Functionalised Fabrics and Wearer Interaction

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Overview

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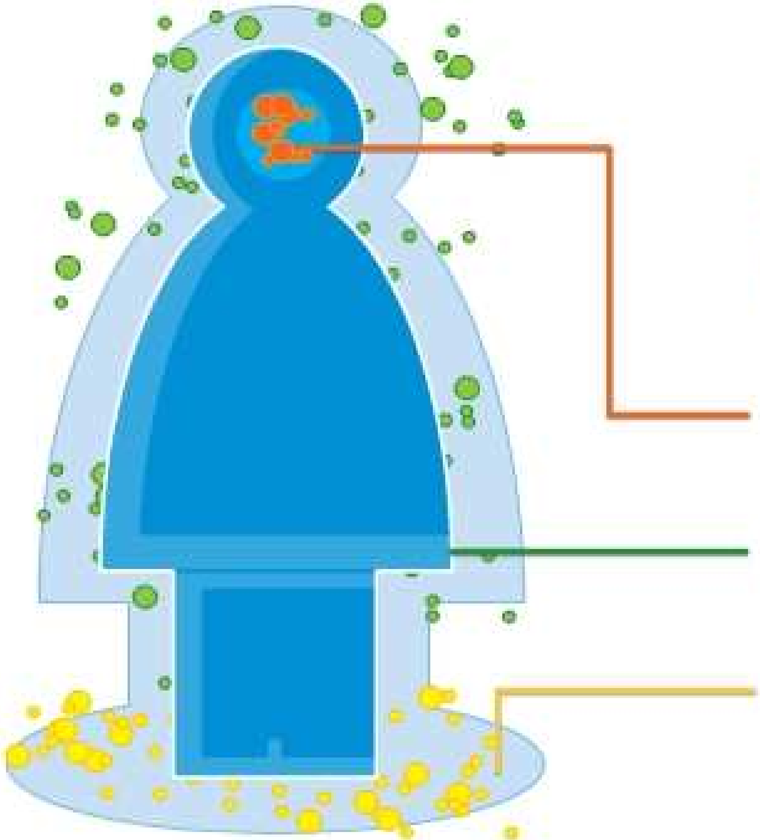
Introduction

Breathing feedback application

Wearable chemical sensors – sensing the body and environment

TennisSense

Vision: Sensing Mind, Body & Place



Understanding and leveraging key sensory information channels

Mind
Sensing people's preferences and intentions

Body
Sensing physical status and wellness indicators

Place
Sensing interaction between people and their environment

Sensors – “Smart shirt”

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Fabric stretch sensors monitor the expansion and contraction of the ribcage and abdomen during breathing.

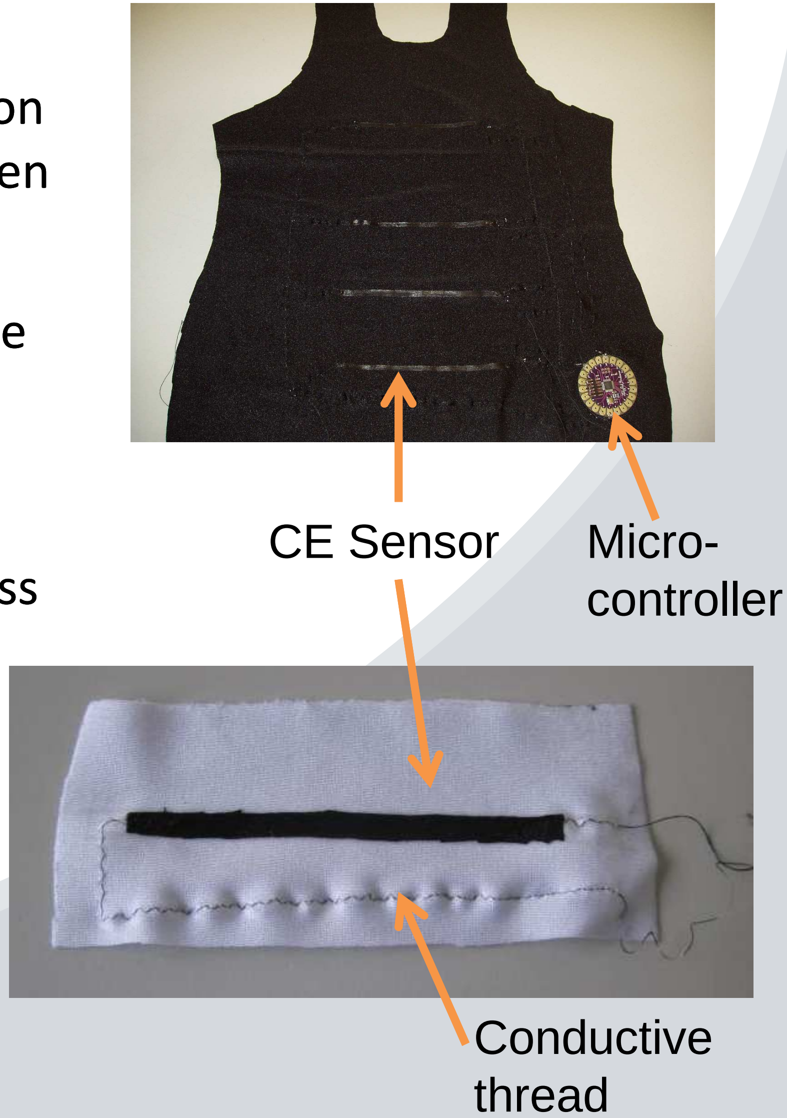
Piezo-resistive textiles – change in resistance due to stretch

Carbon-elastomer(CE) is coated onto fabric

Sensors connected using conductive stainless steel thread.

Resistor leads are embroidered

Wireless micro-controller to collect data



Breathing feedback system

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Project in collaboration with Adelaide and Meath Hospital, Dublin and National University of Ireland, Maynooth

Aim is to develop an encouraging biofeedback game to help children with cystic fibrosis to perform exercises correctly

Wearable Sensor - detect body movement due to breathing

Data capture and Wireless connection

Data processing and User feedback

Respiratory feedback system

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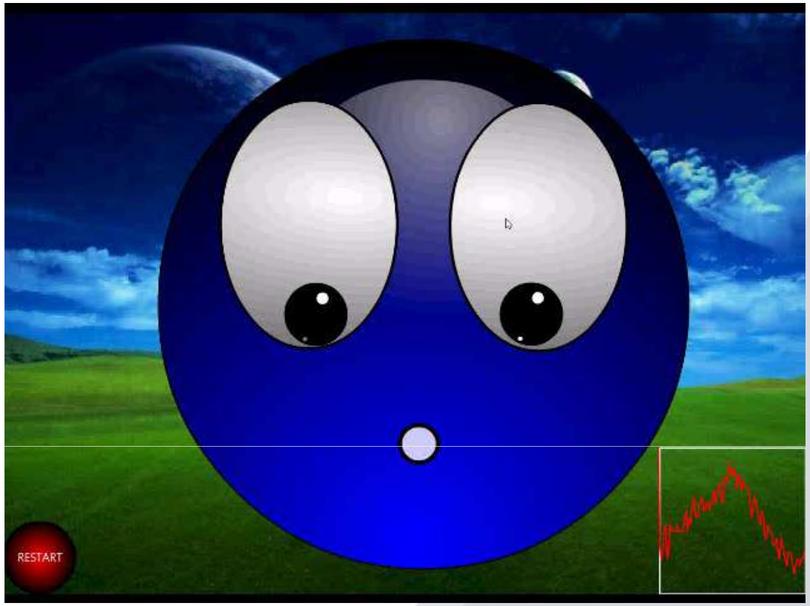
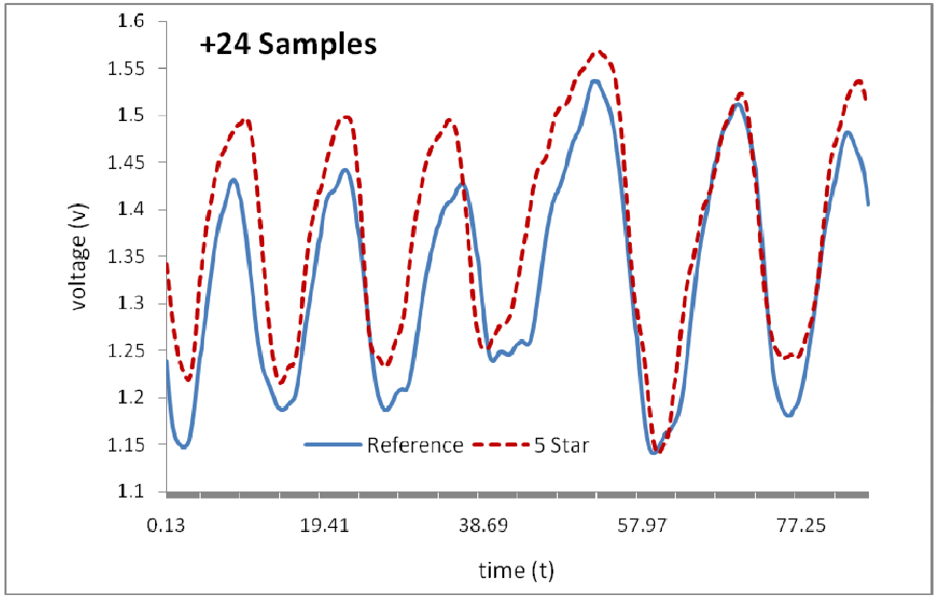


