied to individual textile **fibres** via a patented nano particle catalytic bonding process.
- Results in best in class conductivity.
- Allows electronic circuits to be built directly on textiles.
- Fabric handle, drape, stretch and breathability is **unchanged.**
- Retains functionality after >60 wash cycles.
- Multiple fabric types including non-wovens.

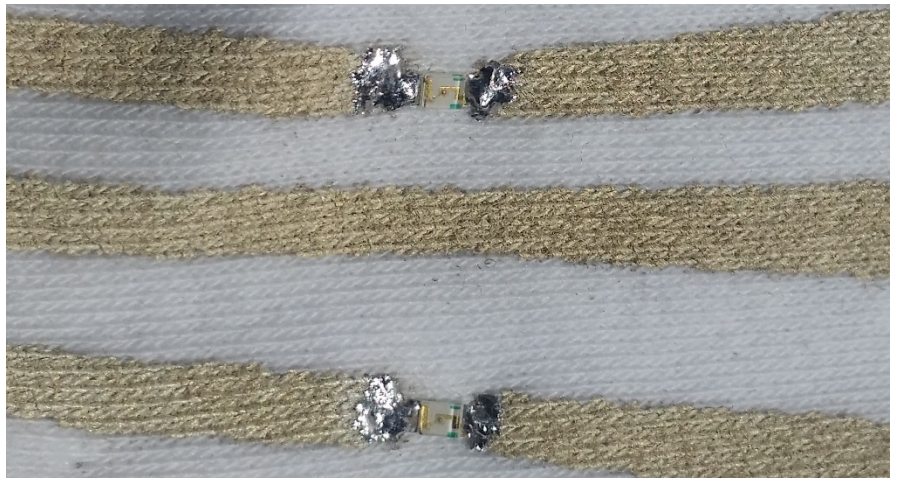




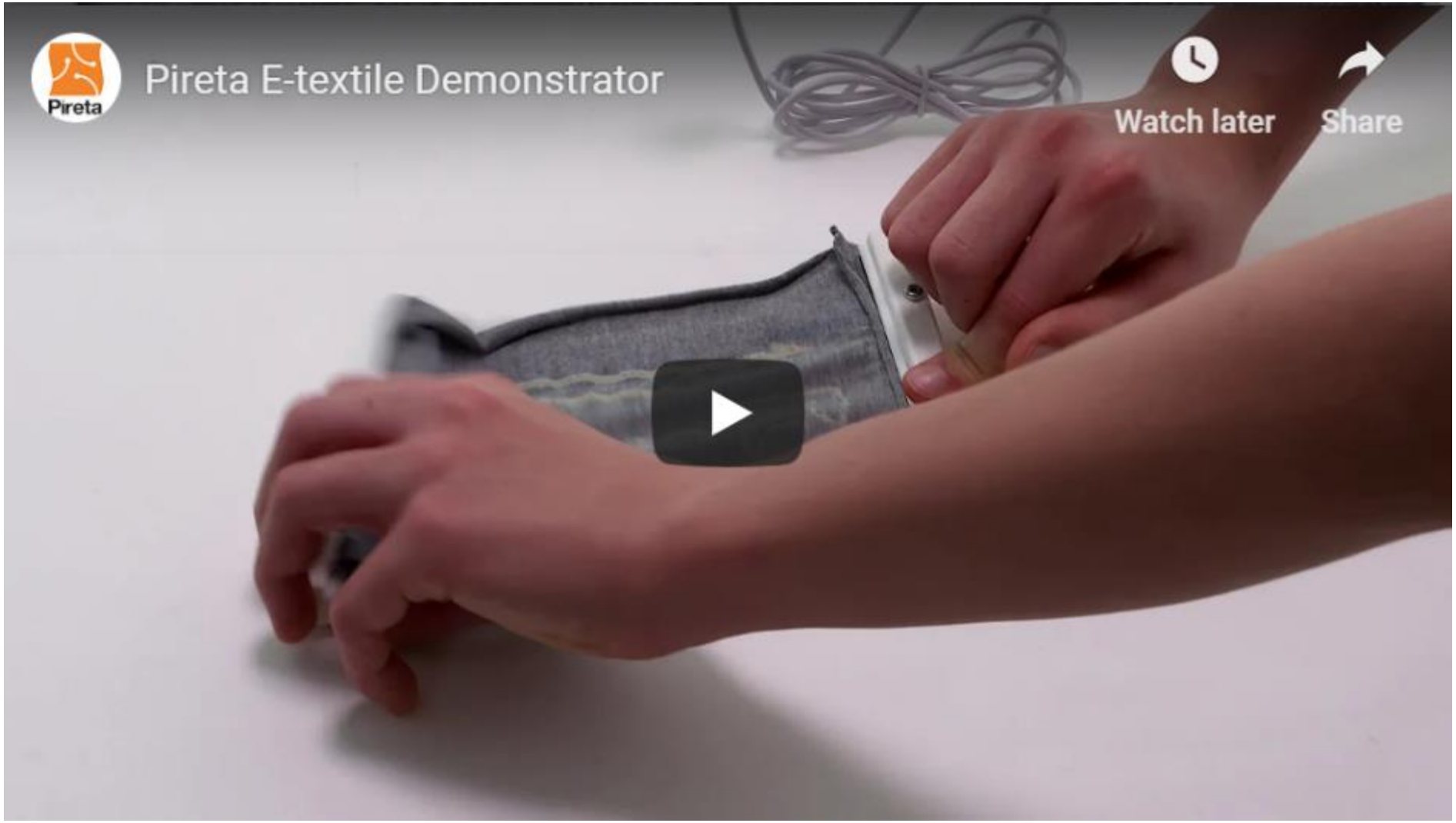
Pireta Technology Examples







Pireta Technology Demonstrator

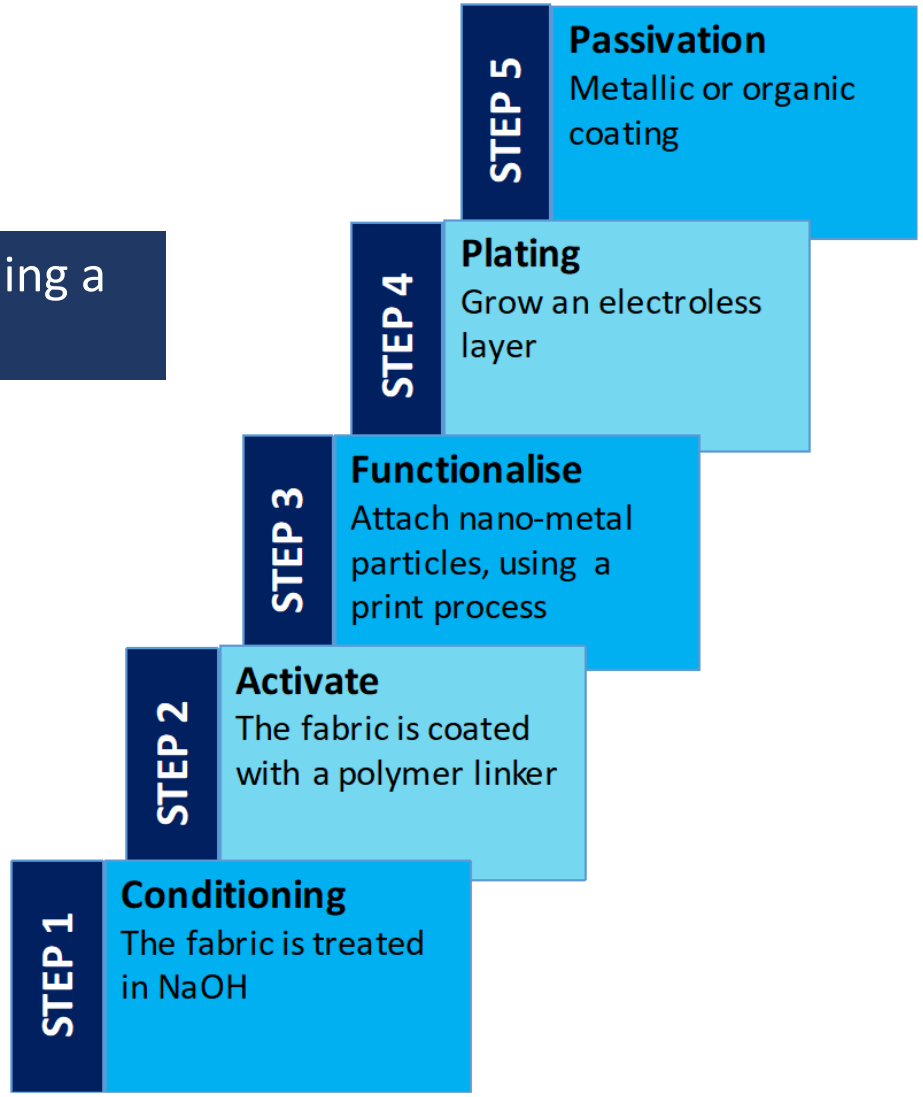


Pireta five-step process

Patented additive process for chemically bonding a metal layer onto fibres in a textile.

