Introduction to EU-H2020 project WEARPLEX: Wearable multiplexed biomedical electrodes

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13th Vienna FES-Workshop
23. September 2019

H2020-ICT-02-2018

Overview

» Introduction to WEARPLEX project and concept
» Motivation for WEARPLEX
» Project Partners
» State of the art multi-electrode systems for FES and EMG
» Printed logic Demultiplexor
» Printed ink development
» E-textile integration
» Application specific development
» Mass manufacturing
» Workshops
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Introduction

WEARPLEX

ICT-02-2018 - Flexible and Wearable Electronics

Grant agreement ID: 825339

- **Aim:** Integrate printed electronics with flexible and wearable textile-based biomedical multi-pad electrodes.

- **Key Focus:**
  - Printed multi-pad electrodes with integrated logic circuits
  - Printed electronics on textiles
  - Optimised use of high density multi-pad electrodes

Start date **1 January 2019**

End date **31 December 2021**

Funded under:
H2020-EU.2.1.1.

Overall budget:
€ 3 732 749,29

EU contribution
€ 3 732 748,75

Coordinated by:
UNIVERSITY OF SOUTHAMPTON
United Kingdom

Why WEARPLEX?

» Medical electrodes market is $1B globally, despite being mostly lab or clinic use.

» Several markets for wearable EMG and FES devices:

- Human-machine interfacing
  - EMG control – gaming, drones, smart home solutions, assisted living.
  - Electrotactile feedback – VR interaction, haptic telecommunications, telemanipulation
- EMG monitoring – sports, posture, rehabilitation
- Neuromuscular Rehabilitation – e.g. Stroke:1 every 2 seconds, expected to be 70 million survivors by 2030
- Pain relief

Why WEARPLEX?

» State of the art multi-pad solutions have many advantages:
  » Simple positioning
  » Dynamic stimulation patterns
  » Fatigue offset
  » Greater recruitment level

» There are two main practical limitations to their use:
  » Number of pads limited by number of leads and available connectors
  » Limited adherence to curved body parts

Why WEARPLEX?

» WEARPLEX aims to develop printed logic circuitry that would allow embedded multiplexing

» Printed electrode pads will be addressable into virtual electrodes.

» Software methods will be developed for automatic personalization of the virtual electrodes.

» Combining with textiles will allow easier setup and adherence to all body parts.

