SOCKET SENSE

A TAILORED FIT OF THE FUTURE

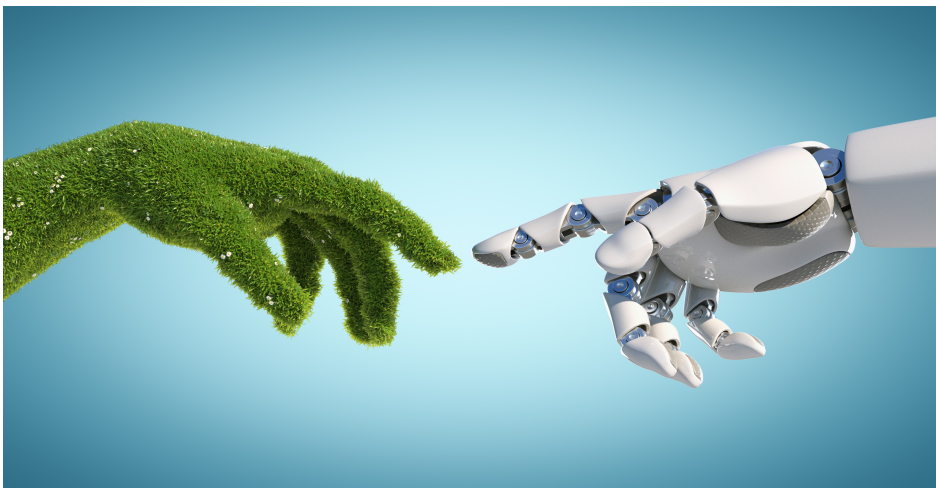
WHITE PAPER - SENSORS

Driving environmental and societal change through innovation

QUANTUM MATERIALS HAVE THE POTENTIAL TO REVOLUTIONISE PROSTHETICS

The Quantum physics world is an exciting one where seemingly impossible things happen all the time. One of the most perplexing aspects is the movement of electrons through seemingly impenetrable barriers. Harnessing these sub-atomic quantum conduction mechanisms in Quantum Materials to drive environmental & societal change through innovation is taking place in the SocketSense project. Electronic assemblies currently contain many elements known to cause issues with human health. Over recent years there has been a massive shift of public awareness regarding the need to improve things. QTSS™ Quantum Materials are patented quantum materials developed to allow low weight, flexible electronic sensors to be made much more environmentally friendly & more simply in order to address society's needs. This current project is based on the need for 'prosthetic socket sensing' to check the personal comfort & fit of a prosthetic socket in a simpler & more financially viable way than is presently available. QTSS™ materials are based on '**natural**' magnetite, which is an abundant and very 'green' material. It is even found on sandy beaches worldwide and gets kicked into sandwiches on beach picnics! …Of course, the other well known electronic element found in sand is silicon and silicon devices have dramatically transformed the electronics world to date. Alternative sensor technologies contain elements and compounds that are not as environmentally friendly or they are expensive and their production processes are complex creating large carbon footprints; QTSS™ materials don't suffer these problems.

INSIDE THIS WHITE PAPER - SENSORS



QTSS™ QUANTUM MATERIALS & THE BENEFITS

Quantum Technology Super Sensor (QTSS™) Quantum Materials harness **'nature's'** sub-atomic quantum conduction mechanisms based on Quantum Mechanics Principles rather than Classical Mechanics Principles. Conduction in these sensing materials is achieved via tunnelling of electrons through insulative barriers around the magnetite particles (see Figure 1 below). Quantum conduction allows these quantum materials to sense across the whole range of electrical conductivity, from insulator to conductor, and provides other unique and very useful electrical effects.

