Wearable technology development in Finland

Prof. Jukka Vanhala
Tampere University of Technology
Department of Electronics
P.O.Box 692, 33101 Tampere, Finland
tel. +358400623237, fax +358331152620
jukka.vanhala@tut.fi

Jukka Vanhala

Dr.tech. Jukka Vanhala

- Professor of Electronics at the Tampere University of Technology
- Head of the Kankaanpää Research Unit for Wearable Technology
- Docent of interactive technology at the University of Tampere
- MSc in 1985, Electrical Engineering, TUT
- Licentiate of technology in 1990, Software engineering, TUT
- Dr.tech. in 1998, Electronics, TUT
- Research interests include
  - embedded systems
  - ambient intelligence
  - wearable technology
- Can be reached at jukka.vanhala@tut.fi.

Sites of activity

Tampere
- Tampere University of Technology main campus
  - **Institute of Electronics**
  - Smart Wear Lab, (Fiber Technology)
- Nokia

Kankaanpää
- Clothing+
- Reima
- **TUT Research Unit for Wearable Technology**

Lahti
- Rukka
- Lahti University of Applied Sciences, Institute of Design

Helsinki
- Nokia
- Suunto
- IST
- TAIK, University of Art and Design Helsinki, (Aalto)

Oulu
- Polar Electro
- University of Oulu

Rovaniemi
- University of Lapland

Kouvola
- Kymenlaakson AMK, University of Applied Sciences

Hämeenlinna
- HAMK, University of Applied Sciences

Personal Electronics

PEG

Prof. Jukka Vanhala

~25 research scientists at Tampere and Kankaanpää (partly funded by European Union Structural Funds)

Research in embedded systems

Ambient intelligence

Wearable technology

User interfaces, usability

Simulator systems

Short range wireless communication

Ultralow power consumption

Electronics integration and packaging

Ambient intelligence

Wearable computing

Smart clothing

Prediction in 1999

Electronics will be embedded into everyday objects

Electronics provides new functionality

Objects provide a use case and an environment

10 years after, the technology is available

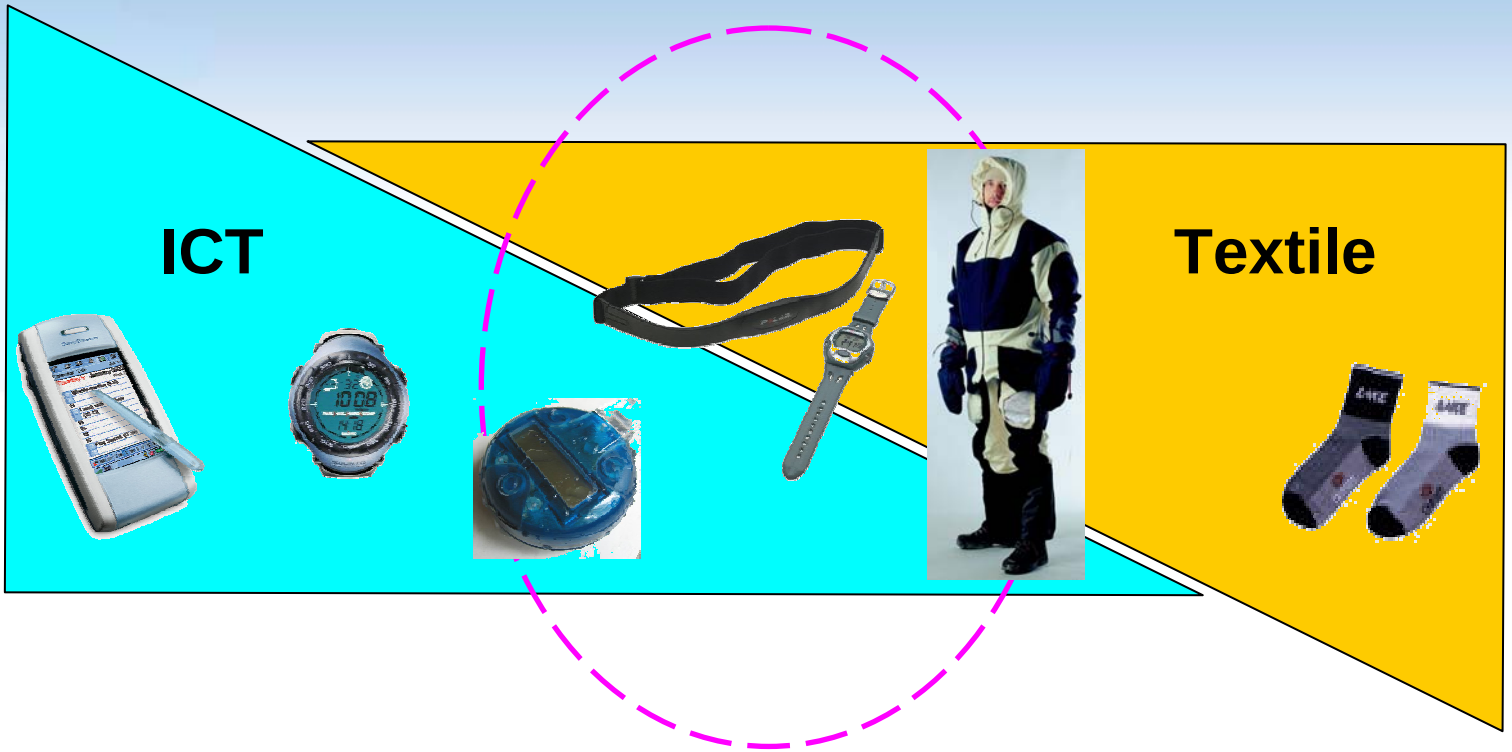
Who does the innovations?

