PROSYS-Laser:
Development of high-tech protective clothing against laser radiation

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Examples of Hand-Held Laser Processing Devices and Applications

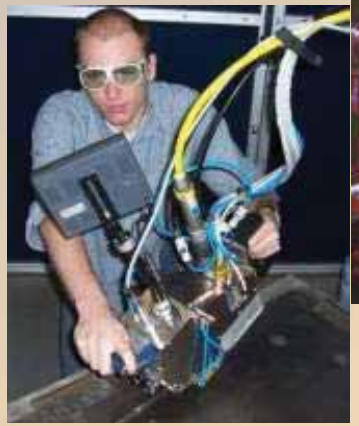
dismantling of installations
cutting applications
source: LZH/EWN

joining of body components
for prototype construction
source: LZH

cleaning applications

cleaning of
tool forms
source: cleanLASER

cleaning of masts
source: cleanLASER



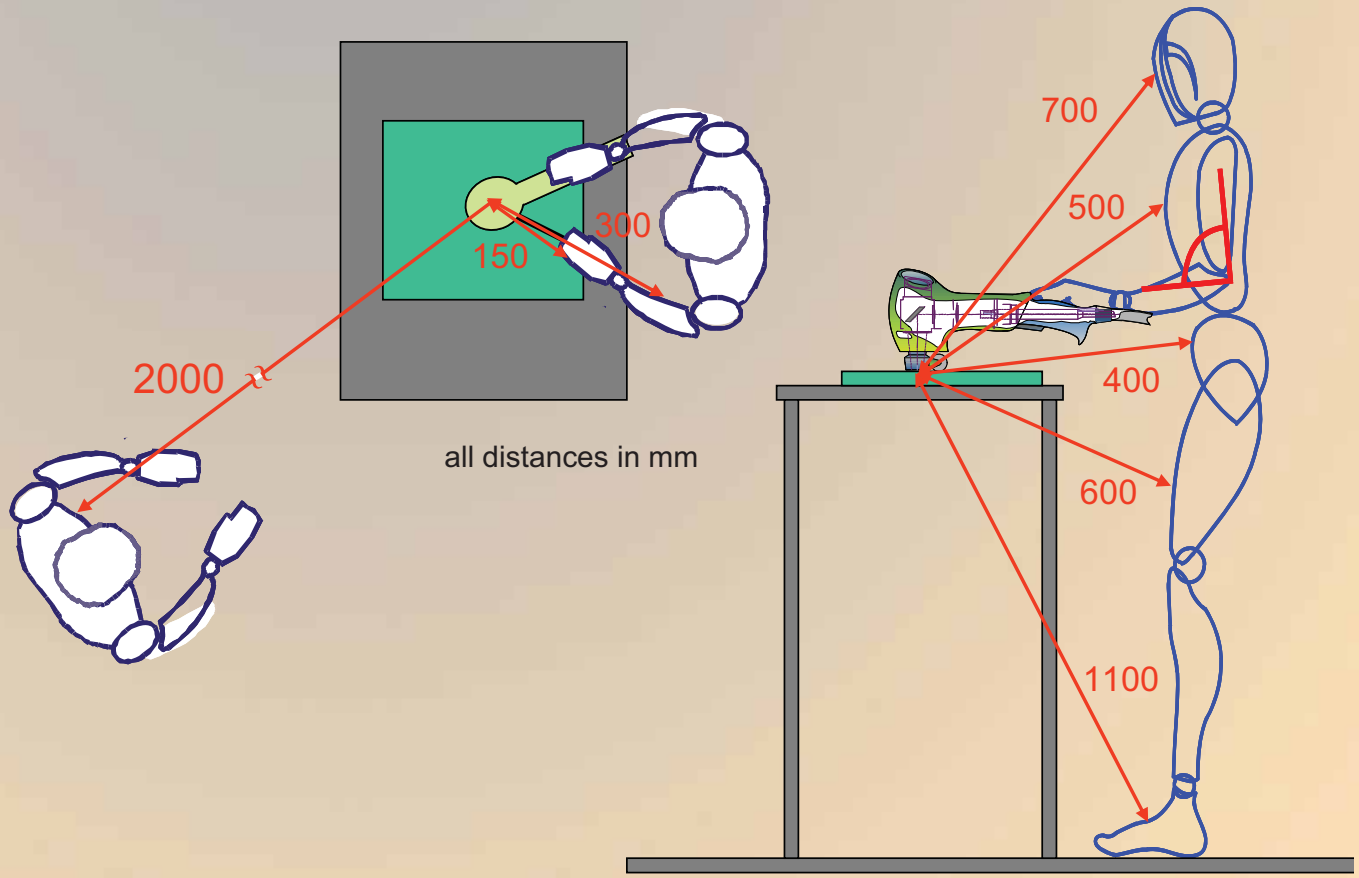
hardening
source: LZH

build-up welding
source: MobilLaserTec

repair of
tool forms

artworks conservation
source: Monumenta und LACONA

Dependence of Hazardous Potential on the Distance Between Process Zone and Body Parts



Problem:

The operator stands next to the process zone.

The intensity of focused laser radiation and thus the hazardous potential of the laser processing increases with the square of the decreasing distance to the process zone.