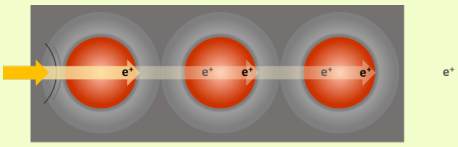


Figure 1

It is also due to these quantum conduction mechanisms that QTSS™ materials have the ability to conduct 'through' the materials only at the point of applied pressure or stimulus (see Figure 2 below) and not throughout the whole body of the material, which is the case for most conductive materials. As these quantum materials are insulators in their normal state (ie. the quiescent resistance of these materials is extremely high) they tick another environmentally friendly box for '**energy efficiency**' during use.

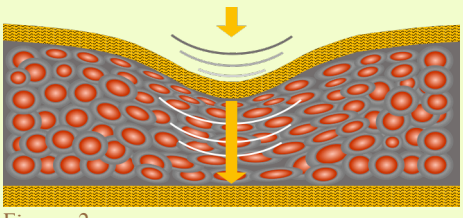


Figure 2

Quantum conduction allows the range, sensitivity and control to provide a real-world pressure-sensing experience that would otherwise not exist. A massive resistance change occurs under pressure over many orders of magnitude (from insulator to metallic-like conductor) and the change is in proportion to the pressure applied. This sensitivity and large dynamic range of QTSS materials pressure-sensing capability provides the significant benefit of being able to not only define a force threshold but also distinguish between the vast levels of force applied (unlike standard percolative piezo-resistive pressure sensors which only have a small dynamic range and are dependent on 'area change', so operate in an entirely different way that is not conducive for curved surfaces or large dynamic ranges). The low latency associated with quantum conduction also enables an 'instantaneous' response and the massive range of integration options allows simplified designs and mass producible, multi-functional sensors that can operate well on curvatures and sense pressure, friction and shear. Add all this to their enviro-friendly aspects, energy efficiency, reduced costs and reduced carbon footprint and one can see why operating off entirely new principles of quantum physics has far reaching benefits.

SocketSense project combines Printed Electronics (Large Area Electronics) and these QTSS™ materials to create mass producible, durable, flexible, lightweight and low-cost multi-functional sensors for monitoring pressure, shear and friction in prosthetic sockets.

QTSS™ inks are printable onto and can transform a variety of substrates into smart sensing surfaces including TPU, PET and flex-pcb but PET has been selected for this socket-sensing application. The socket walls are lined with the QTSS sensors in key identified regions of interest and data capture electronics have been developed for the embedded sensing system to reveal information from the different regions of a patient's stump to assist improvement of patient comfort and fit. Emerging technologies like Quantum Materials & LAE mass producible printable electronics provide new approaches to resolving healthcare needs. For a long time there has been an unmet need for extremely thin, flexible and wearable sensors to measure pressure, friction and shear in prosthetic sockets and to reduce the cost as currently available pressure sensors have failed to meet this need.