Step 1 – Record reference signal, under therapist's supervision

Step 2 – Avatar instruction with real-time feedback

Respiratory feedback system



Step 3 – Cross correlation between reference and recorded signal at end of exercise

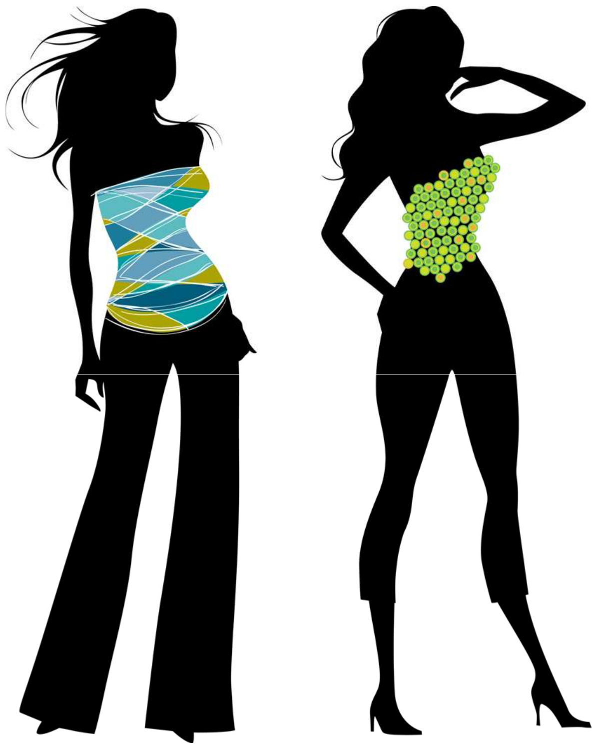
Step 3 – Encouraging feedback with grade (3-5 stars)

Physical vs Chemical sensors

Physical transducers (temperature, pressure, light density, movement…) do not need to be in direct contact with 'the sample' – can be shielded in a protective enclosure

In contrast, chemical sensors and biosensors depend on selective reactions happening at a active surface which must be directly exposed to the sample

Wearable chemical sensors



Smart clothing – interface between the body and environment

“Looking inwards”

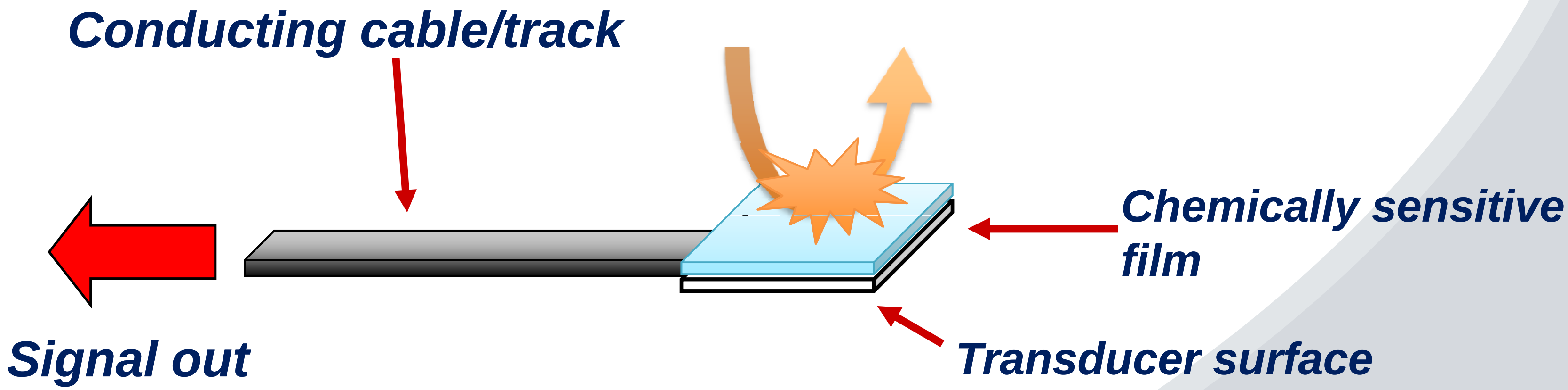
- Body fluids(blood, urine, tears, sweat)

“Looking outwards”

- Warning of hazards in the surroundings (e.g. toxic gases)

Wearable chemical sensors

A chemical sensor is a device, consisting of a transducer and a chemically sensitive film/membrane, that generates a signal related to the concentration of particular chemical species in a given sample'

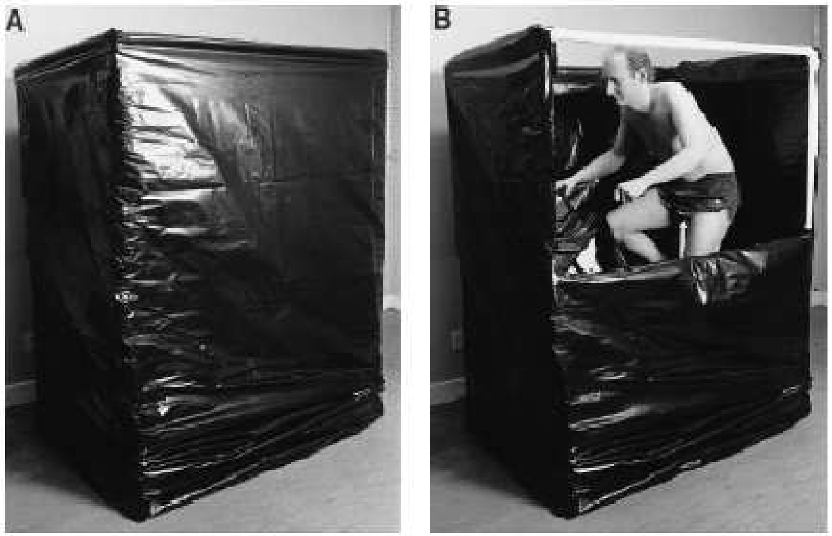


The sensing surface **MUST** be directly **exposed** to, and **interact intimately** with the sample

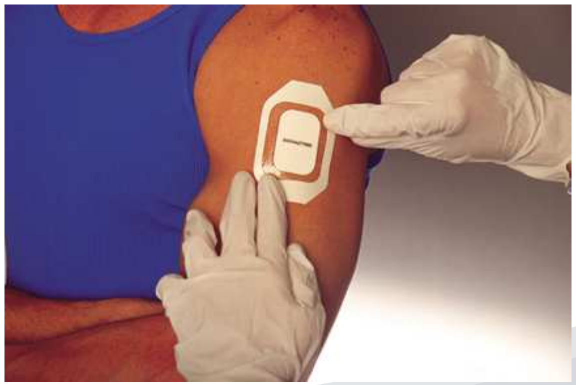
Wearable chemical sensors need to include sample delivery

- Fluid transport in a textile
- Air permeability of textiles

Sweat analysis



Wash-down technique
S. M. Shirreffs and R. J. Maughan , *J Appl Physiol* 82: 336-341, 1997



Patches for sweat collection, PharmChek®

Real-time analysis of **electrolytes** and **volume loss** is important for re-hydration strategies.