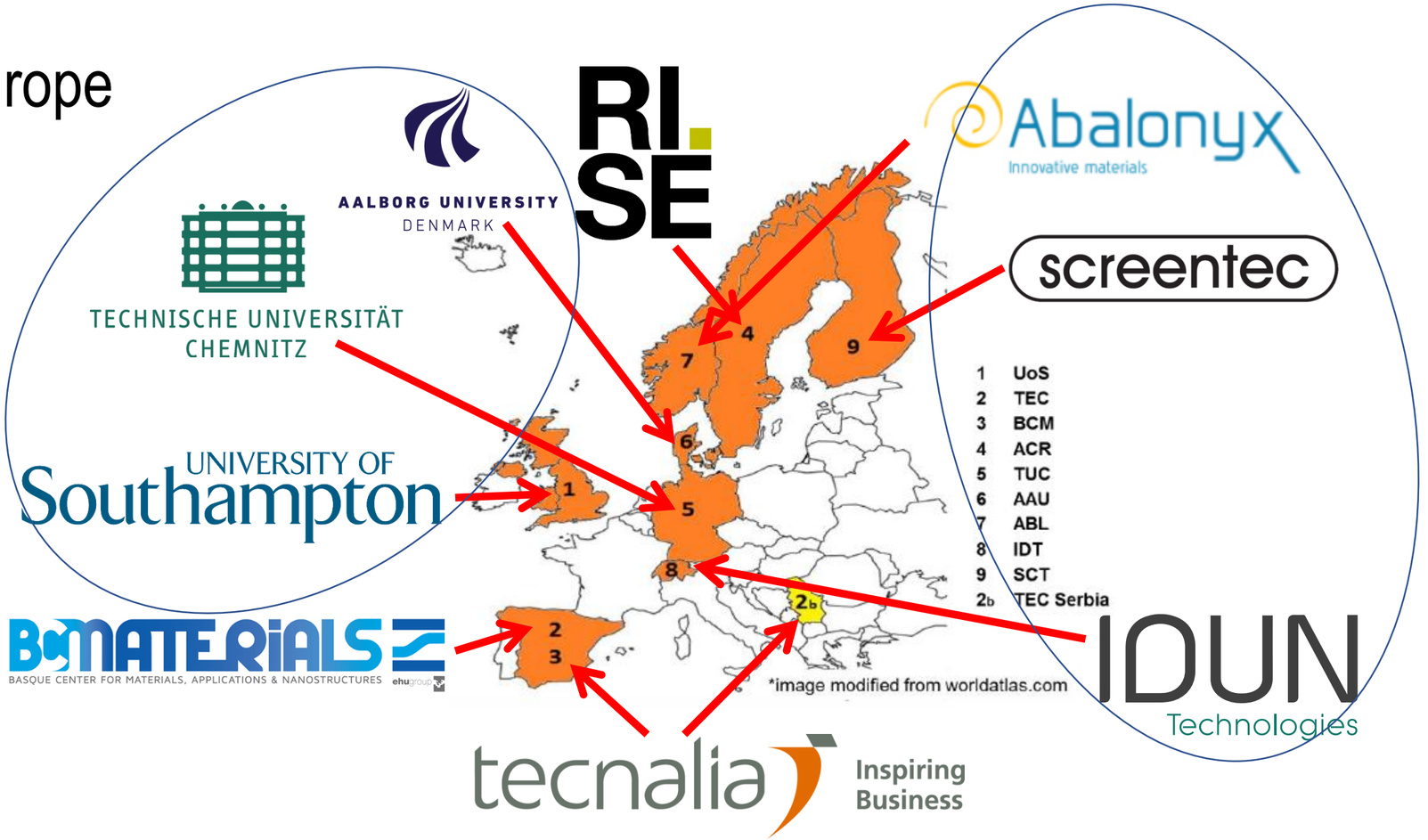
Project Partners

9 Project partners across Europe

» 3 Universities

» 3 Research Institutes

» 3 SME's

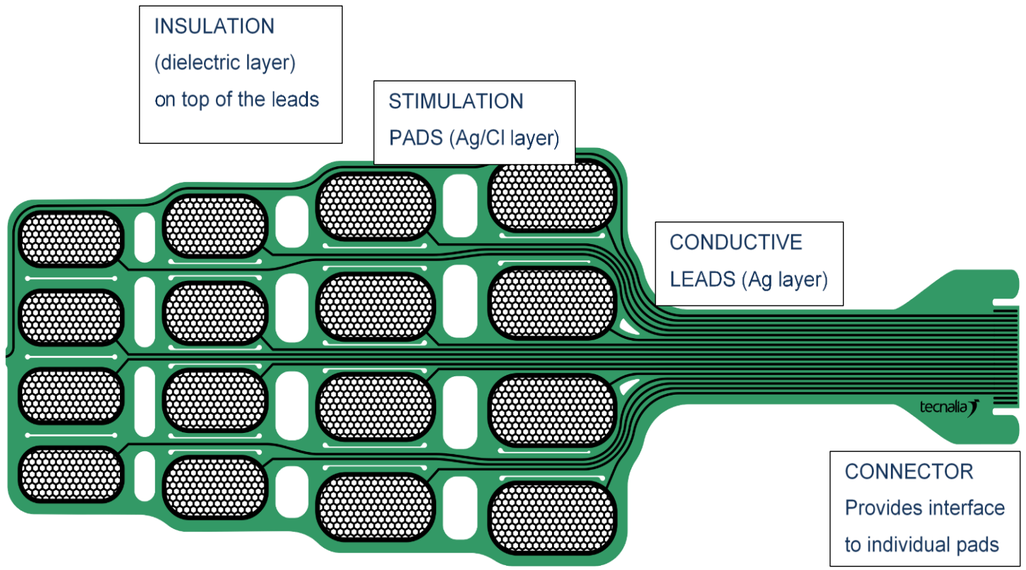


Project Partners

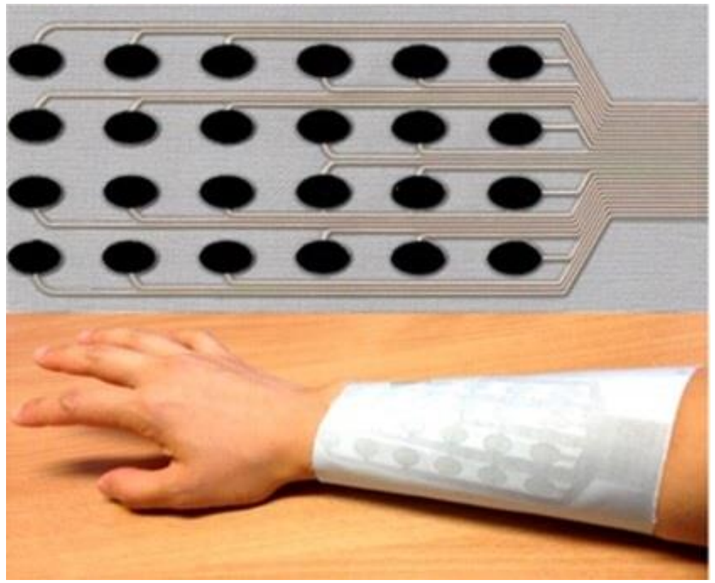
- ***University of Southampton* (UoS)** – Coordinator – expertise in printed electronics on fabric and e-textile fabrication.
- *Technical University of Chemnitz* (TUC) – Printed electronics mass manufacturing.
- *Aalborg University* (AAU) – Expertise in recording and analysis of EMG signals, FES applications & clinical assessment.
- *Tecnalia Research and Innovation* (TEC) – Expertise in multi-pad electrodes, FES applications and biomaterials.
- *Basque Centre for Materials, Applications and Nanostructures* (BCM) – Expertise in printed ink development.
- *Research Institutes of Sweden* (RISE) – Printed electrochemical transistors and logic devices.
- *Abalonyx* (ABL) – Expertise in GO and rGO for printed electronics.
- *IDUN Technologies* (IDUN) – Expertise in electrode design and biopotential monitoring.
- *Screentec* (SCT) – Expertise in industrial printed electronics and medical devices.

State of the Art Electrode Technology

» Existing multi-pad electrode structure using printed electronics on flexible plastic and FES electrode array printed directly on fabric.



Printed FES electrode array on plastic (TEC)