THE FRAMEWORK PROGRAMME FOR RESEARCH AND INNOVATION
HORIZON 2020

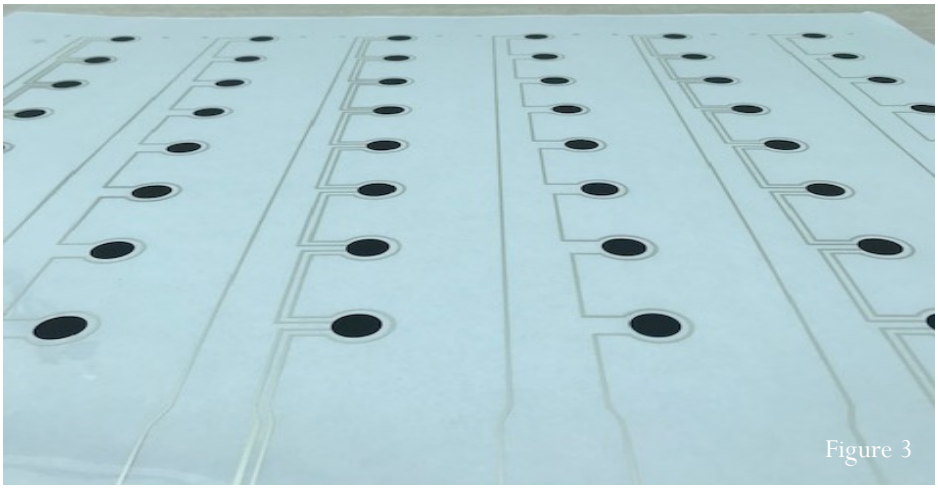


Figure 3

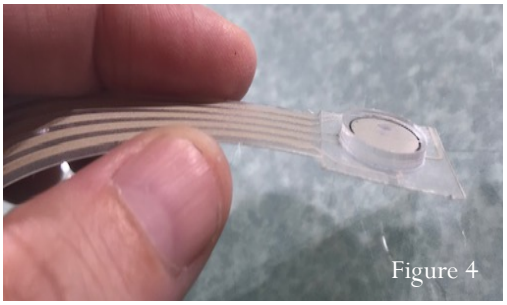


Figure 4

MULTI-FUNCTIONALITY:

QTSS™ Pressure sensor strip (see Figure 3 showing a printed sheet of uncut strips)

These multi-point sensor strips consist of two printed PET layers adhered together. They can be trimmed to any size depending on the length of the socket and placement of the individual sensels. The top layer is printed with silver and carbon inks and the bottom layer is similar but with the addition of the QTSS™ pressure sensing ink. A very 'simple' printed design has been utilised which allows for mass production worldwide by multiple parties. For this particular application the sensor has been designed to respond to pressures up to around 300 kPa, but QTSS™ inks sensitivities can be altered for different applications. One can imagine future versions being printed onto more environmentally friendly and recyclable substrates or even 3D printed electrodes inside socket walls with QTSS™ recyclable stickers applied in identified locations.

QTSS™ Shear sensor (see Figure 4)

The QTSS™ shear sensor is also printed onto PET and is interchangeable in a socket with a QTSS™ pressure sensing strip. Trimmable to any length it can be placed at key locations in the socket and indicates the size and direction of resultant tangential forces.

SUMMARY OF BENEFITS

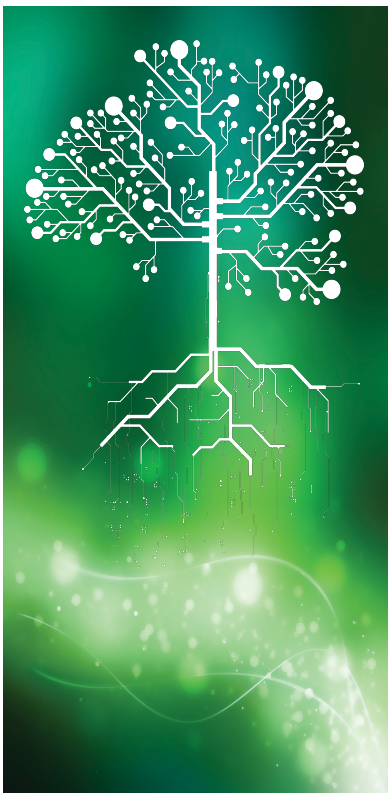
QTSS™ materials make it possible to have products which:

- Have new form factors, are ultra-thin, lightweight, flexible & customisable.
- Have low voltage operation & low power consumption.
- Are simple to manufacture in large scale.
- Reduce environmental impact.
- Achieve new low-cost structures and multi-functionality

SUMMARY

Electronic devices are becoming increasingly pervasive in our everyday lives in an ever increasingly connected world. Utilising these new 'smarter' and multi-functional enviro-friendly Quantum Materials that harness control of quantum conduction mechanisms will enable significant generational advances for simplified and more economically viable sensing solutions. Control of conductivity and other responses, individually or in a mix of resistive, capacitive, emissive or receptive modes provides us with new ways to protect and enhance human health and well-being as well as positively impacting on the world by looking after the environment for future generations.

AWARD WINNER Toxicant Replacement Hero Award IDTechEx Show! Berlin 2018



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QUANTUM TECHNOLOGY SUPERSENSORS

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SOCKET SENSE PROJECT

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