Extreme cases of **dehydration** or **hyponatremia** can have serious consequences

Current techniques for analysis are time-consuming and awkward

Need **real-time** measurements

Sweat analysis – Sample handling

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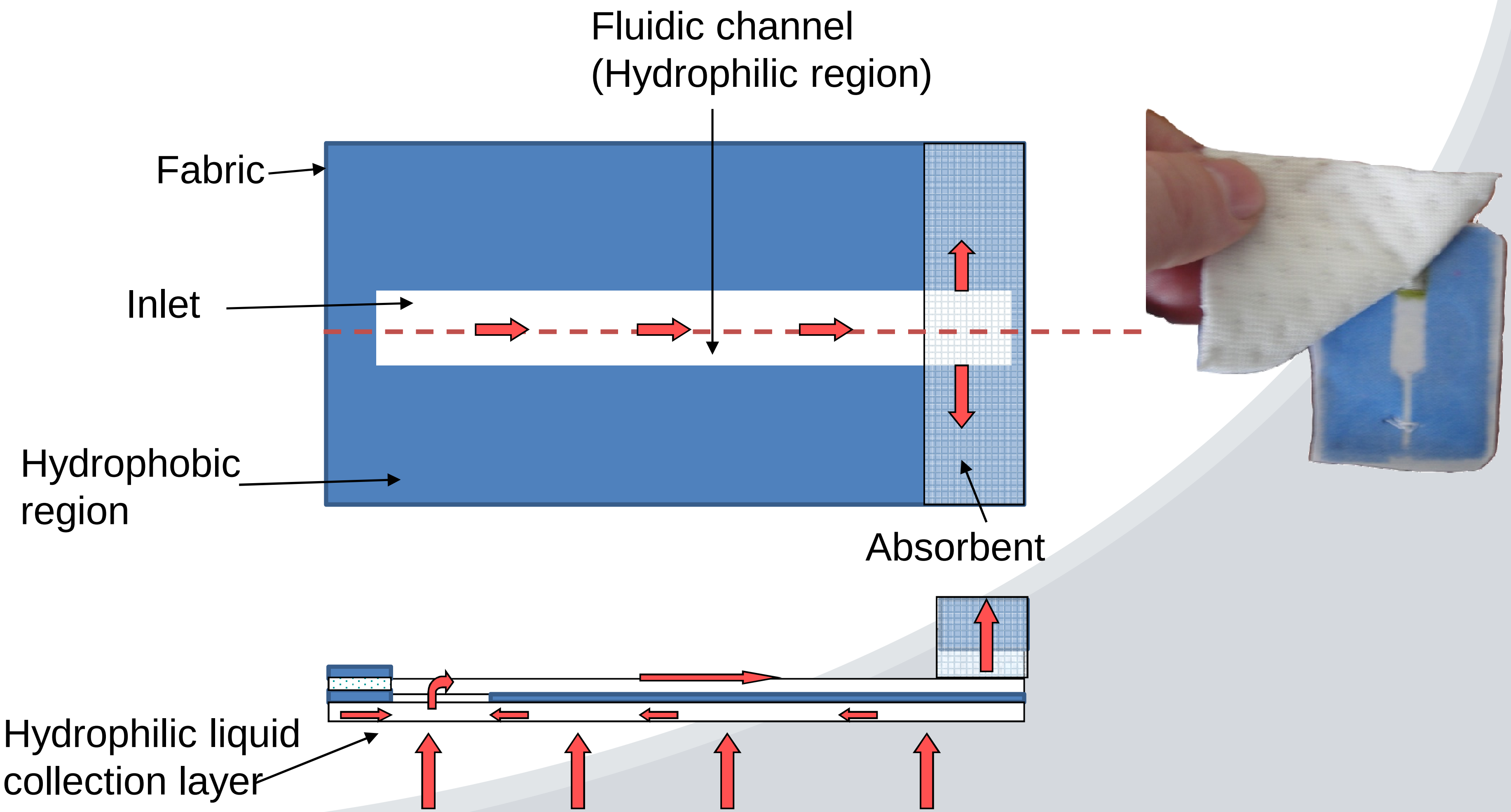
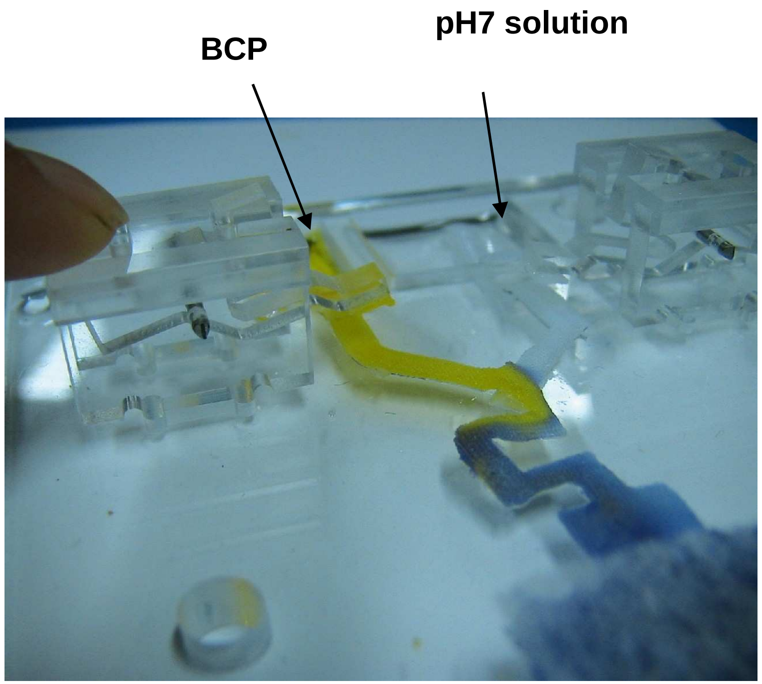
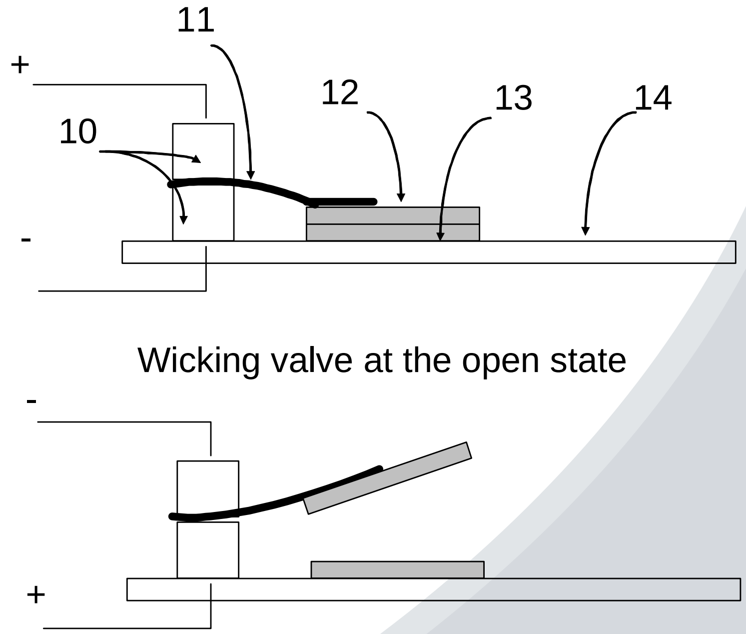


Sample delivery in textiles



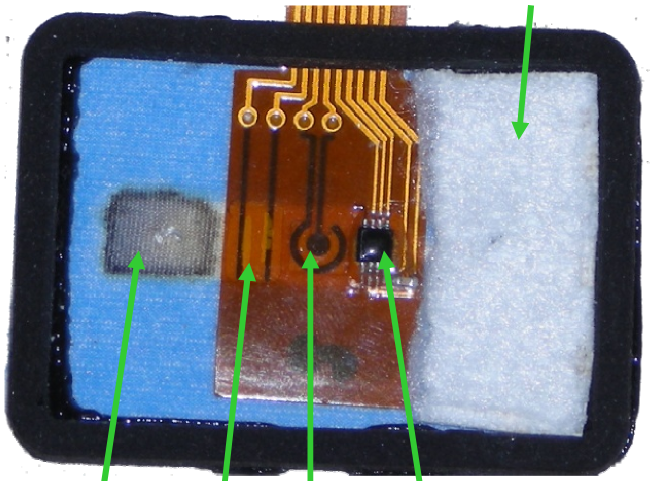
Fabric fluidic system – mixing reagents



Wicking valve at the closed state

WALLACE, G., DIAMOND, D., LAU, K., COYLE, S., WU, Y. & MORRIS, D. (2008) Flow Analysis Apparatus and Method, U.S Patent Application No. 20080213133