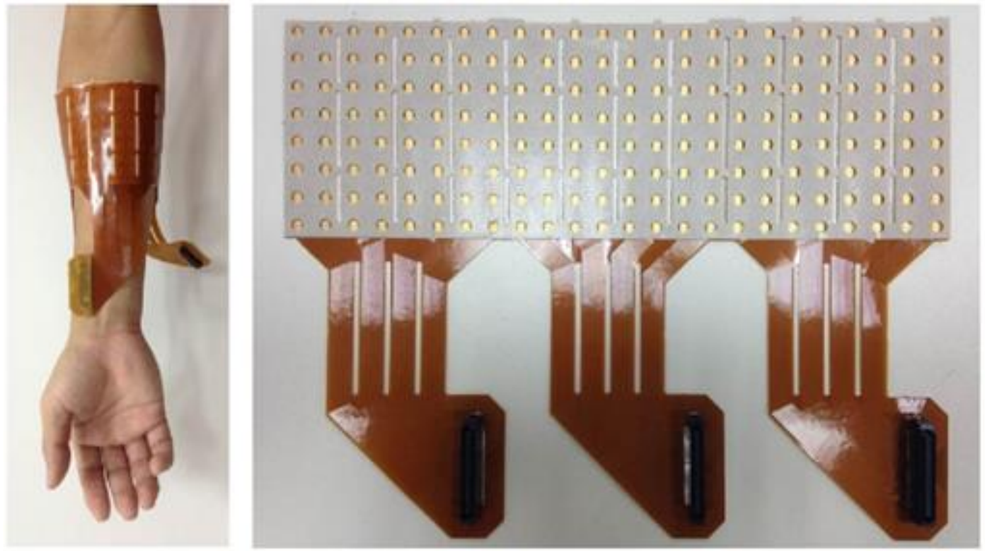


Printed FES electrode array on fabric (UoS)

» For each device, the electronics is connected separately and is not integrated within the electrode structure.

State of the Art Electrode Technology

» High density EMG electrodes exist (192 channels) but all switching is performed using external electronics and flat cables.



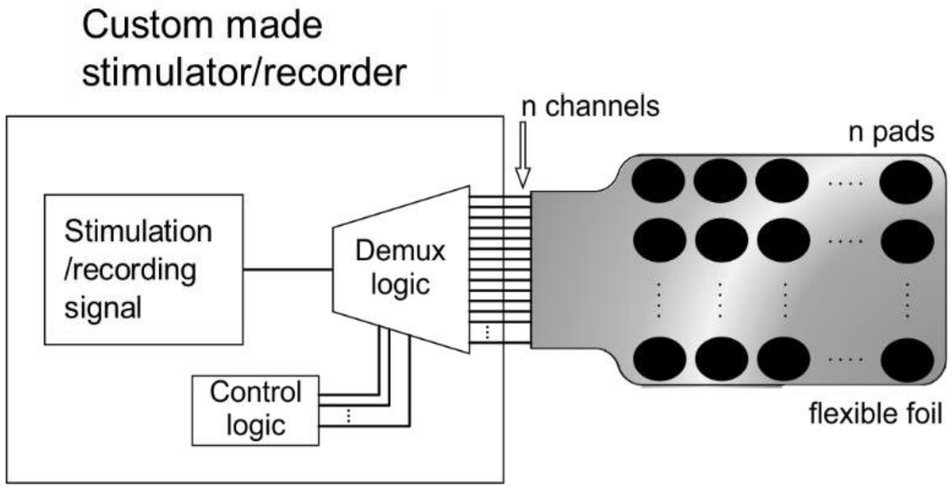
Etched copper EMG electrode array on plastic

Extensive cabling required

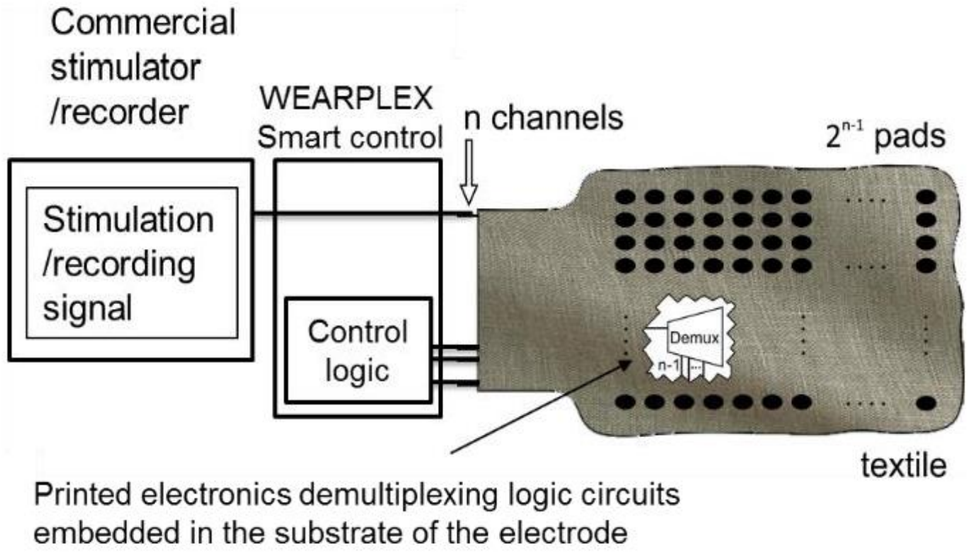
» No commercially available devices combining EMG and FES and no fully printed examples in the literature.