User measurements

INTEGRATION

- Medicare
- Elderly care
- Health and fitness
- Sports

Continuum



information appliances

wearable technology

smart clothing

intelligent textiles

Swimmers distance meter

Clothing+ swimmers distance meter

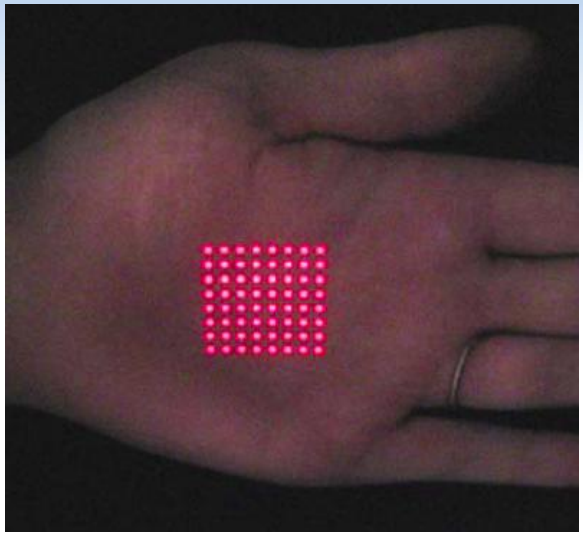
Calculates the direction of movement of a swimmer using magnetic sensors and signal processing

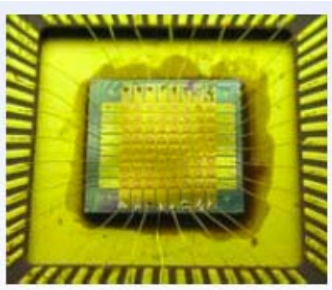
Typical design

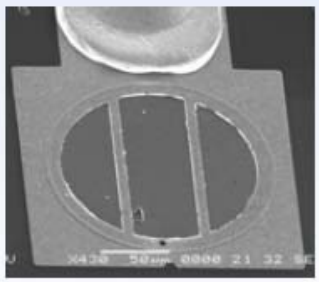
- cheap sensors
- novel signal processing algorithms
- implementation on a micro controller
- small display, few buttons
- injection molded enclosure

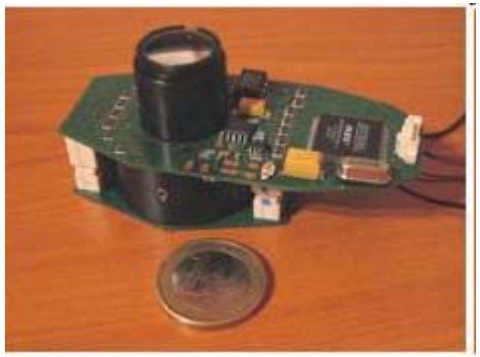
Miniature display projector

- Miniature projection display capable of projecting the image onto the user´s palm
- Miniaturized electronics, optics
- Ultra-bright Resonant Cavity Light-Emitting Diode (RCLED) -based display element









Smart clothing

Clothing with enhanced functionality

Enhanced basic functions

- protection
- looks
- pockets

Additional functions

- communication
- measurements
- etc.