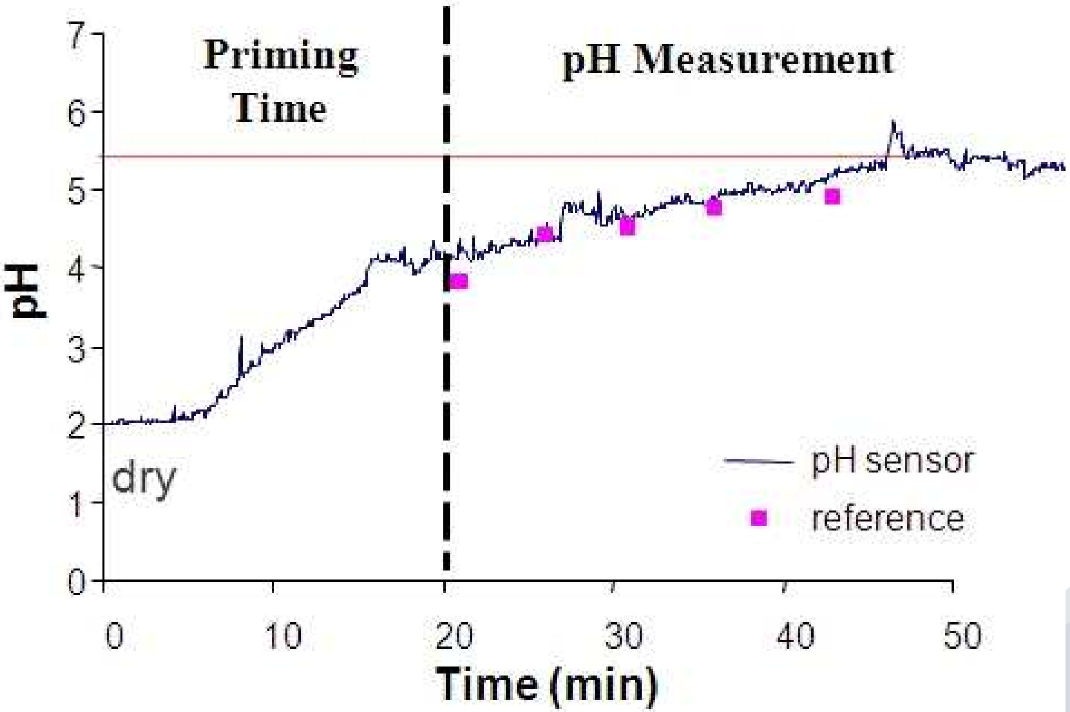
Wearable chemical sensors



BIOTEX (EU FP6 project, 2005-2008)

Real-time analysis of sweat
Fabric fluidic structure with
integrated sensors

Sweat analysis

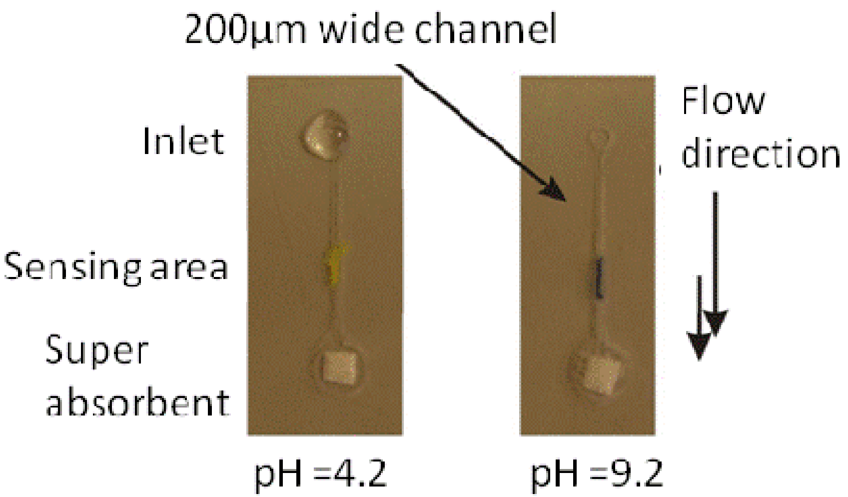


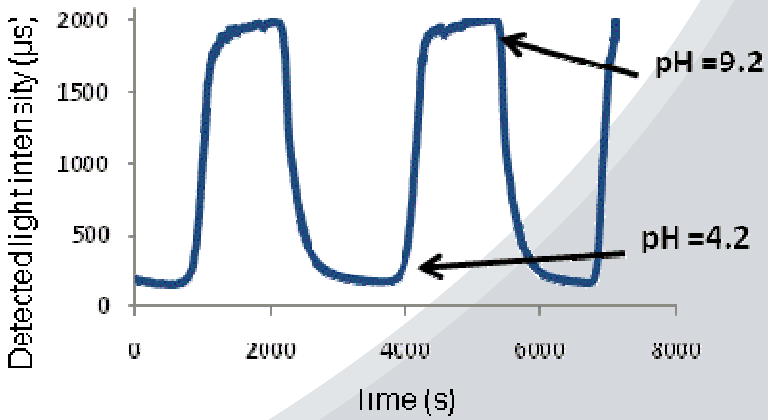
Need to reduce "priming time"

- Miniaturise device so that it functions at lower sweat rates and reduce dead volume

Microfluidic Device for Sweat Analysis

Microfluidic chip





Microfluidic Device for Sweat Analysis

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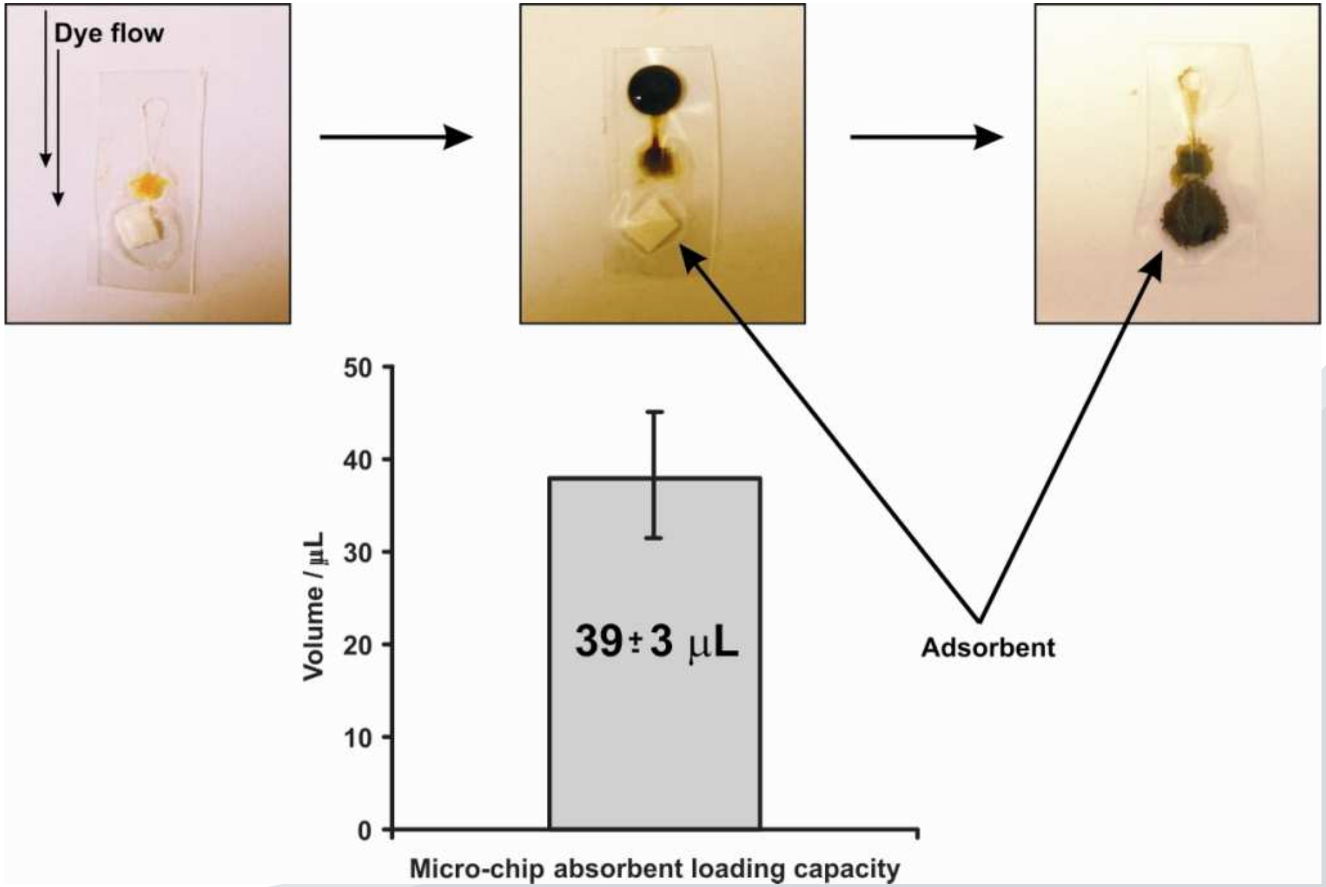
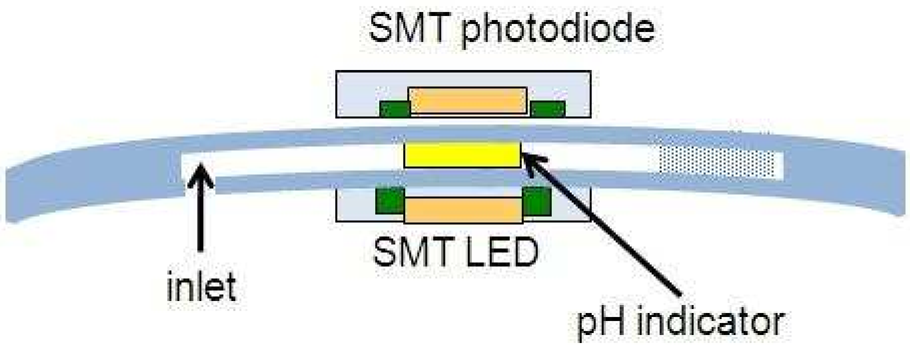
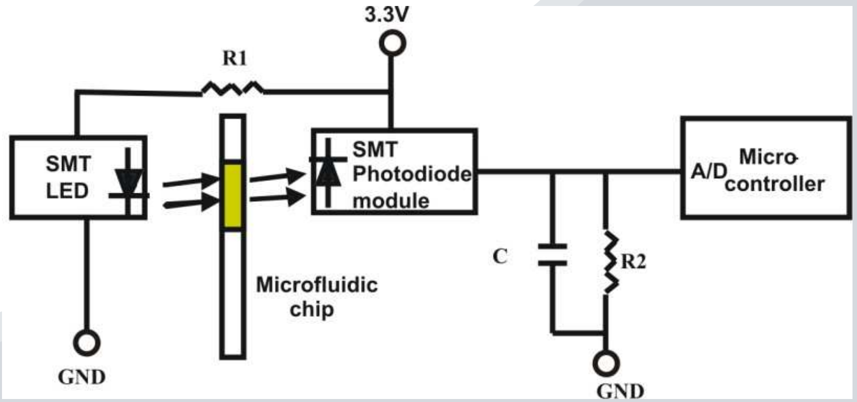