Progress beyond the state of the art

» Proposed WEARPLEX solution combining electrode structure and multiplexing circuitry on one smart textile device.



Current state of the art multi-electrode system



Proposed WEARPLEX solution

Progress beyond the state of the art

» Proposed WEARPLEX solution combining electrode structure and multiplexing circuitry on one smart textile device.

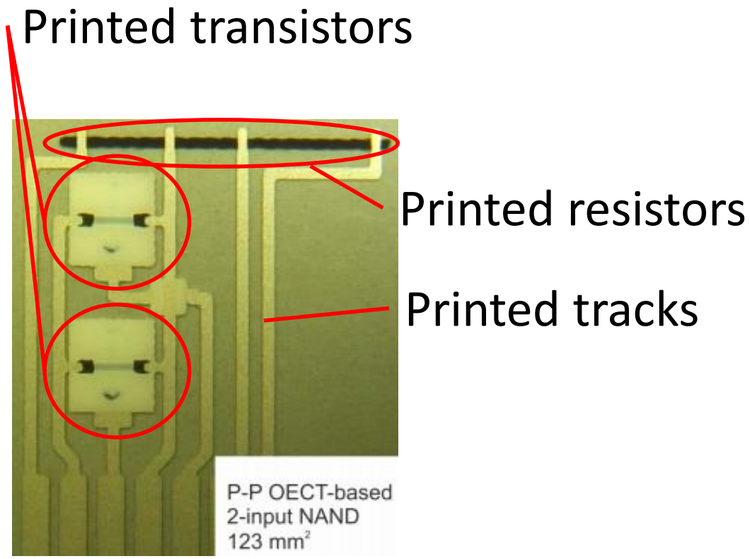
» Exponentially advancing the number of supported pads, usability and comfort

WEARPLEX concept of ‘virtual’ electrodes

*modified from
http://www.rockbandaide.com

Printed Logic - Demultiplexer

- **Organic ElectroChemical Transistors** based embedded logic and current-routing circuitry
- OECT can achieve large current throughput (~5mA) at low driving Voltage (~5V)
- Significantly less sensitive to layer thickness (1-10 µm) compared to OFETs (100nm), making them the viable option for printing on textiles (interface surface roughness is 1-5 µm).
- Relatively slow switching time (100+ ms)



Screen printed digital circuits based on vertical organic electrochemical transistors, P. Andersson Ersman, et al., Flexible and Printed Electronics 2 (2017) 045008.

- RISE Acreo is the global leader in development of OECT technology.

Materials development - Printed Ink

» Breakthroughs in material science are needed for two reasons:
  » To enhance the printed electronics performance (speed, throughput, robustness)
  » To enable transfer to textile substrate and better adherence to the body.

» Semiconductor inks (BCM, ABL) –high performance printed logic circuits.

» Primer ink (UoS) - provides smoothing layer on the fabric; printed only where required to minimise loss of fabric properties.

