Part 2: Advanced Textile Materials
Smart Textile

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Outline

- What is smart textile
- Phase-change material
- Shape memory material
- Wearable technology
- Video and website for latest development
Smart Textile Materials

• Smart fabrics and interactive textile solutions are defined as products that enable or enhance any of the following with its environment (change in temperature) or user:
Smart Textile

- Conduct, transfer or distribute electric current, light energy or thermal energy through the material (optical fiber)
- Either through an external signal command from user or an internal or environmental stimulus, certain physical properties of the material change.
- Provide environmental and hazard protection against biological, chemical.
- Through the incorporation of sensor or actuator elements, it can performs biophysical applications
Smart Textile

- Two techniques are used:
  - 1) Phase Change Material
  - 2) Shape Memory Material
Phase-change Materials

- Specific for the phase-change materials (heat storage material) is that they change between solid and liquid (ice to water) state in the temperature range where the material is used.

- A change from solid to liquid (melting) involves the absorption of heat, and similarly a change from liquid to solid (crystallization) the release of heat.
Phase Change Status
Phase Change materials

- A melting heat-absorption temperature of 20-40°C and a crystallization of heat-releasing temperature of 30-10°C are effective in clothing.
- The Phase-change materials currently used in textile structures are paraffins. The heat storage capacity is shown in Table
Phase change paraffins and their properties

<table>
<thead>
<tr>
<th>Phase change material</th>
<th>Melting (°C)</th>
<th>Crystal Temp (°C)</th>
<th>Heat Storage (J)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eicosane</td>
<td>36.1</td>
<td>30.6</td>
<td>247</td>
</tr>
<tr>
<td>Nonadecane</td>
<td>32.1</td>
<td>26.4</td>
<td>222</td>
</tr>
<tr>
<td>Octadecane</td>
<td>28.2</td>
<td>25.4</td>
<td>244</td>
</tr>
<tr>
<td>Heptadecane</td>
<td>22.5</td>
<td>21.5</td>
<td>214</td>
</tr>
</tbody>
</table>
Application

• It can be applied when a person is moving frequently between warm and cold environments or handling cold pieces.
• The absorption and releasing of heat is a repeatable cycle, which takes place at skin temperature without unpleasant low and high temperature.
• E.g Climator [http://www.climator.com](http://www.climator.com)
Shape Memory Materials

- Shape Memory Materials (SMMs) react to changing environmental conditions (increasing or decreasing temperature) by changing their geometrical shape.

- The production principle is that the material is first processed to receive its permanent shape. Afterwards, it is deformed to a temporary shape, which is fixed.
Shape Memory Transition Temperature

Diagram showing the transition of a laminated film and clothing layers between two temperature states: T > 25 °C and T < 25 °C.
Shape Memory

• Shape memory effects can be utilized in several types of functional textile and clothing products:
  - Variable thermal insulation through SMM spacer between liner and outer fabric.
  - Variable moisture permeability membranes
  - Shock damping materials
Application

- The Shape Memory Polymer with flexible moisture barrier property has been developed by Mitsubishi called Diaplex
- Website: http://www.diaplex.com
- Before the glass transition temperature, the molecular structure is rigid and prevents absorption of water.
- When the temperature increases, the thermal vibration of soft molecule creates gaps between the membrane molecules, thus increasing the moisture permeability.
Other Smart Textile Materials

- A new material for different type of impact protection (police/security) has been introduced called d3o.

- In the normal state, the molecules flow past each other at low rates of movement, but when they are subject to an impact that would require them to move very quickly, they instantaneously lock together to form a rigid protective barrier.

- As soon as the impact has passed, they unlock to provide normal flexibility.
Other Smart Textile

- Thus, garment does not restrict body movements as conventional body armour products but give protection when it is needed.
- The base material for d3o is polyurethane, but other polymers are also used.
- Applications are in head, foot and body protection for motorbike riders, downhill skiers.
- Website is [http://www.d3olab.com](http://www.d3olab.com)
Conductive fibres and textiles

- Textile materials have low electric conductivity, i.e., they are electric insulators.
- Conductive metal or carbon-based fibers have been inserted in some special products, for example, to decrease the electrostatic charge problem or to shield electromagnetic radiation.
- With increasing interest in wearable electronic systems, new conductive materials have been developed for sensing, actuating and signal transmission.
- Conductive components (metal, carbon) can be added to the textiles in all stages of production (fiber, yarn and fabric formation) using conventional technique.
Conductive fibre

- Interactive electro-mechanical systems have been produced by coating a polymeric fabric with a thin layer of conductive polypyrrole.
- Conductive yarns have been achieved by immersing the yarn in a rubber carbon solution and heat treatment.
- The electrical resistance of these products shows a drastic change when the material (yarn or fabric) is stretched.
Philips Research Lab

- Light emitting textile
- Photonic Textile (Flexible LED)
- Video Demo
  - [mms://Ntstream2.ddns.ehv.campus.philips.com/efi/86090/Photonic.wmv](mms://Ntstream2.ddns.ehv.campus.philips.com/efi/86090/Photonic.wmv)
Wearable Technology

• A totally new generation of garments has been created with the incorporation of Information and Communication Technology (ICT)

• The extremely rapid development in sensor technology and ICT has brought miniaturized and efficient devices to the market, which make it possible to use the clothing as a platform for measuring a variety of biophysical and other metrics.
Wearable technology

- The wearable computers have been defined as devices that meet at least the following criteria:
  - The hardware device must contain a Central Processing Unit (CPU)
  - The device is able to run user-defined software application
  - The system is supported by the user’s body enabling a greater hands-free computing or bio-monitoring functionality.
  - The computer should always be accessible and ready to interact with the wearer, either through the use of wireline or wireless communication
Wearable Technology
Applications

• Applications of wearable technology can be found not only in garments but also in belt, glasses, shoes as well as implants.

• All the functions can be manifold: biophysical monitoring (hear rate, temperature, moisture), amusement (music, game), position (GPS), motion monitoring.

• Many technical issues such as power supply, interfacing, signal transmission, care and durability have to be considered at development stage.
Examples on Wearable Electronics

- LifeShirt, a health-monitoring system
- It consists of three parts: a garment, a data recorder and analysis software.
- Sensors in the garment continuously monitor respiration, electro-cardiogram (ECG), activity and posture, and data are analysed and visually displaced.
- Video Demo
  - http://www.vivometrics.com/site/system_overviewvideo.html
Discussion

• What is smart textile?
• What is wearable electronics?
• What are their applications in apparel textile?