Microfluidic chip



Microfluidic pH sweat sensor.



Circuit diagram for microfluidic pH sweat sensor.

Real-time sweat analysis

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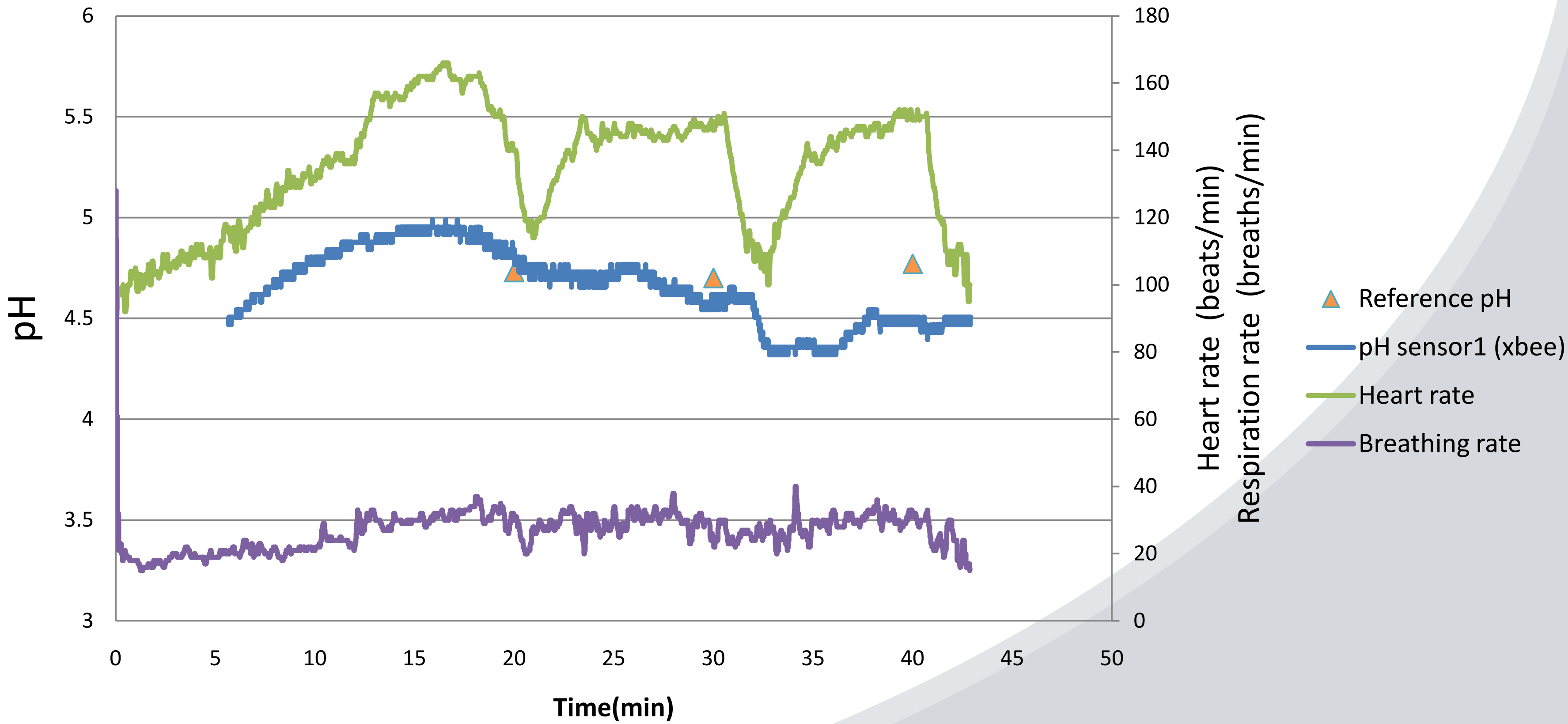

Real-time pH measurements with simultaneous measurements of heart rate and breathing rate using QinetiQ vest