Personal Protective Equipment for Use with HLDs

Face protection

Hand protection

Protective clothing

Foot Protection

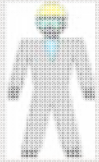
Possible materials:

- natural material (e.g. leather)
- natural fibres (e.g. cotton)
- synthetic fibres (e.g. aramid)
- blended fabrics
- glass fibres
- multi-layer fabrics (e.g. coated, laminated)

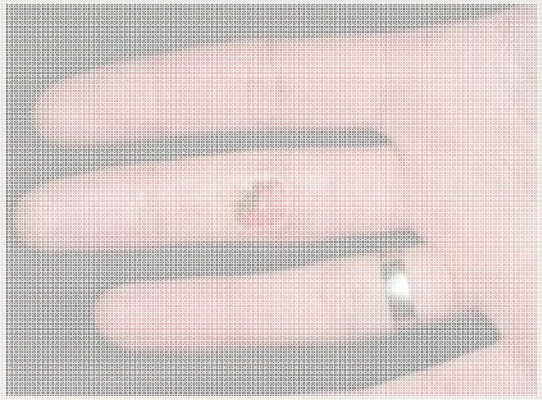
- **No special PPE (except laser protective eyewear) is available on the market.**
- **No standardized requirements on laser PPE and testing methods exist.**

Today, predominantly intuitive choice of PPE for the use with HLDs

Laser-Accidents: Exposure of the Skin

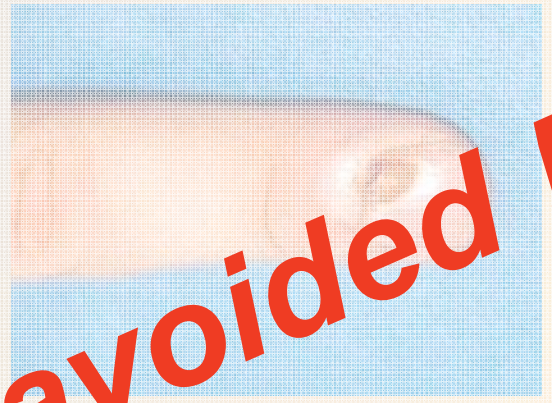


Exposition

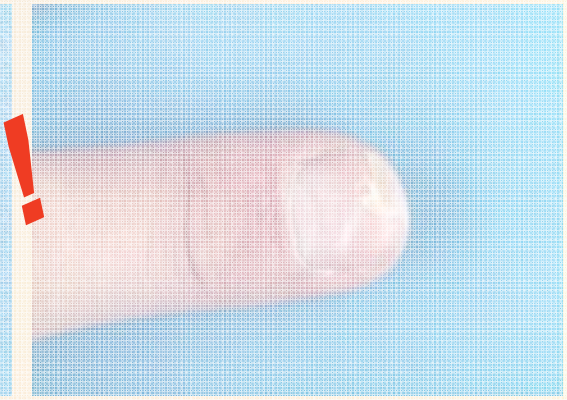


Day of Accident

Laser: CO_2
λ = 10600 nm
Left:
P_m = 500 W
Pos. = defocus.
Right:
P_m = 500 W
Pos. = near to focus



day of accident



30 days later

To be avoided !