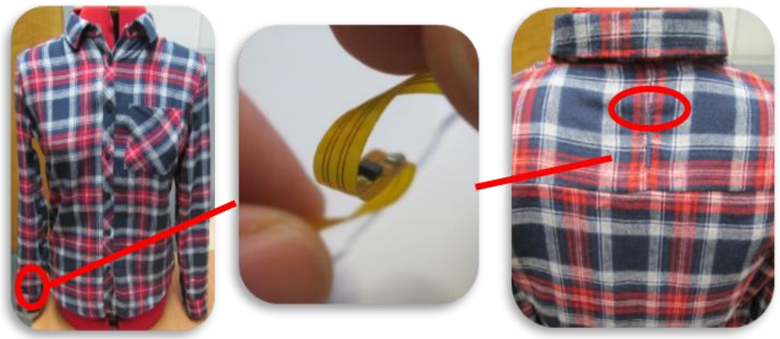
» Conductive inks (BCM) – used for conductive tracks between electrodes and interconnects with printed logic circuits.

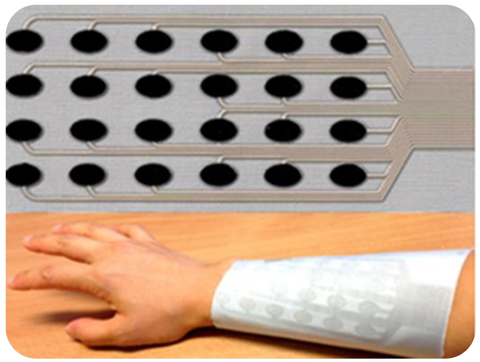
» Skin interface (IDUN, TEC) – adherence, comfort, transfer of energy.

E-Textile Integration

» WEARPLEX combines printed electronics with textiles to create e-textiles.

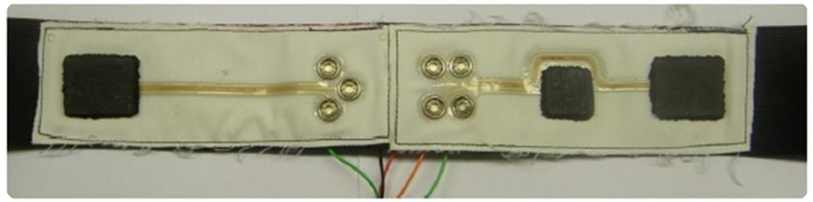
» UoS has developed a number of printed electrode devices on textiles.





Printed FES array on fabric

Printed Full Frank configuration

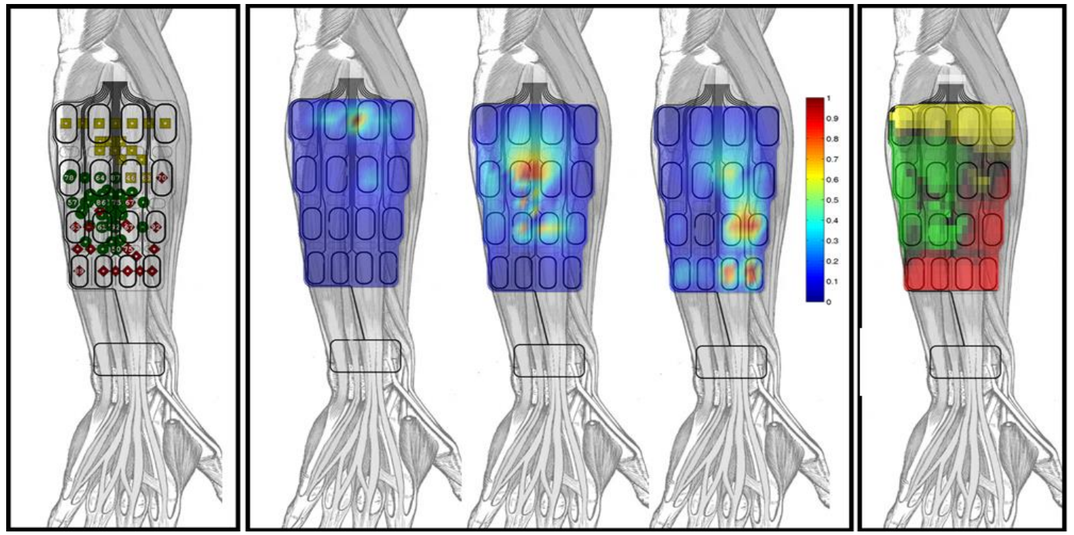


Printed ECG electrodes on fabric

» And integration of flexible electronic circuits into textiles.

