

## Sports related research in Emerging Materials group

- 1. Textiles with integrated sensors**
  - Posture and skin deformation sensors
  - Smart soccer shorts (CAS project)
- 2. Cooling garments**
  - Cooling for cyclists/rowers
  - Cooling for paraplegics (CAS project)
  - Cooling for sailing (Tokyo 2020)





**Emerging Materials group**  
Industrial Design Engineering  
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Challenge the future 1

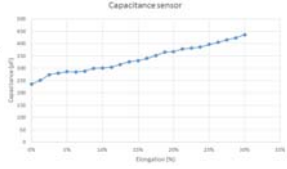
## 1a. Integrated stretch sensors


Master thesis Ruben Schevers (Jan. 2016)

→ **Design of own washable and stretchable textile sensor**

1. Non-stretchable conductive electrode fabric with conductive textile wire
2. Glued to stretchable non-conductive fabric (polyester/elastane)
3. Separate from 2<sup>nd</sup> electrode by non conductive fabric












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## 1a. Integrated stretch sensors

**Application: Smart fitness shirt for back posture correction**

1. Sensor location 
2. Electronics 
3. Assembly  



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## 1b. Skin stretch sensor


Master thesis project Bailey Tarren (ongoing work)

**Design of disposable skin sensor**

1. Stretchable pleister (KT-tape like) as basis
2. Sticks to skin for several days
3. Screen print pattern with stretchable ink (Dupont)
4. Measure resistance changes

→ Unobtrusive way of monitoring local movements

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## 1c. Smart Soccer Shorts

Part of NWO Citius Altius Sanius project (just started)

**Purpose**

➢ Monitor hip and knee movements to prevent injuries during professional soccer training



**Team**

- Kaspar Jansen (TU Delft)
- Koen Lemmink (Groningen)
- Geert Savelsbergh (VU)
- Edwin Goedhart (KNVB)








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## 1c. Smart Soccer Shorts

➢ Stresses in joints and muscles are highest during acceleration and deceleration

Kick plate at KNVB and corresponding Vicon video



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## 1c. Smart Soccer Shorts

**Problems**

- No information on limb acceleration forces of individual athletes
- Some athletes may underperform during training, some overperform and get injured ("Robben effect")

**Proposed solution**

- Short with integrated sensors (acceleration and maybe also heart rate, perspiration)
- Data handling and wireless transmission to medical staff
- Determination of maximum load per athlete
- App with simple indicators




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## 2. Cooling garments

**Thermal control of body temperature**

- STW project, May 2016 – May 2018
- Sports, medical, industrial safety
- Potentially high societal impact
- Smart design with thermal model
- With VU, Teijin, Inuteq



**Project team:**  
 Kaspar Jansen, TU Delft  
 Hein Daanen, VU Amsterdam  
 Nina Bogerd (TUD)  
 Laura Duncker (UvA)  
 Linda Plaude (UvA/TUD) students

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## Case 1: Vest for women with hot flashes

Master student: Geertje Hofstee

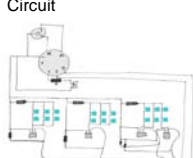
**Idea**

Use thermoelectric cooling elements too cool or heat


**Concept**



**Circuit**



**Final result**

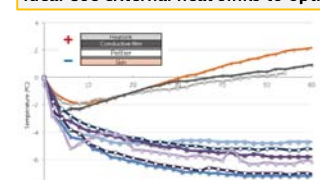


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## Case 2: Cooling vest for cyclists

Master student: Louis Brouwers

**Idea: Use external heat sinks to optimize Peltier cooling**




no heat sink

heat sink

**Measurements show**


- heat sinks work
- heat spreading foils do not work



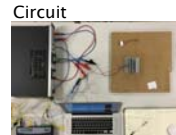
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## Cooling vest for cyclists

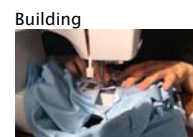
**Concept**




**Circuit**



**Building**



**Final result**



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## Case 3: Cooling vest for rowers

Master student: Joshua Stewart

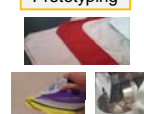
**Basic idea:**

- Water is very effective as cooling medium
- Open foam for larger heat transfer area
- Should be comfortable and unobtrusive


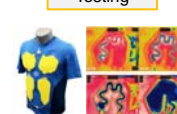
**Design**



**Prototyping**



**Testing**

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### Case 3: Cooling vest for rowers

Master student: Joshua Stewart

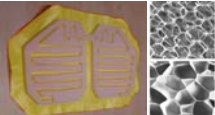
**Basic idea:**

- Water is very effective as cooling medium
- Open foam for larger heat transfer area


Concept



Open cell foam pad



Testing



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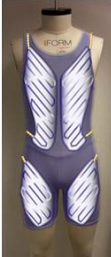
### Case 3: Cooling vest for rowers


Improved design by Linda Plaude


Design

Details

Result







Improvements in pads, tubing and sealing


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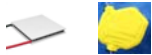
### Design optimization by Simulations

Postdoc dr. Nina Bogerd

**New device for measuring cooling capacity**

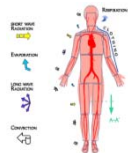
- Surface kept at 37°C
- Peltier voltage and water flow/temp varied
- Power to maintain 37°C is recorded





**Fiala model for thermoregulation simulations**

- Measured cooling capacity as input
- Prediction of effects on body core temperature
- Predictions of increase in comfort level
- ➔ Feedback to design cycle



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### Design with Emerging Materials

“Using technology to enrich peoples life”









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