Conductive metal layer bound around individual fibres, giving excellent coverage, with good adhesion and flexibility

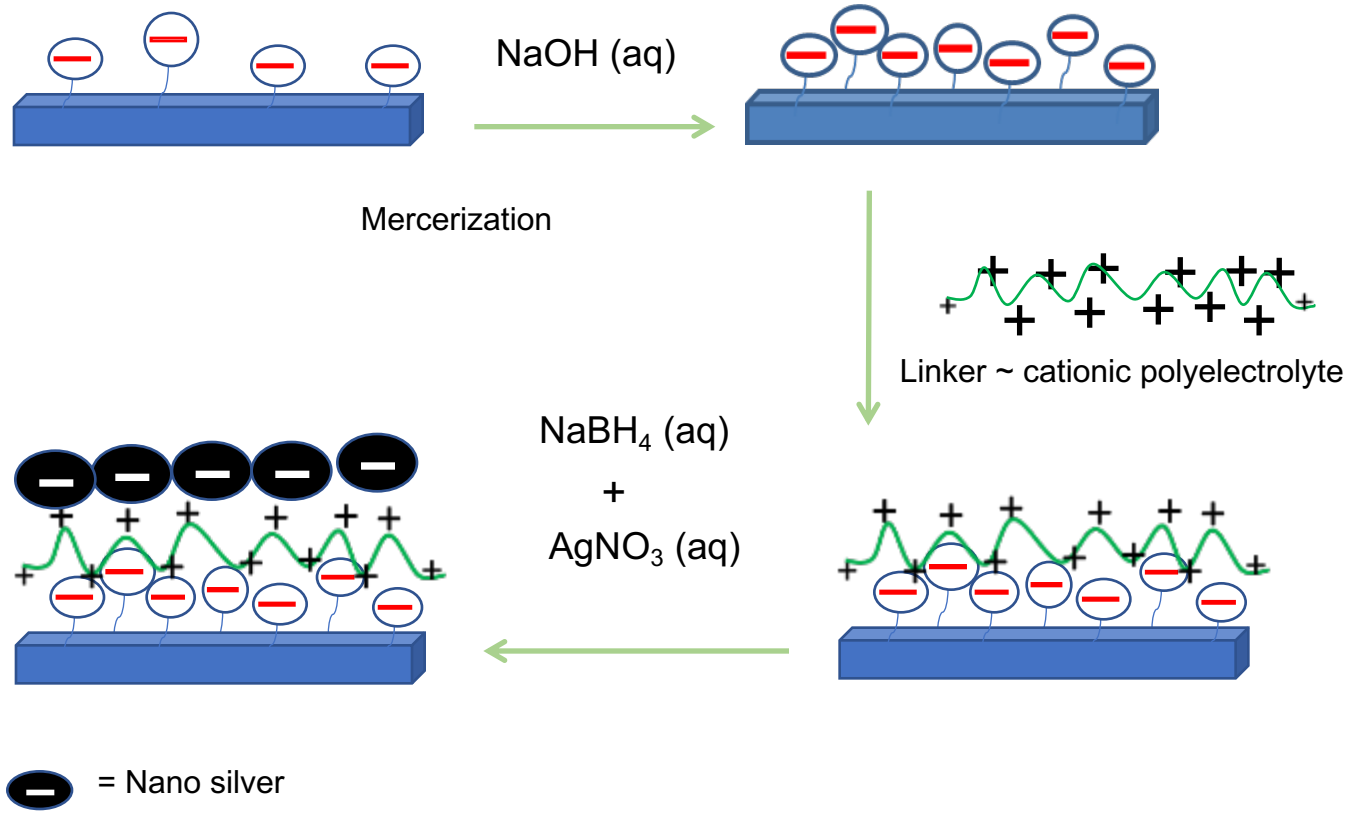
The Pireta solution uses commercially available, proven processes and operates at atmospheric pressure and at temperatures below 60°C throughout.