Barcode and Microfluidic Devices Based on Ionic Liquids

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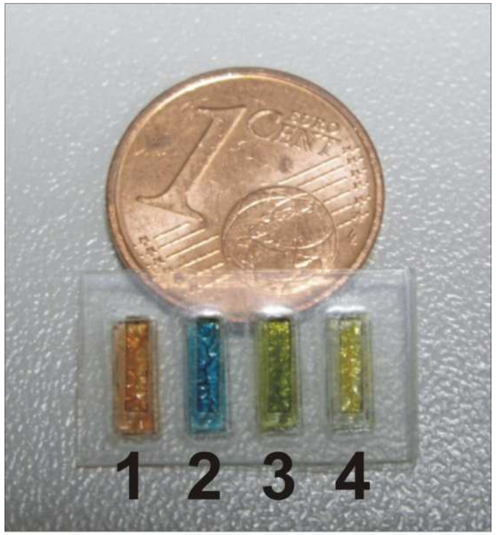
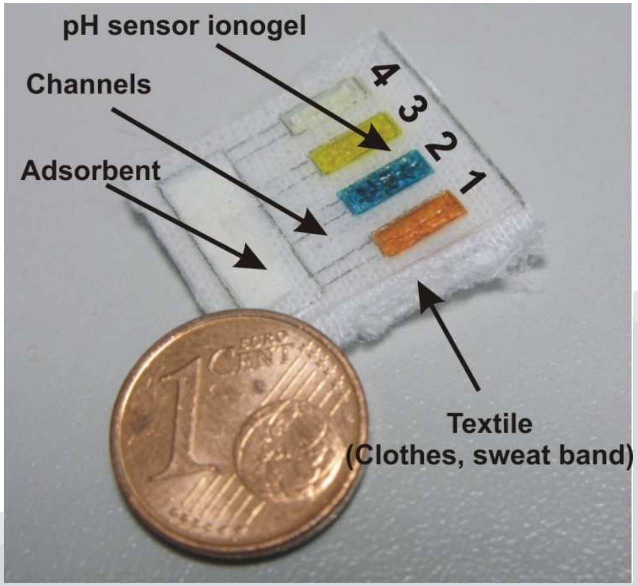
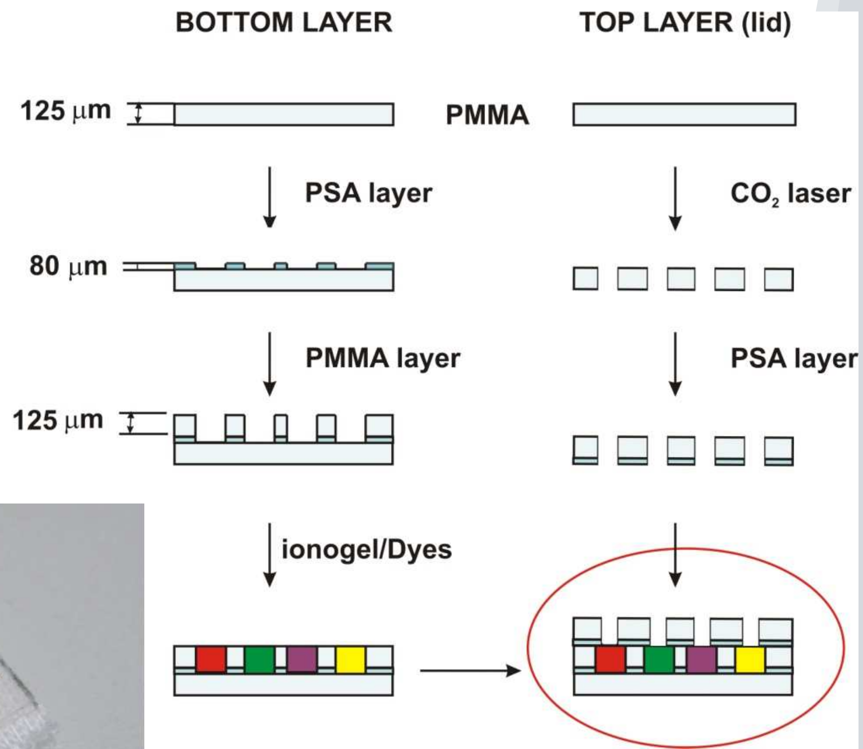
Barcode and Microfluidic Fabrication



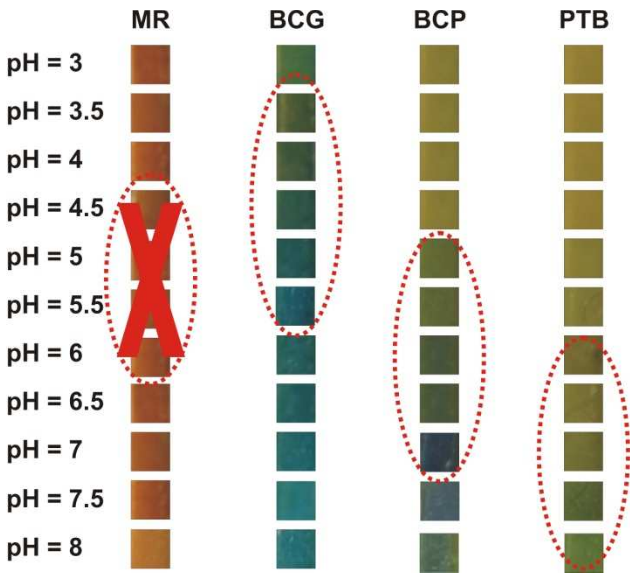
	pH
1- METHYL RED	4.4 - 6.2
2- BROMOCRESOL GREEN	3.8 - 5.4
3- BROMOCRESOL PURPLE	5.2 - 6.8
4- BROMOTHYMOL BLUE	6.0 - 7.6