The need for good product concepts must be emphasized

Cyberia survival suit, TUT

TESC

Technologies Enabling Smart Clothing - project

One research prototype for studying usability of electric heating in garments

- usability, user experience
- technologies
- energy balance
- effect on sweating
- measures
  - temperature
  - humidity
  - power consumption
- controls heating

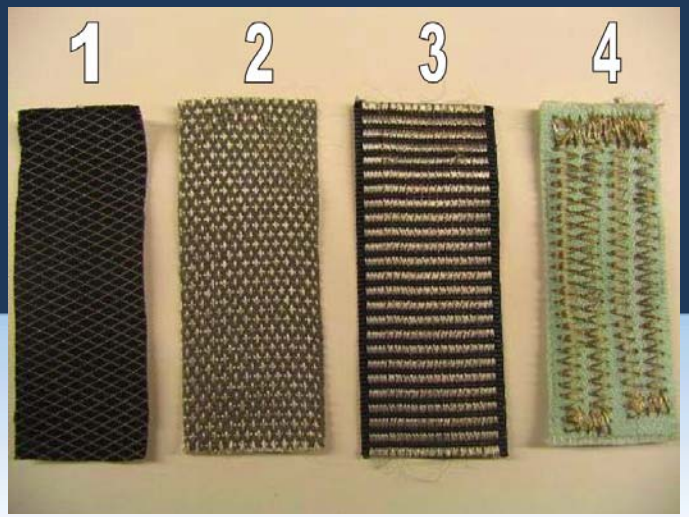
The difficulty with research prototypes

Other implementations in TESC

- bioimpedance measurement suit
- user interface for outdoor use

Electically heated clothing, TUT

Textile electrodes



Pola: Electrode materials evaluated at TUT

Scilingo et al. IEEE Proceeding ITB 2005

Need for

- Reliable stable soft dry electrodes

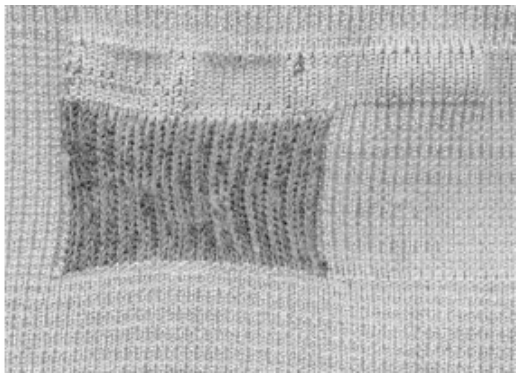
A lot of reports have been published

- Knitted, embroidered, woven, plastic, rubber

Performance comparable to standard electrodes

In commercial mass production for sports applications

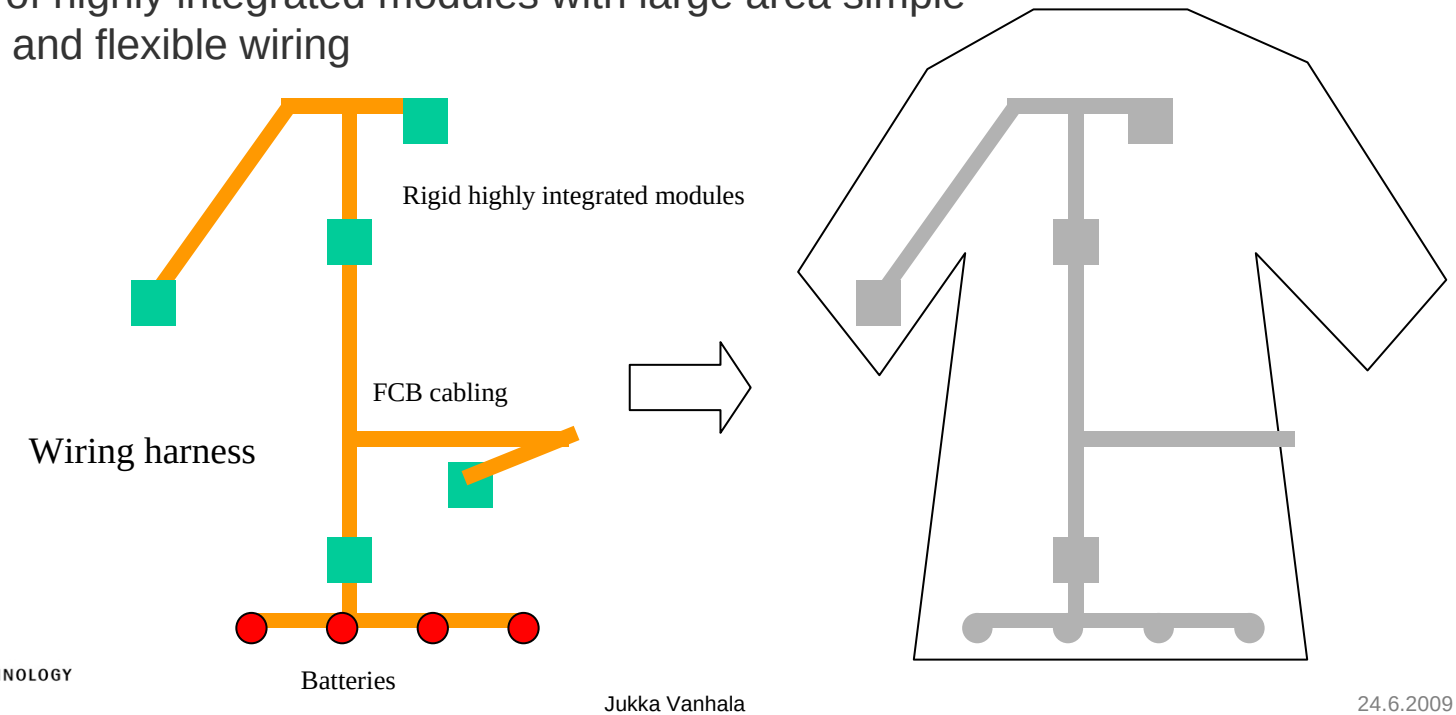
- Clothing+, Adidas, Polar-Electro, NuMetrex