Process Overview

Nano-metal deposition

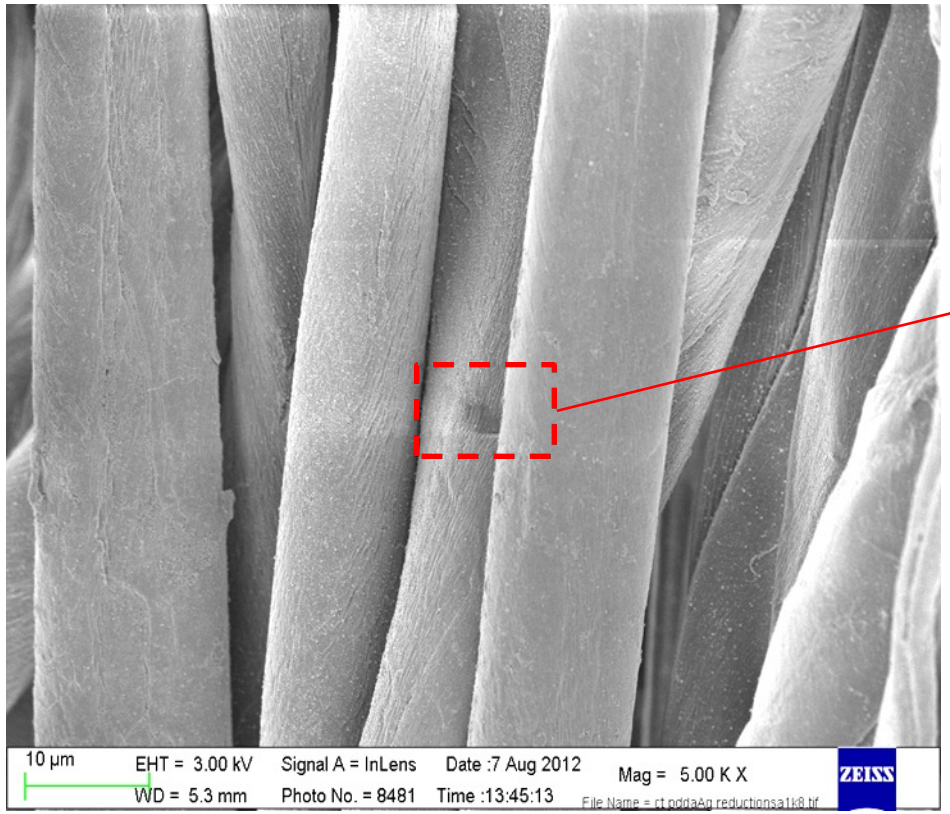
Steps 1 and 2

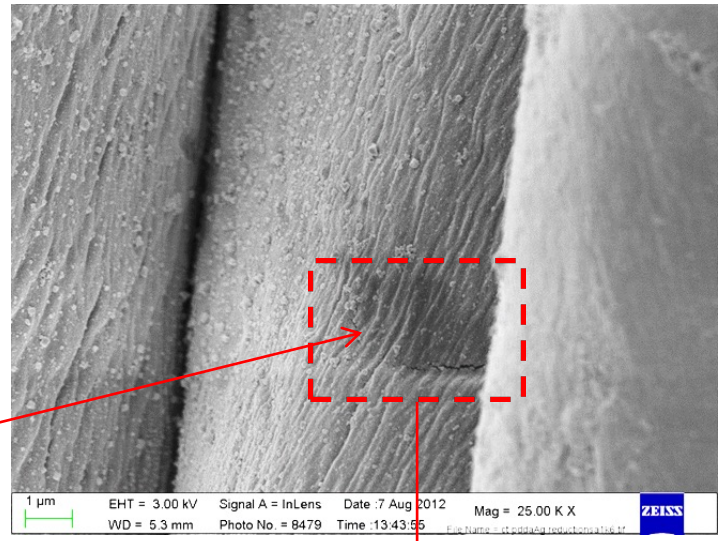


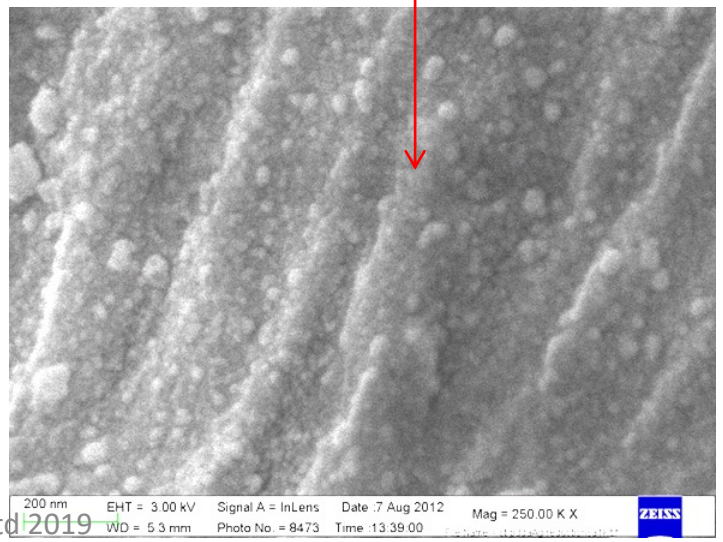
Sodium hydroxide is a suitable reagent to add functionality to the fabric.

Standard procedure is to then add positively charge polymer to initiate adsorption of the silver catalyst.

