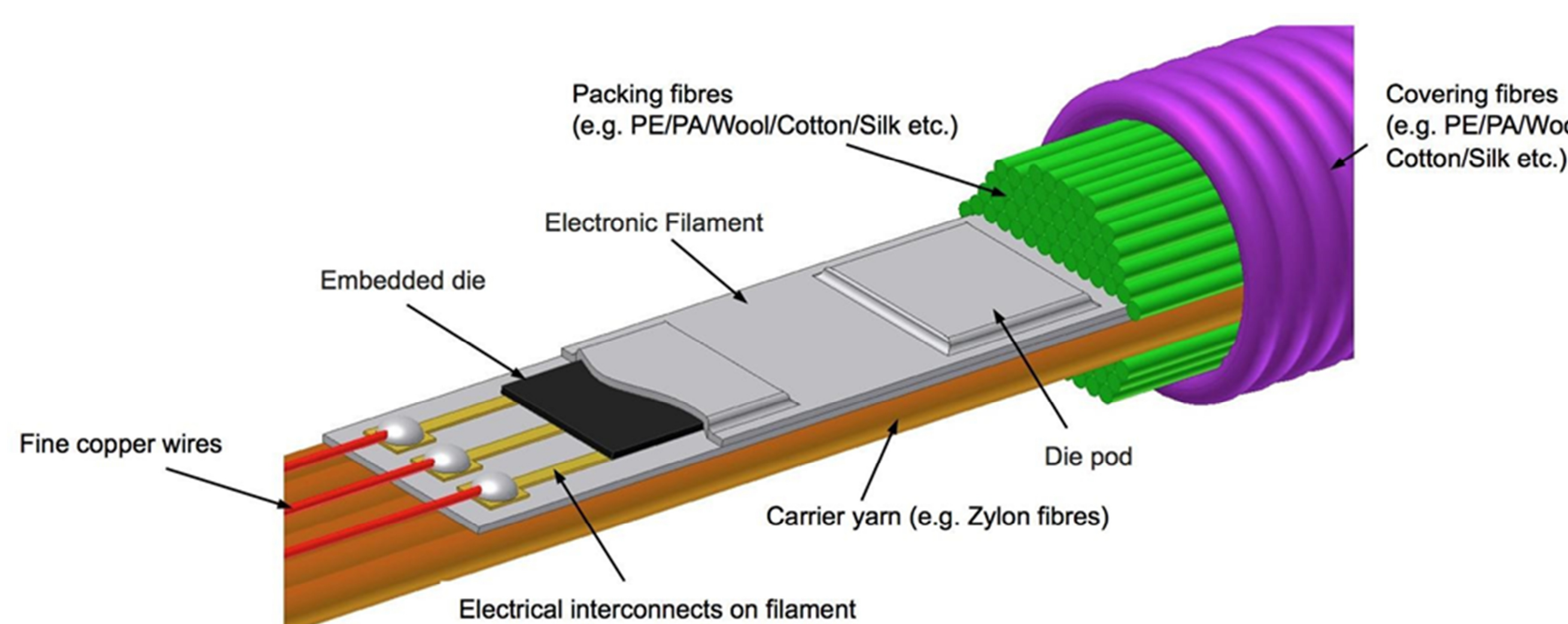


## Project Abstract

This poster introduces work on a new EPSRC project at the University of Southampton and Nottingham Trent University developing novel manufacturing methods for functional electronic textiles (FETT). The overall objective of the research is to develop new manufacturing assembly methods that enable the reliable packaging of advanced electronic components (e.g. microcontrollers) in ultra-thin die form within a textile yarn. The project is investigating approaches for mounting the ultra-thin die onto thin flexible polymer films strips that contain patterned conductive interconnects and bond pads. Individual die are located on the strip and connected via tracks to form a very thin, flexible circuit or filament. The filaments will then be surrounded by classical textile fibres (e.g. polyester, cotton, wool, silk) by Nottingham Trent University and connected via conductive wires to form an electronic yarn that will, essentially, appear to be a standard textile yarn but which has embedded within it, circuitry and sensors.

## Project Concept

The concept of the project is to insert complex electronic circuits into the middle of standard textile yarns to create e-yarns. The figure shows the initial concept for the project whereby an electronic filament circuit is mounted on to a carrier yarn and then surrounded by packing yarns and then the complete final structure is covered by textile fibres wrapped around it to create the final e-yarn. This e-yarn can then be woven, knitted or embroidered into the desired fabric form exactly like a standard textile yarn but with the enhanced circuitry and sensors inside to allow the creation of an e-textile.



## Circuit Construction and Potential Applications

Screen printing, evaporation and etching have been demonstrated using materials such as gold, aluminium, silver and copper for the conductive tracks. The most promising technique providing the most reliable and repeatable results for both the circuit construction and component adhesion is etching with copper on flexible substrates.