Laser: Yb:YAG
λ = 1030 nm
P_m = 1600 W
Pos. = near to focus

day of accident

10 days later

21 days later

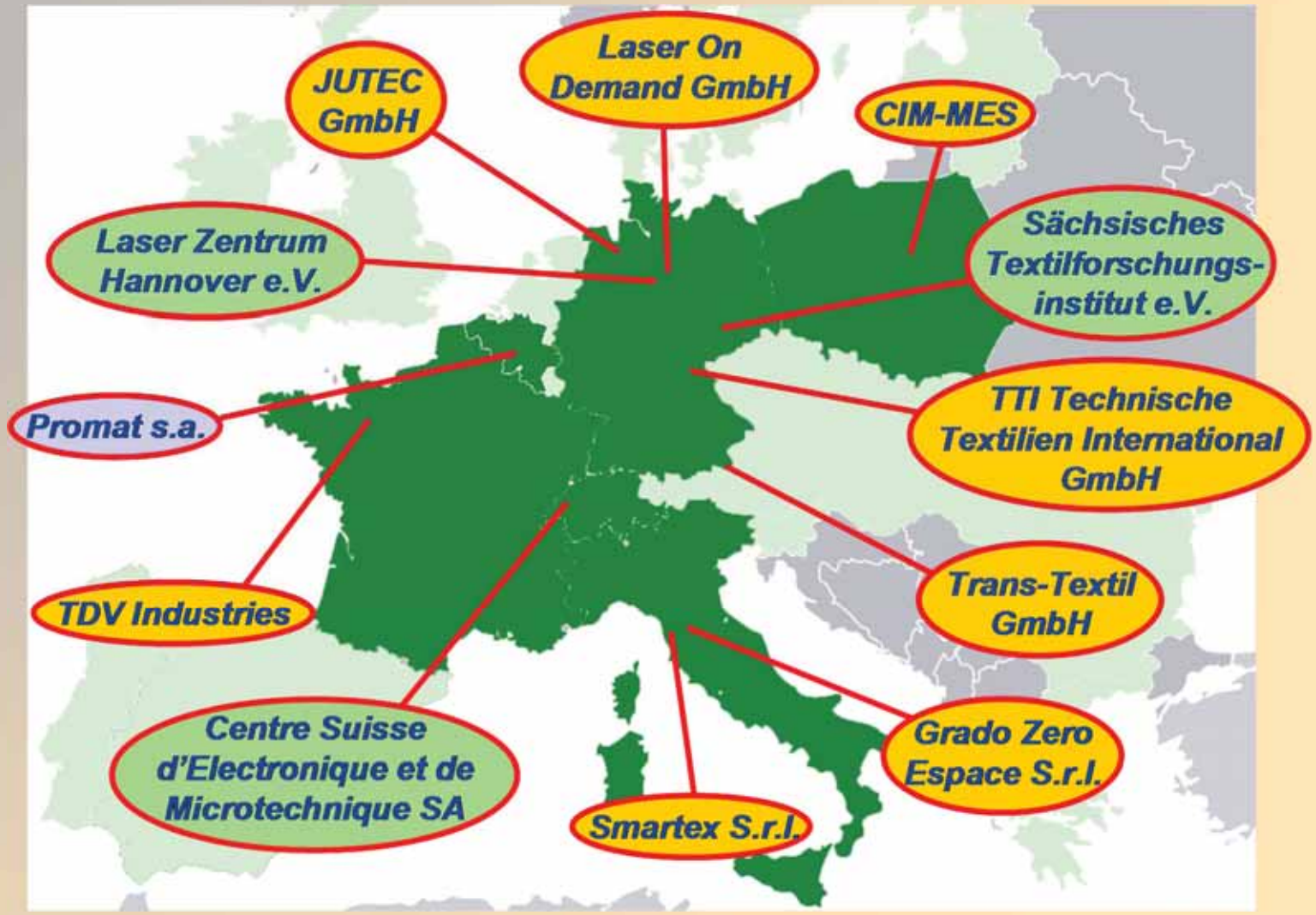
Approach and Objectives

- Combining innovative laser technology with high performance textile technology
- Development of passive functional multilayer technical textiles, providing a high level of passive laser resistance
- Development of active functional multilayer textiles incorporating sensors which detect laser exposure and, by means of a safety control, isolate/deactivate the laser beam automatically
- Development of test methods and testing set-ups to qualify passive and active functional technical textiles and tailored PPE, respectively
- Transfer of results to European standards in terms of new work item proposals (NWIP) within the CEN (European Committee for Standardization) or the ISO (International Organization for Standardization)