Nano-silver coated fabric

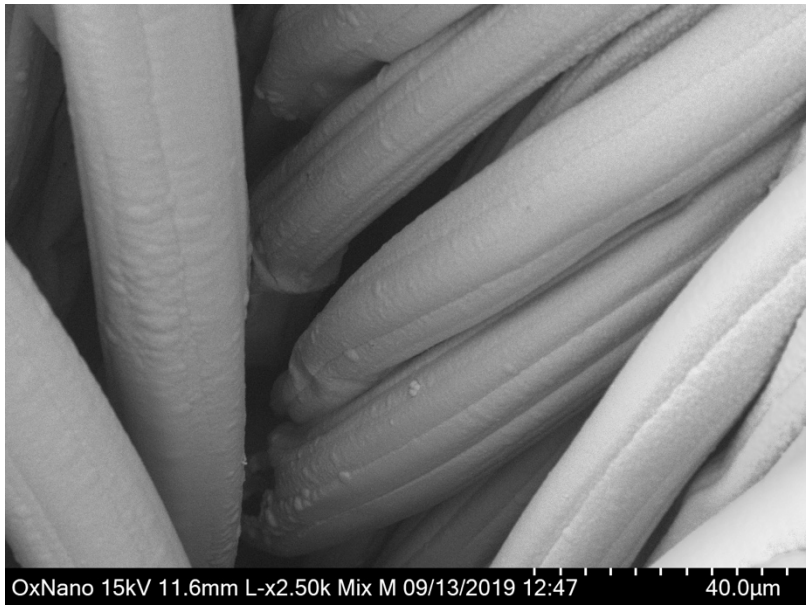


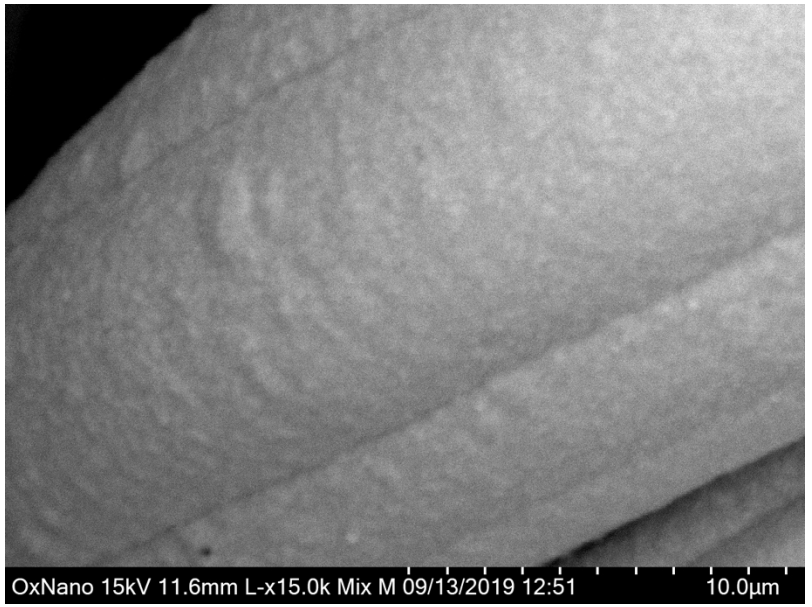




Additive metallic layer thickening

SEM images of electroless copper plating

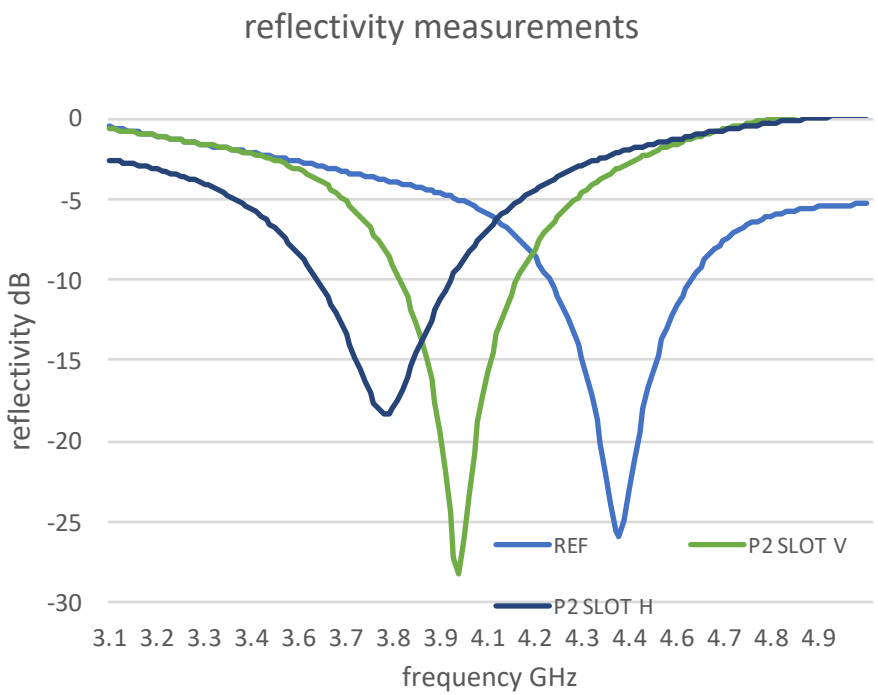


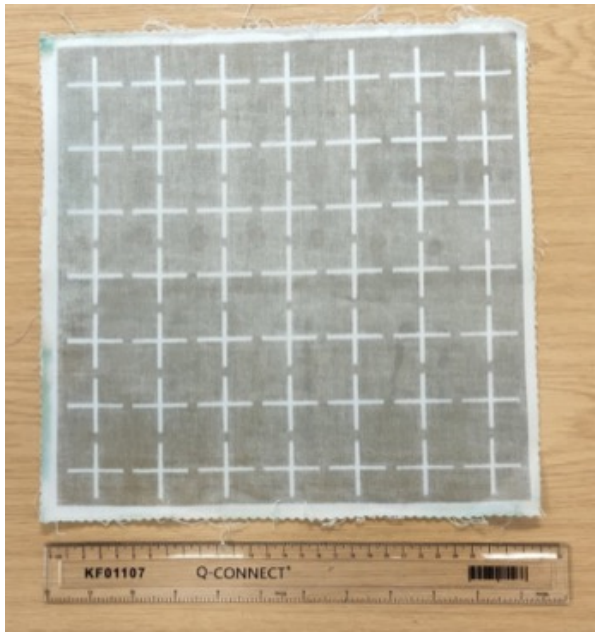


- Electroless plating to bring conductor layer to ~3µm thickness. Low resistance, typically R= <0.1Ω/sq depending on textile