To achieve the full e-yarn concept, the circuits must ultimately be less than 1mm wide, however the width is currently limited by the availability of sufficiently small components. The component size reduction is currently driven by the mobile phone and tablet market. The smallest available packages are wafer level chip scale packaging (WLCS) where the final package is no larger than the required circuit area. Passive components are available in 0.1mm x 0.05mm packages but these are difficult to handle and currently expensive to manufacture. Smaller thinner chip packages provide greater flexibility, further enhancing future e-yarns.

The smallest commercially available chip packages are either WLCS or LGA (Land Grid Array) in the 1 to 2 mm dimension range. Thus the initial demonstrator strip widths are slightly wider to allow these devices to be incorporated, typically 2-4 mm wide but this is still compatible with the NTU yarn knitting process.

Device applications commercially available in this range include: Accelerometers, Gyroscopes, Pressure sensors, Proximity sensors, Flow sensor, RFID, Image sensor, eCompass, Magnetic sensor, Thermal conductivity sensors, Microphones and Heart Rate sensors.

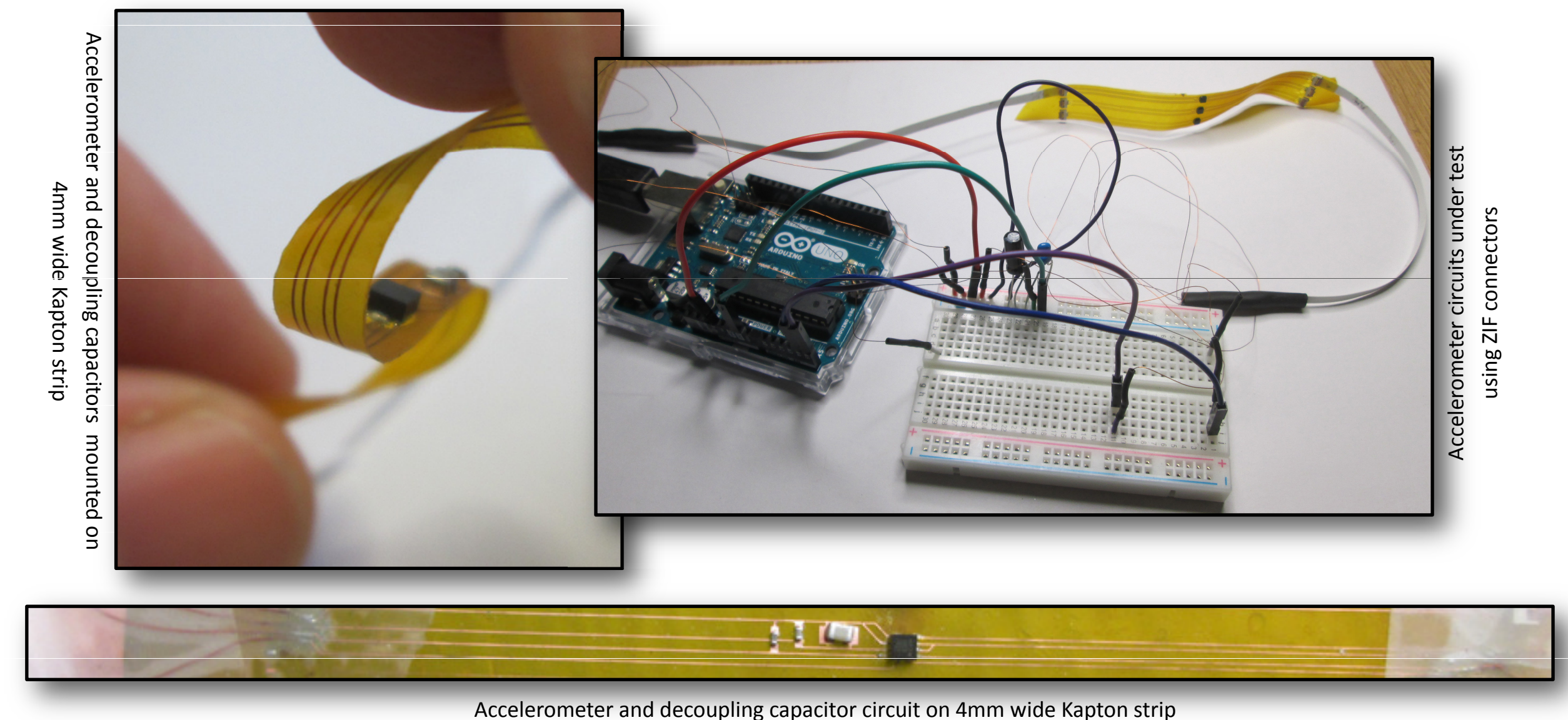
## Demonstrator 1: Temperature sensor with LED output

This demonstrator includes a microcontroller, thermistor and LED output. The microcontroller is programmed to measure the output from the thermistor and activate the LED output in sequence depending on whether the temperature is above or below a pre-set threshold which can be re-programmed via the microcontroller. This circuit is just to demonstrate it is possible to use a microcontroller within this platform but the application could be used in warning workwear and medical applications.