→ FP7 Project: PROSYS-Laser

PROSYS-Laser Consortium

- research institute
- SME
- larger enterprise



Coordinator:
Laser Zentrum
Hannover e.V.

General Considerations: Passive Systems

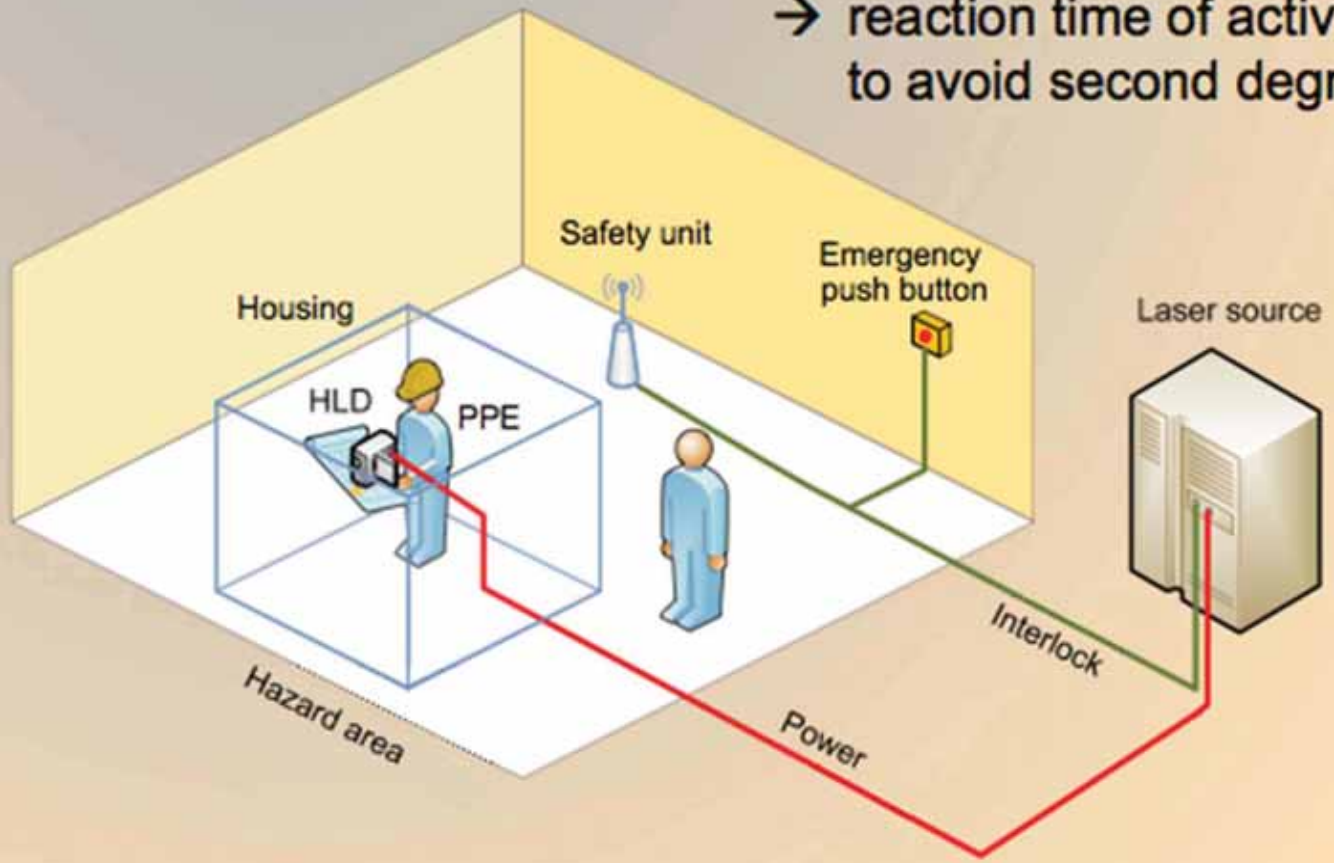
- **Avoidance** of **second-degree burn** (blister formation) or even more severe injury
- **Destruction** of passive system **should be delayed** as long as possible → minimization of absorbance and transmittance
- **High diffuse reflection** of incident laser radiation
- **High spreading** of absorbed energy
- Small amount of heat should be transferred to skin to **make the irradiation sensible** → **removal of body parts** out of irradiated zone
- Maximisation of **time difference between pain threshold and second-degree burn** (> 4 s if possible)