- Additive deposition is throughout the fabric with excellent adhesion, that allows the fabric to stretch and not effect the drape and handle

Cross Dipole Slot Band-pass filter @ 4.3GHz

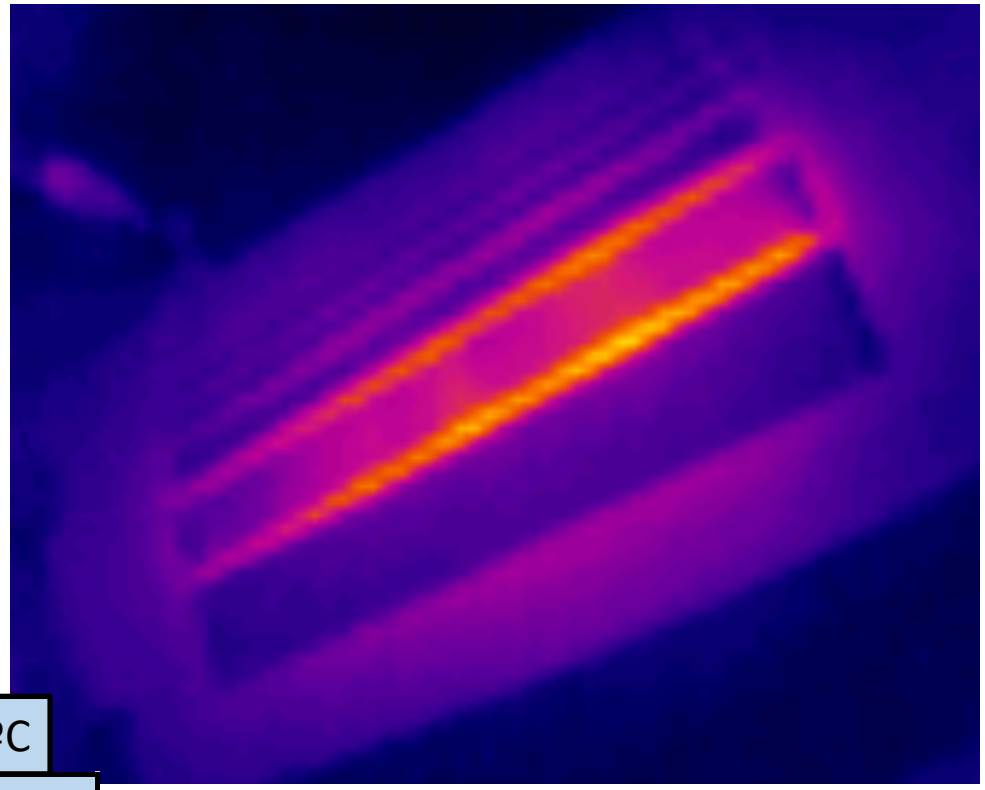
- Theses results show that when compared to a metal foil reference, the textile sample has superior performance.
- The frequency shift is due to slight dimensional differences.
- The difference between the vertical and horizontal axis in the fabric is due to the fabric anisotropy.





