Basic requirements of cleanroom garments

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Basic requirements of Cleanroom garments

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Roadmap

- Cleanrooms
- Essential requirements of cleanroom garments
  - Linting
  - ESD-performance
- Textile materials and garment design
Cleanrooms

- **What:**
  - Areas with specified number of particles per unit volume

- **Where:**
  - Microelectronics industry
  - Pharmaceutical industry
  - Biotechnological industry
  - Food & beverages
Cleanrooms classification
ISO 14644-1

ISO Class 9
ISO Class 8
ISO Class 7
ISO Class 6
ISO Class 5
ISO Class 4
ISO Class 3
ISO Class 2
ISO Class 1

Log(particles/m³) vs. Particle size (µm)
Classification versus activities

- **ISO 4:**
  - High speed video duplication
  - Glass lamination

- **ISO 3:**
  - Compact disk manufacturing
  - Optical manufacturing

- **ISO 2:**
  - Semi-conductor manufacturing
  - Pharmaceutical products

- **ISO 1:**
  - Latest wafer and chip manufacturing
  - Hard disk manufacturing
Cleanroom garments

- **Why necessary?**
  - Humans are broad-spectrum particle and aerosol generator
  - Prevent contamination of cleanroom by cleanroom worker (barrier-function)

- **Danger**
  - Garments can shed particles (linting)
  - Garments can damage microelectronic components through ESD events
# Particles generated by humans

<table>
<thead>
<tr>
<th>Source</th>
<th>Classification</th>
<th>Type of contamination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operator</td>
<td>Particulate</td>
<td>Skin flakes, hair, cosmetics</td>
</tr>
<tr>
<td></td>
<td>Biological</td>
<td>Bacteria, virusses</td>
</tr>
<tr>
<td>Street cloths</td>
<td>Particulate</td>
<td>Silica dust</td>
</tr>
<tr>
<td></td>
<td>Fibers</td>
<td>Cellulosic, ...</td>
</tr>
<tr>
<td></td>
<td>Chemicals</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Biological</td>
<td>Bacteria</td>
</tr>
</tbody>
</table>

- **Skin flakes:**
  - average size: 20µm
  - Number: 500,000 – 1,000,000/min moderate operation
Performance requirements

- Particulate barrier properties
- Garment cleanliness
- ESD performance

- Comfort
- Durability (sterilisation)
Garment linting
Helmke drum-test & Gelboflex

Helmke drum test

Gelbo-flex test
Linting propensity

<table>
<thead>
<tr>
<th>Particle Size (µm)</th>
<th>microfilament polyester</th>
<th>polyester - cotton</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.19 - 0.3</td>
<td>0.3 - 0.5</td>
<td></td>
</tr>
<tr>
<td>0.5 - 1.0</td>
<td>1.0 - 3.0</td>
<td></td>
</tr>
<tr>
<td>3.0 - 5.0</td>
<td>3.0 - 5.0</td>
<td></td>
</tr>
<tr>
<td>&gt; 5.0</td>
<td>3.0 - 5.0</td>
<td></td>
</tr>
</tbody>
</table>

Number of particles per minute: 0 - 50000
Measurements
Cleanroom facilities in Centexbel
Cleanroom garments
Materials and construction

◈ Materials
  ◈ Reusable materials:
    ◆ Densily woven polyester material
    ◆ Knitted materials (less critical areas)
    ◆ Tri-laminates
  ◈ Non-woven materials
    ◆ Tyvek
  ◈ Construction
    ◆ Seams
ESD-failure of electronic components

- **Failure rate**
  - 30-50% of all failures due to electrical overstress
  - Decrease of component dimensions increases ESD sensitivity

- **Failure modes**
  - Direct discharge from operators body (HBM)
  - Discharge from a charged device to ground (DM)
  - Discharge from a charged cleanroom garment
ESD performance
Failure modes of components

- Human body model
  - 0.1 – 10 A peak current
  - 100 – 200 ns duration
ESD performance
Failure modes of components

- Device model
  - 5 – 10 A peak current
  - 1 - 2 ns duration
## ESD-performance

### Sensitivity of electronic devices

<table>
<thead>
<tr>
<th>Technology</th>
<th>Typical HBM sensitivity (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MR heads</td>
<td>10 – 100</td>
</tr>
<tr>
<td>Flat panel displays, CCDs</td>
<td>50 – 150</td>
</tr>
<tr>
<td>Laser diodes</td>
<td>200 – 1500</td>
</tr>
<tr>
<td>LEDs</td>
<td>500 – 8000</td>
</tr>
</tbody>
</table>
Requirements of ESD garments

- Garments should:
  - Low propensity for triboelectric charging
  - Low resistance for fast dissipation in order to avoid charge accumulation
  - High resistance to slow down the charge decay and to limit the energy transfer in a discharge
  - Total suppression of E-fields from charge on clothing
Cleanroom garments
ESD-measures

- Material design
  - Conductive yarns
  - Gridstructures (5 by 5, 2 by 2 mm)
- Garment design
  - Electrical conduction garment
  - Earthing of the operator
- Cleanroom design
  - Conductive shoe wear
  - Earthed floor
Standard test methods

Point to point resistance according to IEC 61340-5-1
Standard test methods

- Standard test methods are resistive measurements
- Originally developed for homogeneous materials – suited for inhomogeneous materials?
- Charging propensity of material is not taken into account
- Effect of grounding is not evaluated
ESTAT project

◆ Aims to:
  ◆ Provide a basis for understanding charging and discharging behaviour of complete system (operator – clothing – environment)
  ◆ Study test methodologies and performance requirements for protective ESD garments

Project website: http://estat.vtt.fi
### ESD performance requirements

<table>
<thead>
<tr>
<th>Garment class</th>
<th>Performance target</th>
<th>Required garment performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class 1</td>
<td>Ultrasensitive devices</td>
<td>High protection level, special recommendations for grounding, undergarments etc...</td>
</tr>
<tr>
<td>Class 2</td>
<td>ESDS with &gt; 100 V</td>
<td>Normal protection level corresponding to typical stat-of-the-art ESD garments</td>
</tr>
<tr>
<td>Class 3</td>
<td>ESDS with &gt; 200 V</td>
<td>Low requirements for the electrostatic performance, some normal garments may pass the requirements</td>
</tr>
</tbody>
</table>
Conclusion

- Cleanroom garments:
  - A growing market

- But:
  - Stringent performance requirements