→ **Innovative PPE construction (multilayer system)**

General Considerations: Active Systems

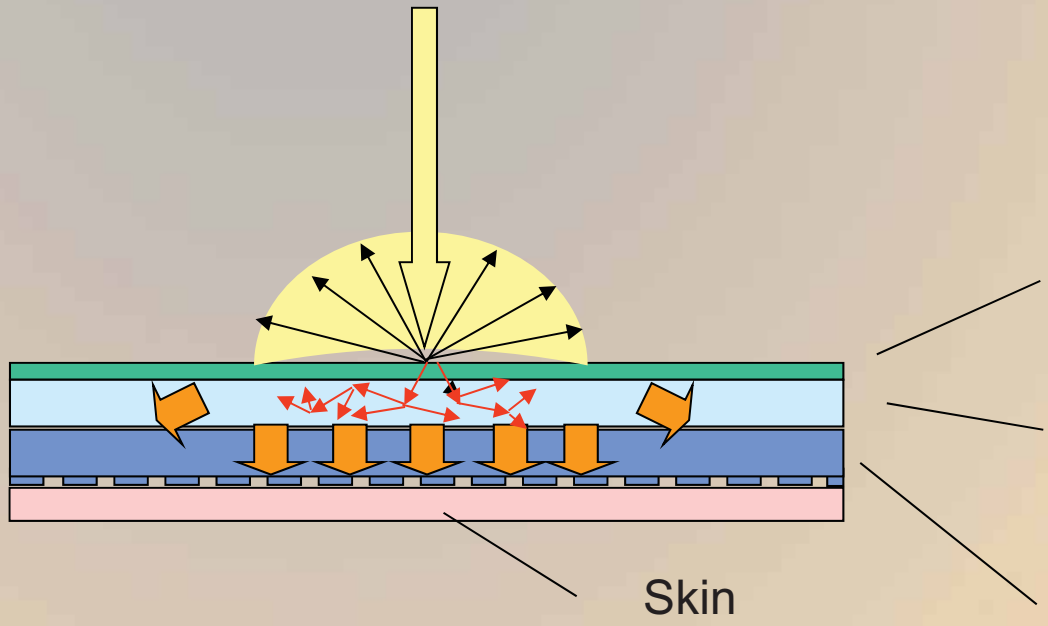
Automated shutdown of laser source / laser stop upon irradiation above a defined threshold

→ reaction time of active system < reflex time to avoid second degree burn (passive protection)



Laser Protective Textiles / Clothing: Approach A

<u>Passive</u> functional textile systems for PPE (clothing)



All layers:
- Flame retardant
- Heat resistant (to high temperatures)