Heating effects

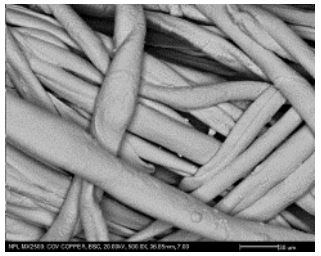
- Heating effects are observed in tracks as the current is increased. The current (A) needed to produce a track temperature of 40ºC is given in the table below for two different track types, or conductivities.
- Hence, either the desired current carrying capacity or desired heating effect can be selected.

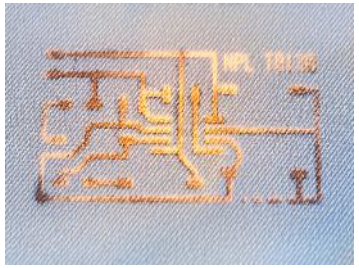


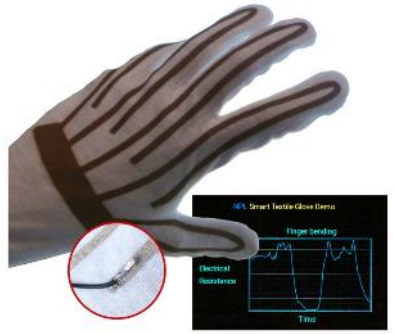
Current (A) flow to generate a track temperature of 40ºC				
40°C	5 mm	10 mm	20 mm	40 mm
170 mΩ/□	1	1.6	2.4	4
85 mΩ/□	2	3.2	4.8	8

Our Technology – Key Benefits

- Textile *itself* is made conductive
- Handle, drape, stretch and breathability unchanged
- Supports direct soldered connection
- Provides best-in-class conductivity
- Fully washable and durable
- Applicable to synthetic & natural fibres, knitted, woven & non-woven fabrics
- Utilises established industrial processes and straightforward aqueous chemistry

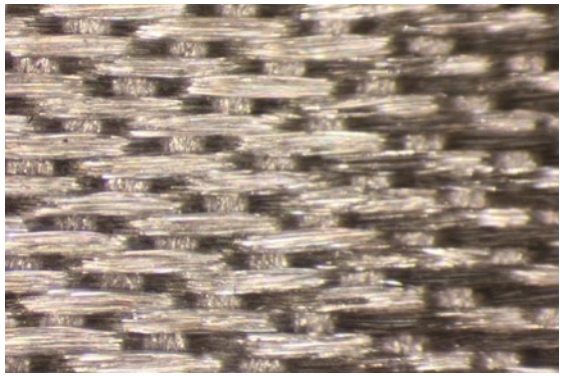




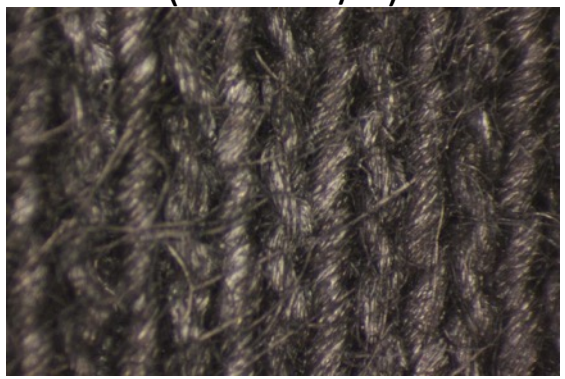


Compatible with a wide range of textiles

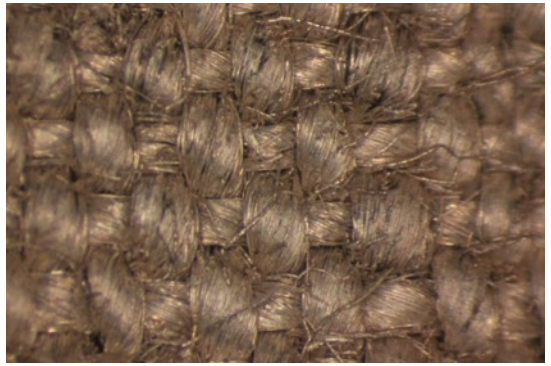
Polyester Satin (R=0.5 Ω/□)



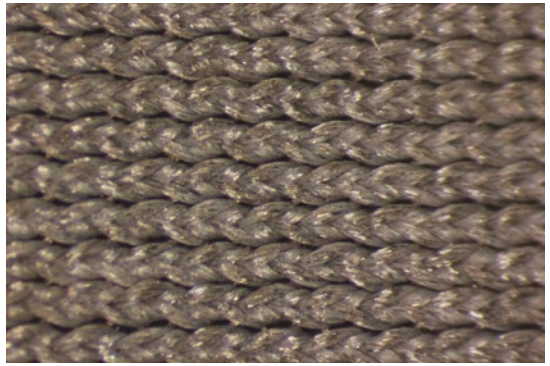
Jersey Cotton Tubular (R=0.2 Ω/□)