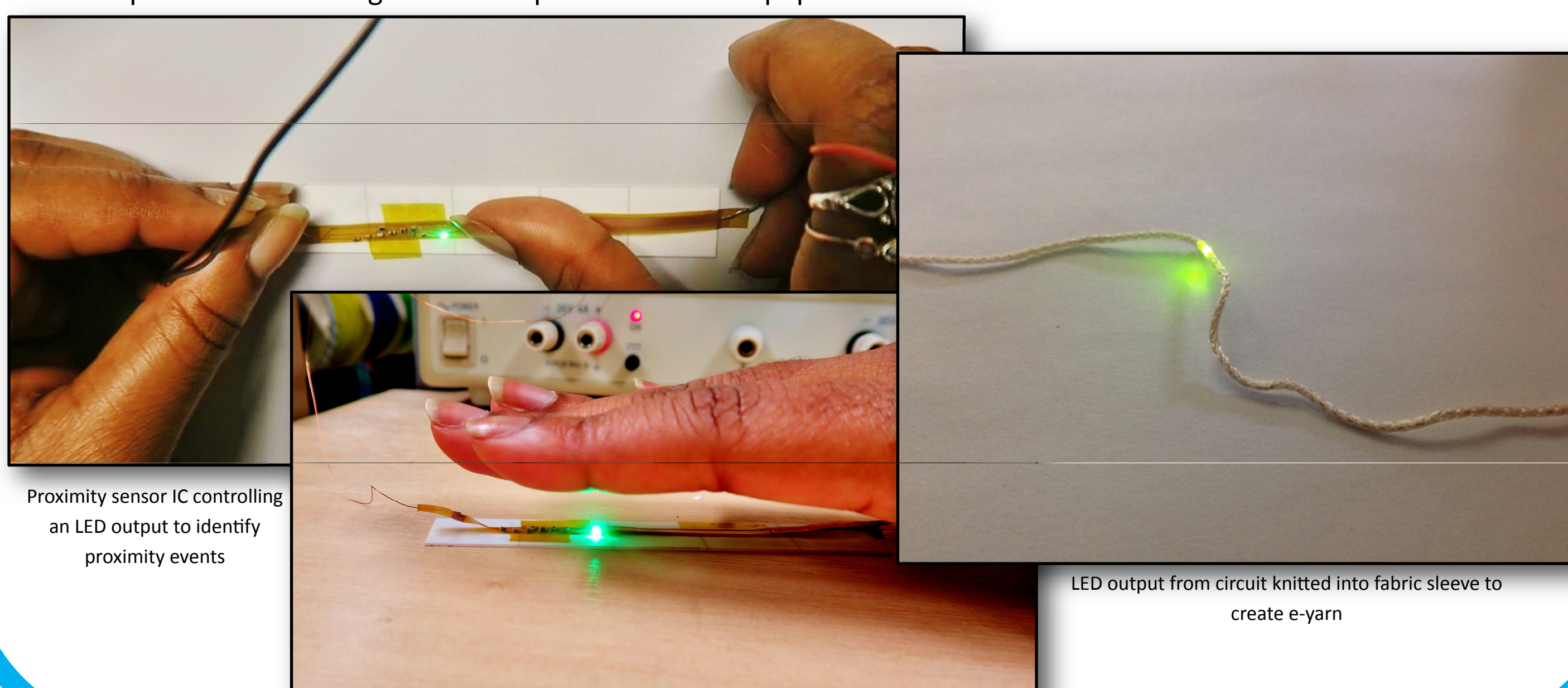
## Demonstrator 2: Accelerometer

This demonstrator uses a 3 axis accelerometer with de-coupling capacitors mounted along side on the strip. Testing has shown that the accelerometer circuit can function with just 4 input wires connected: Power, Ground, Clock and Data. This configuration allows the minimum of wiring for the circuit and thus maintaining the minimum width of the strip and overall wiring in the yarn. The accelerometer output can be used in a broad range of applications such as: sports and fitness tracking, monitoring subject movement, medical devices such as goniometers or other joint movement evaluations, fall and impact detection.



## Demonstrator 3: Proximity/touch sensor

This demonstrator allows the detection of motion nearby the fabric via a proximity/touch sensor. In this case it is connected to an LED output to provide a simple visual verification of proximity detection but this could be combined with the microcontroller circuit to provide a trigger mechanism for further functionality within the final garment. This sensor could be used to control other items within the garment or external items such as answering a mobile phone or switching on and off personal audio equipment.



## Conclusions and Future Work

A number of early demonstrators have been achieved, showcasing this platform technology. The circuits achieved show a wide range of devices can be incorporated into these e-yarns and thus allowing a significant amount of increased capability in future e-textiles.

Future work is considering other demonstration circuits, methods of repeatable industrial scale construction and improved methods of encapsulation of the circuits to protect them from damage during the yarn processing, manufacturing of the garments and general degradation during wearing and washing.