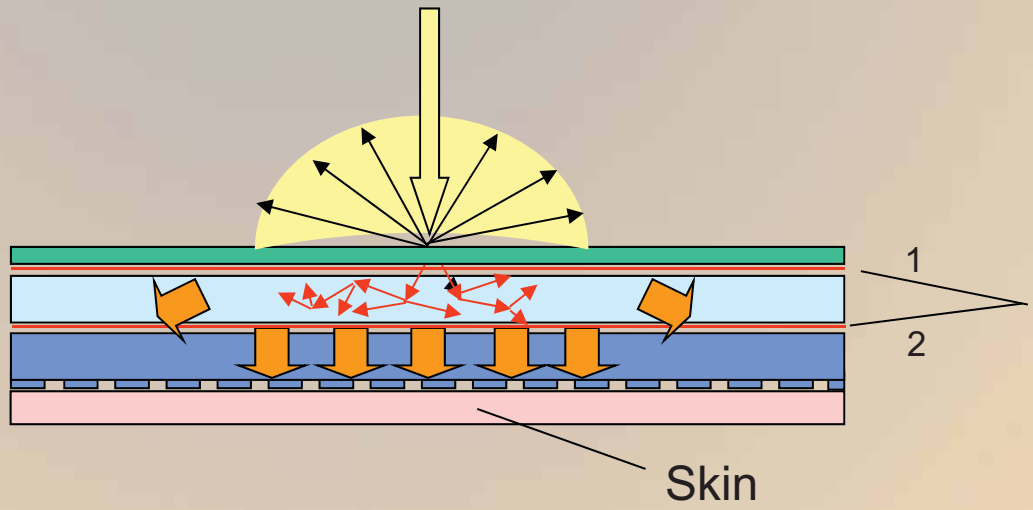
Layer and function with respect to laser resistance

1. Surface layer
   scattered/diffuse remission of radiation
   low absorbance; low/no transmittance
2. Middle layer
   scattering of laser radiation to widen the absorption volume
3. Inner layer
   good isolation properties:
   low heat transfer to the skin

Laser Protective Textiles / Clothing: Approach B

<u>Active</u> functional textile systems for PPE (clothing)

B1) Electrical System



Concerning the functionality, the sensors have to be implemented in the multilayer system in one or more layers

Active System

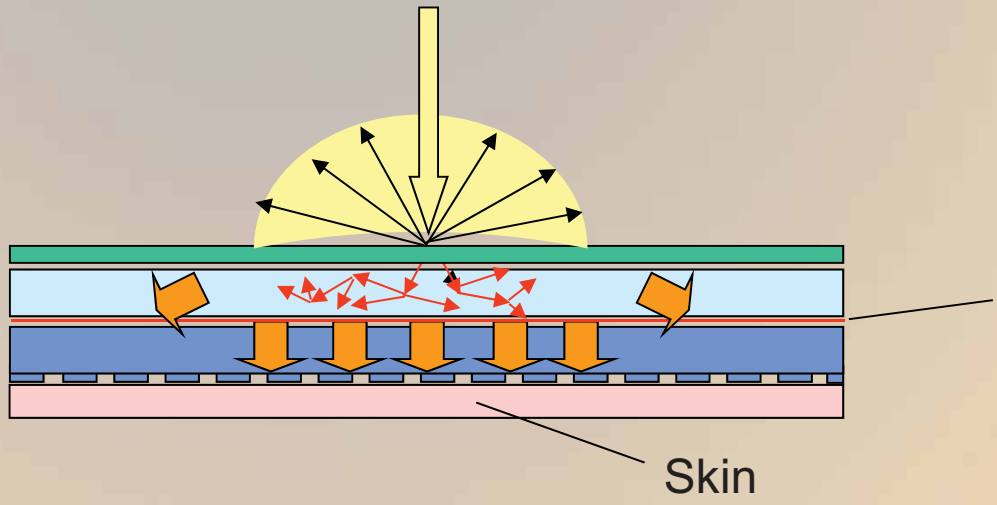
- Metallic wires/yarns, metallised yarns or conductive foils
  → change in resistance
  1) by damage,
  2) by heat dependent resistance as NTC or PTC with low pass filter
- Conductive foils
  → change of capacity

→ - low cost;
- easy signal processing;
- interference with electromagnetic fields

Laser Protective Textiles / Clothing: Approach B

<u>Active</u> functional textile systems for PPE (clothing)

B2) Optical System



Concerning the functionality, the sensors have to be implemented in the multilayer system in one or more layers

Active System

- Optical fibre (glass or polymer) with fibre-bragg grating
  → change in wavelength (Raman effect) by temperature (distance of grating)

- Optical fibre/foil
  → Guidance of optical radiation to optical sensor
  → Photovoltaic effect

→ - High costs;
- complex signal processing;
- no interference with electromagnetic fields

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THANK YOU!

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SEVENTH FRAMEWORK
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