Application specific development

- Increase in the number of pads implies an exponential increase of electrode setup complexity
- TEC and AAU are developing the methods for automated system calibration to enable personalisation and high usability.
- Methods for printed circuit control for optimised current propagation and mitigation of printed electronics limitations are also investigated.
- Demonstrator for FES and EMG recording applications is developed within the Beta and Gamma stage of the project



Modified from Malešević et al. (2017) "Temporal and spatial variability of surface motor activation zones in hemiplegic patients during functional electrical stimulation therapy sessions." *Artificial organs*

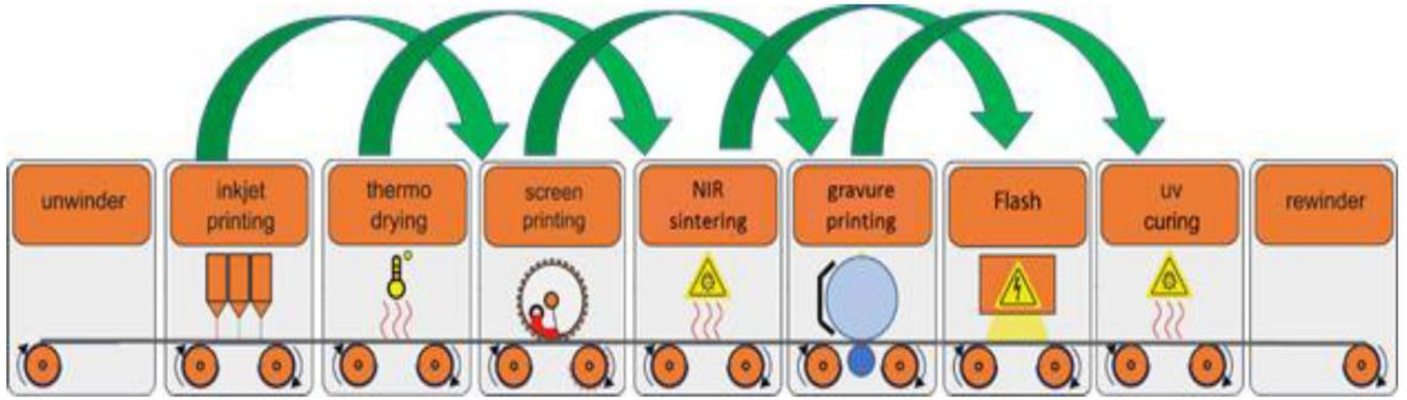
Mass Manufacturing

» To ensure maximal impact, novel fabrication processes are addressed

» Scale up of WEARPLEX system production is aimed through modular approach that leverages r2r and s2s approaches for printed electronic applications.

» Delivery is at the end of the project for Gamma prototype

» Lead by Technical University of Chemnitz and Screentec.



Modular roll to roll process machinery concept from TUC

Stake Holders Board and Workshop

» Seeking members for a Stake Holders Board for the project.

» Representatives from the relevant industries, health and sports professionals, patient associations.

» 3 workshops to be held during the project:

- WS1 – Alpha demonstrators - Specifications: Half day event, here in the 13th Vienna International Workshop on FES, **September 25th**
- WS2 – Beta demonstrators – Technological leap: 1 day event adjacent to a Wearable electronics international conference in 2020.
- WS3 – Gamma demonstrator – WEARPLEX powered products: 1 day event at Medica fair or Wearable electronics international conference in 2021.

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Some of the consortium at the WEARPLEX meeting in Sweden – July ‘19

Call to Action

» Attend the WEARPLEX Workshop! Join the Stakeholder Board!

» First results shown

» Discussion on technical, clinical and business issues.

» **Wednesday 25th September**, 8:45 – 12 + Lunch.

Contact the coordinator

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https://uk.linkedin.com/company/wearplex-project

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