Rubber electrode, Mühlsteffa and Such, IEEE EMBS 2004

Manufacturing technologies

- Wearable designs are human size, e.g. user interfaces must be used with fingers
- Electronics miniaturization an overkill
- Distributing functionality evenly is probably not a good idea (textile computing)
- Composition of highly integrated modules with large area simple electronics and flexible wiring



Encapsulated modules

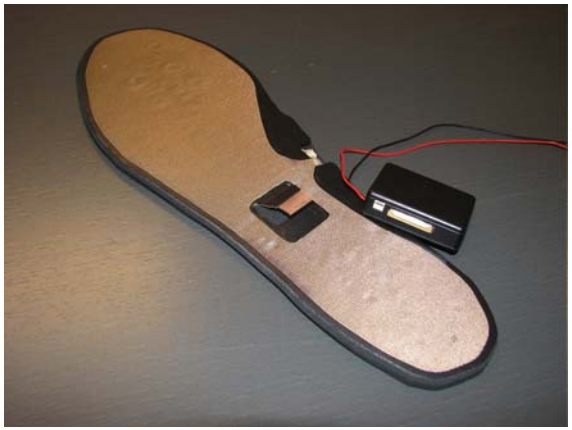
- Electronics in a detachable module
  - Mp3-player
  - Mobile phone
  - Gps-receiver
  - Medical measurement devices
- Straightforward design for electronics, consumer electronics
- Electrodes, wires, UI-designs and other washable components permanently in the garment

ECG-Shirt, TUT

Textile electrodes sewn inside the fabric

Detachable ECG-datalogger with snap fasteners

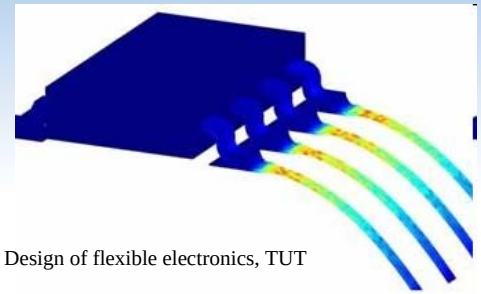
PUHVI-project, TUT



Textile pressure sensors in the structure of the insole and detachable electronics

Layout design

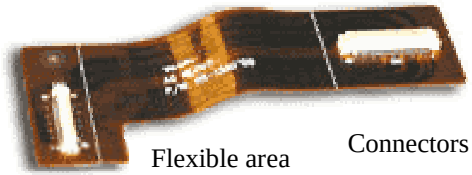
Flexible designs can be implemented on flexible PCBs (FCB)