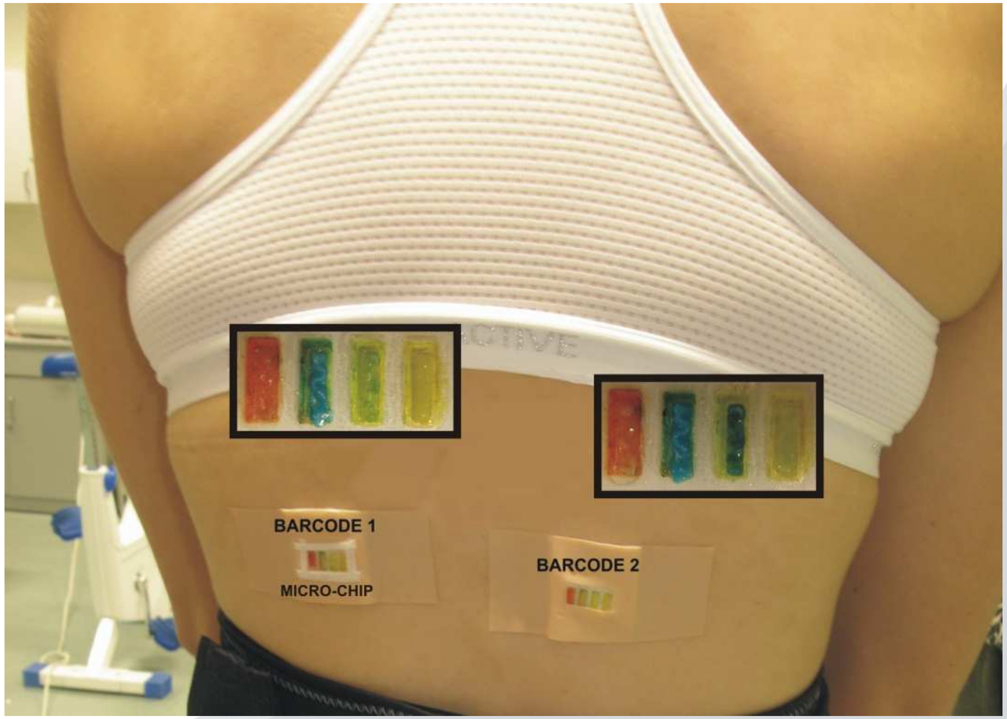




Barcode and Microfluidic Devices Based on Ionic Liquids

On-Body trials



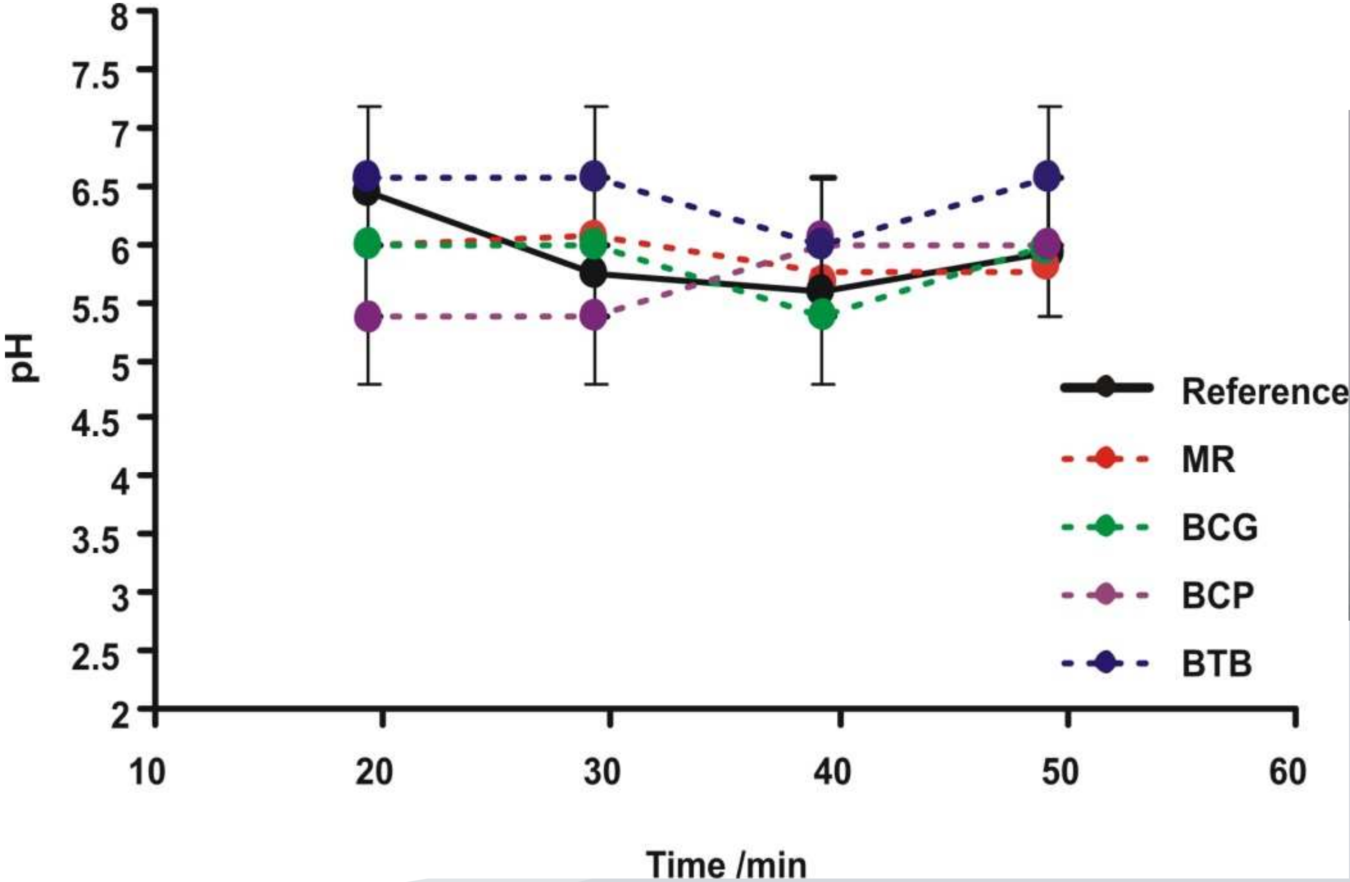


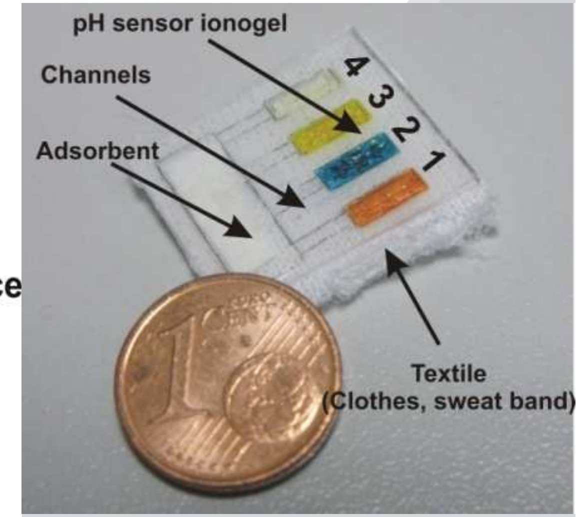
Colour profile of each of the indicators at different pH's (pH range: 3-8).

Picture of the back of a trainer with a micro-chip (1) and barcode (2) systems.

Barcode and Microfluidic Devices Based on Ionic Liquids

Results





Protecting the wearer

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PROETEX is an EU project which develops textile based sensors to improve the safety and efficiency of emergency workers.
23 partners in consortium

DCU's role
Monitoring the individual's exposure to CO and CO_2 gases

Oxygen deprivation can result in permanent brain damage, coma and even death.

Garment provides a warning when a significant threshold has been reached, indicating that the individual should go to a secure place to breathe clean air and detoxify

Protecting the wearer – CO_2 monitoring

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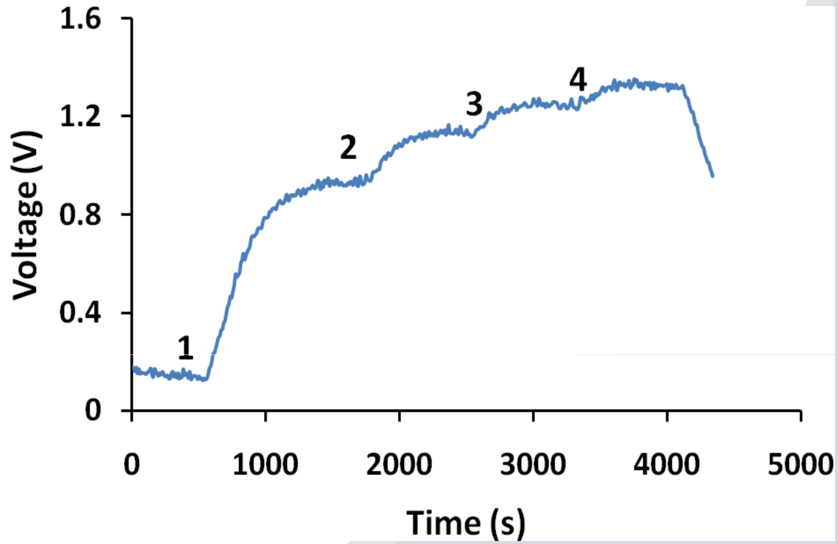

Response profile of a 4-step calibration, from atmospheric (initial base line) to (1) 9750 ppm, (2) 19500 ppm, (3) 29300 ppm, and (4) 42800 ppm CO_2

Protecting the wearer – CO monitoring

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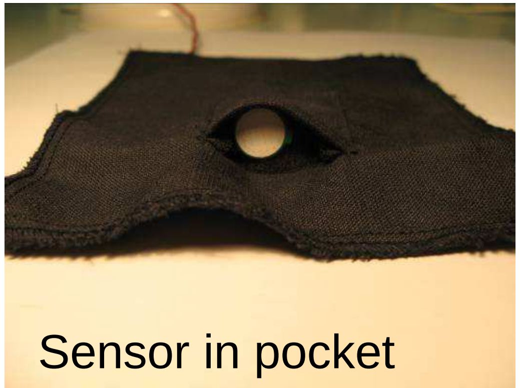
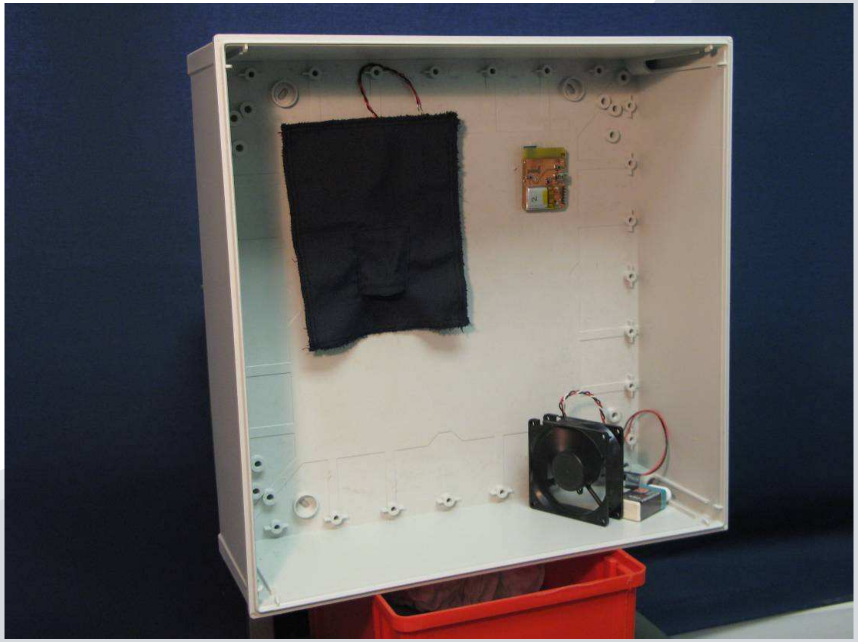
Sensor integrated into jacket



Sensor in pocket



Testing chamber

TennisSense

Infrastructure to gather data – contextual, biomechanical and physiological

Real users - Feedback to athletes/coaches

Tennis Ireland

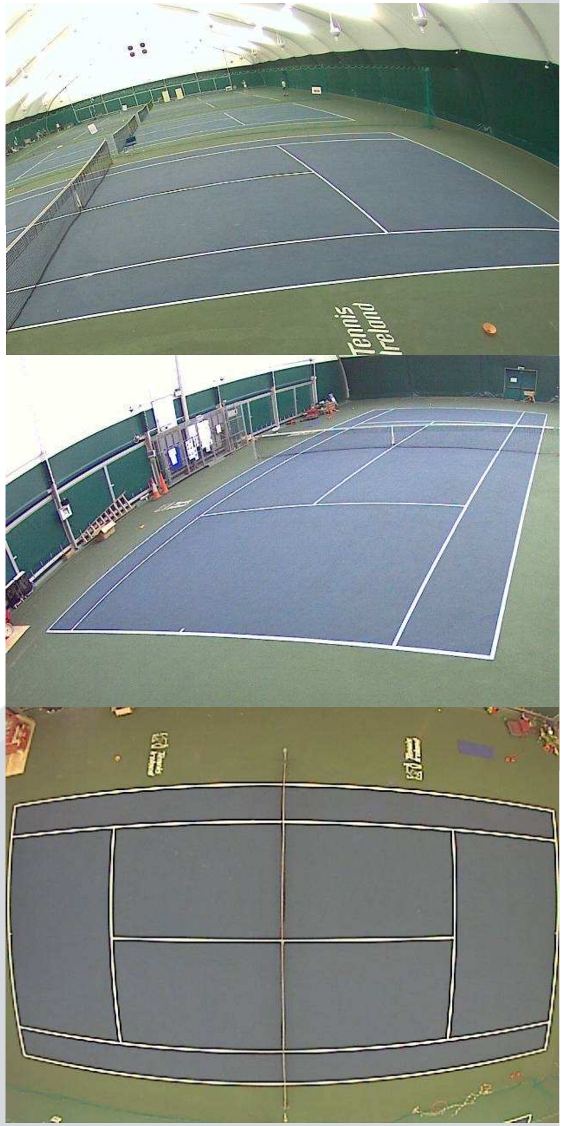
- Real-time feedback during training
- Longer-term analysis: fitness levels, performance

Sports Performance **Research**
What factors lead to peak performance?