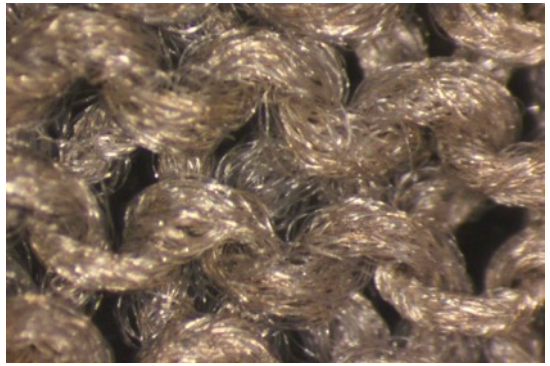
Linen (R=0.06 Ω/□)



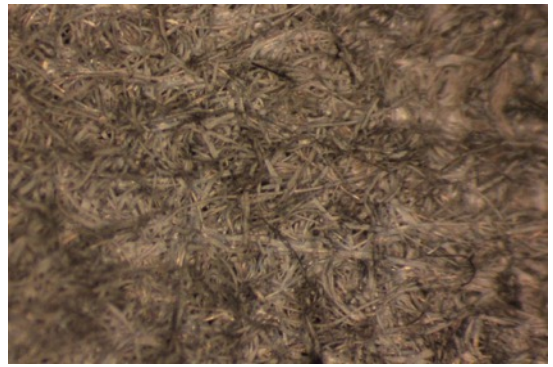
Lycra(R=2.0 Ω/□)



Polyester (R=0.1 Ω/□)



Non Woven (R=0.006 Ω/□)

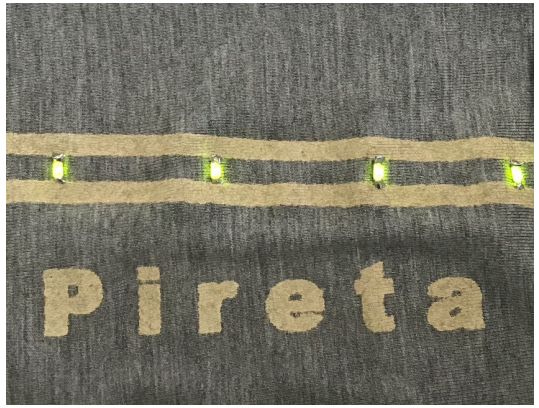


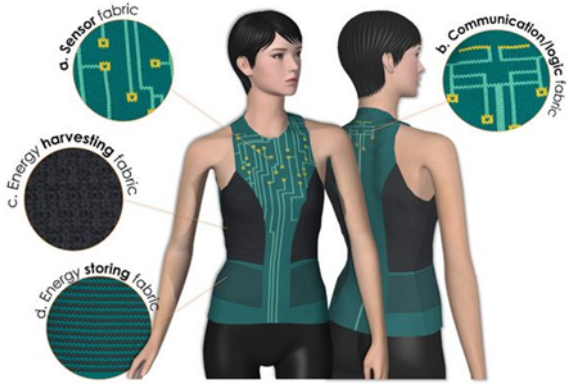
Pireta is the path to Truly Wearable Technology

Pireta technology enables E-textiles

E-textiles enable functionalised clothing

Functionalised clothing enables truly wearable technology





Our Target Market

- Healthcare, Medical & Bio Science
- Wellness, Fitness and Sports
- Defence & Emergency Services
- Automotive and Transportation
- Fashion and Apparel

talk2myShirt: T Morrison, Uni. of Washington

Key benefits: Pireta process

- Uses proven reliable aqueous processes and commercially available chemistry for ease and flexibility of integration into your existing textile finishing process.
- Provides a seamless interconnect solution by enabling electrically noiseless joints to the textile.
- Textile can be dyed after conductive coating has been applied.
- Applicable to knitted, woven and non-woven, natural and synthetic textiles.
- Patterning can be achieved via a simple printing process, enabling complex designs.
- Highly conductive textile compared to current best in class solutions with resistance as low as 6 mΩ/sq is achievable. Conducts in the RF range and supports 20Mb/s data rates
- Robust, wash, stretch and fold performance, conductor does not crack
- Doesn’t impact on drape and handle
- Very different approach to other conductive textiles

Similarities with the PTH process

- Conditioner
  - Common chemistry
- Activation & Catalyst
  - Combined in the PTH process
  - Separate in Pireta process. Catalyst can be screen printed, uses Ag
- Electroless
  - Common chemistry
- Passivation
  - Common chemistry
- Electrolytic copper
  - Possible on fabrics, design permitting

Summary

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