Design of flexible electronics, TUT

Flexible PCB is normally used as a flexible cable

- Periodic bending, hinges
- May be bent millions of times

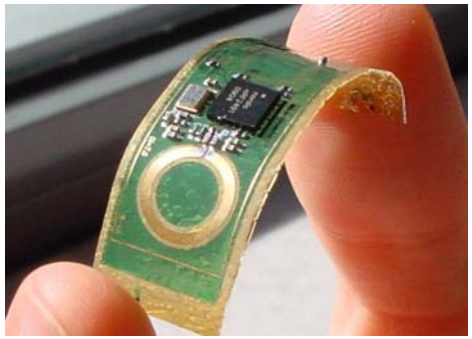


Flexible area Connectors

University of Gent

Flexible PCB with components are seldom used

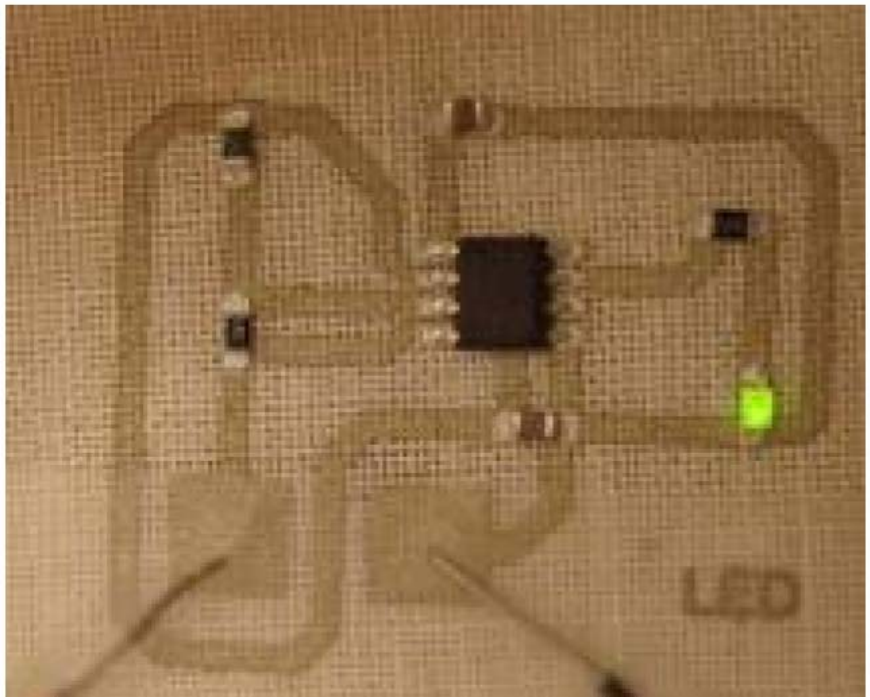
- Reliability problems, low bent count before breakage
- Free form packaging, no bending after assembly
- Special design rules
- Plain traces OK, bonding areas a problem
- Possibly for wearable applications



Screen printed traces

TUT has studied printing patterns on different unconventional substrates

Silver paste screen printed on cotton and conductive silver adhesive for bonding



Communication application examples

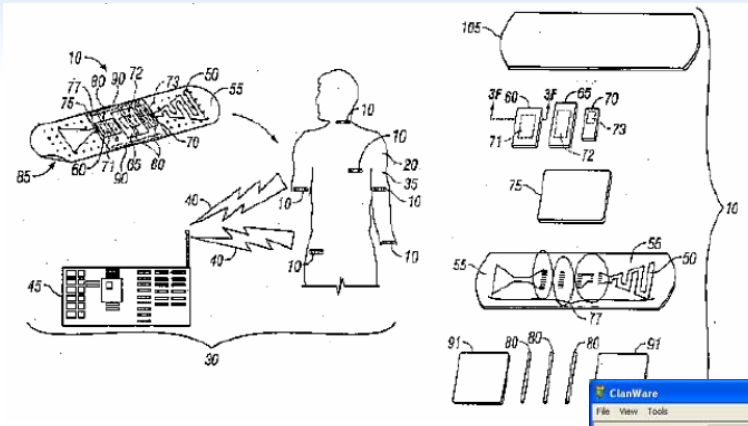
Fire fighter, environment

Business card exchange, intra person

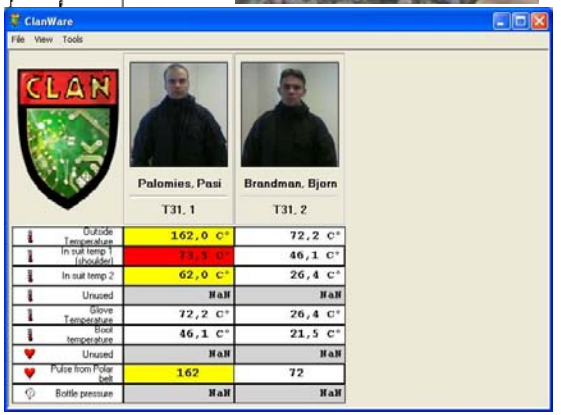
Implanted system, intra body

Home care, Internet

[Pat. US2005/096513



PUHVI –project at TUT



CLAN –project at TUT

Thank you!