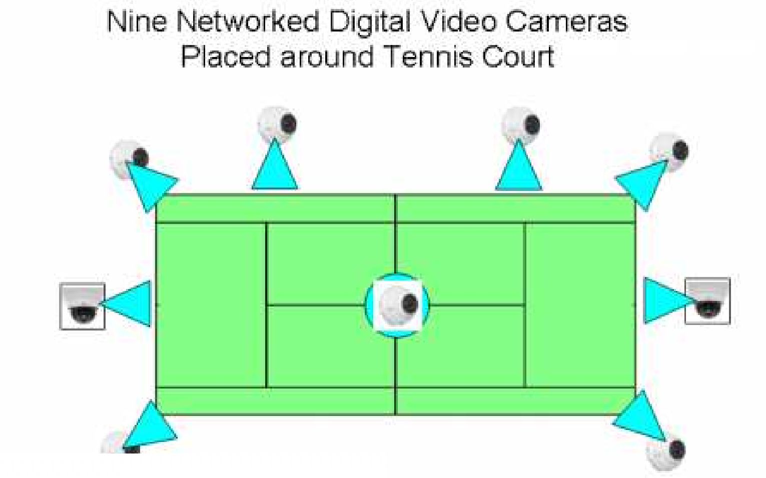
Platform for exciting research and new technology

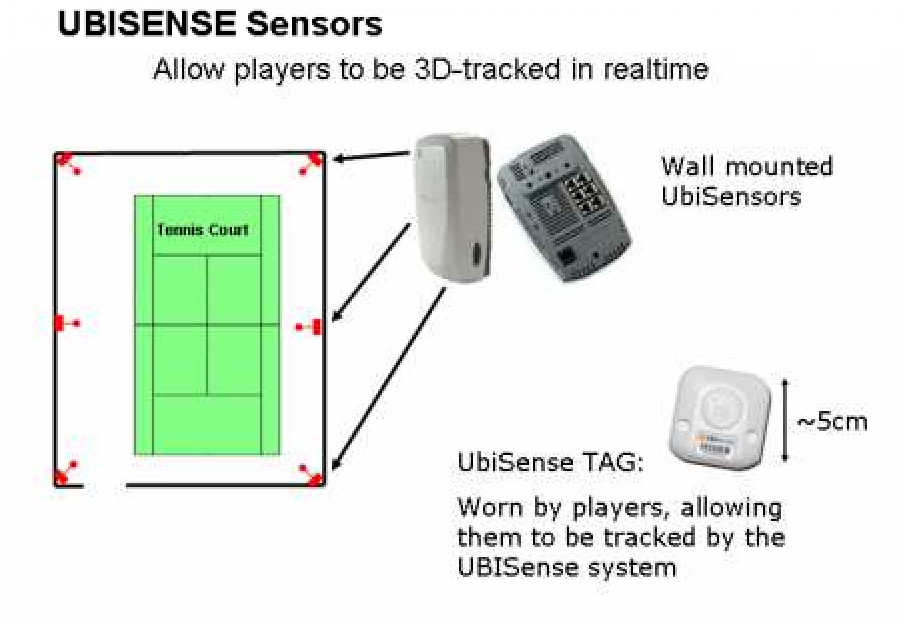
Multi-source data-mining and data fusion

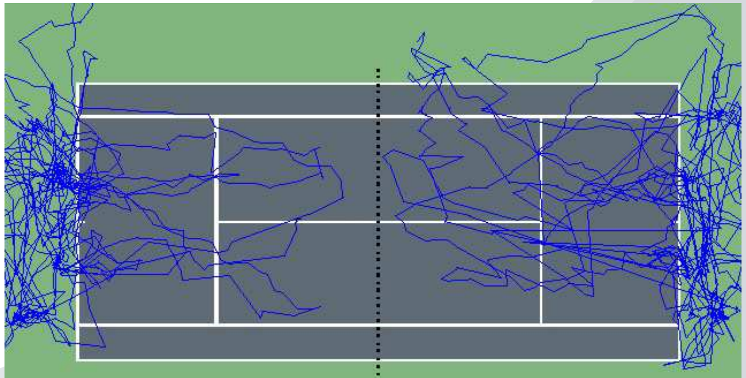
Wearable sensors



TennisSense







Distance covered	2189.96m
Average speed	1.23 m/s
Max Speed	9.03 m/s

Biomechanical data

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WIMUs (Wireless Inertial Measurement Units)

3-axis Accelerometers
3-axis Gyroscopes
3-axis magnetometers

Vicon – Motion Capture System

Physiological Data

QinetiQ physiological monitoring vest – measures heart rate(HR), respiration rate(RR)

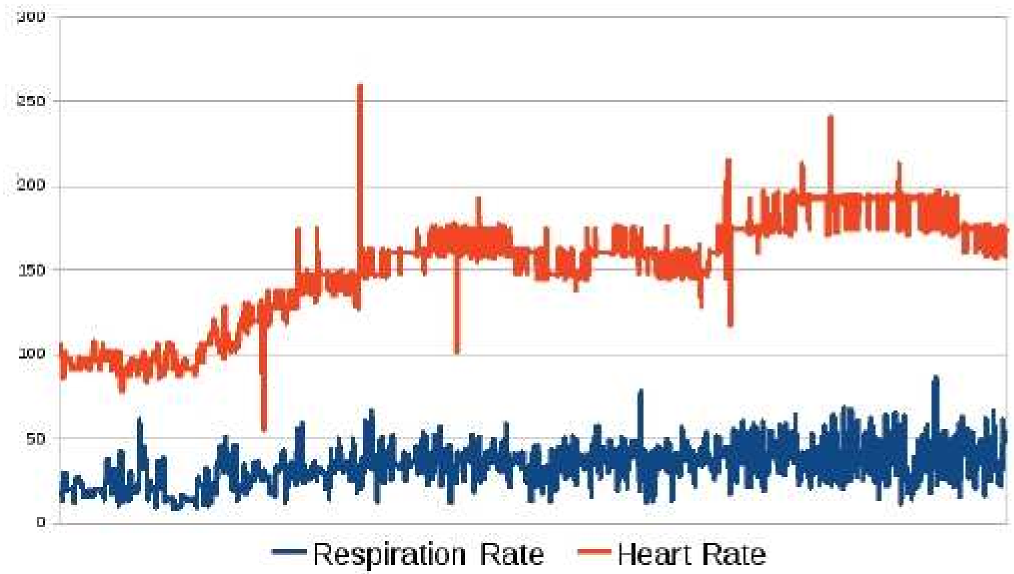
Parameters of interest
- Heart rate and Respiration rate between shots

- Average HR and RR across sets

- Peak HR and RR

-Difference between training and matches

- Comparison on different surfaces (e.g. clay can have longer rallies)



A Sensing Platform for Physiological and Contextual Feedback to Tennis Athletes, Damien Connaghan, Sarah Hughes, Gregory May, Philip Kelly, Ciaran ´O Conaire, Noel E. O'Connor, Donal O'Gorman, Alan F. Smeaton and Niall Moyna, BSN 2009

Conclusions

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Challenges in adding functionality to garments, signal processing, noise reduction etc.

Wearable chemical sensors – new tool for healthcare and wearer safety

Wearable sensors can gather vast amounts of information over long periods of time. Feedback methods are important – must be beneficial, easy to use, appropriate.

Interaction with end users is crucial throughout the development phase

Acknowledgements

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CLARITY: Centre for Sensor Web Technologies

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