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TecInTex RTD 2009
FNSNF

Polymeric Optical Fibers for sensing in textiles

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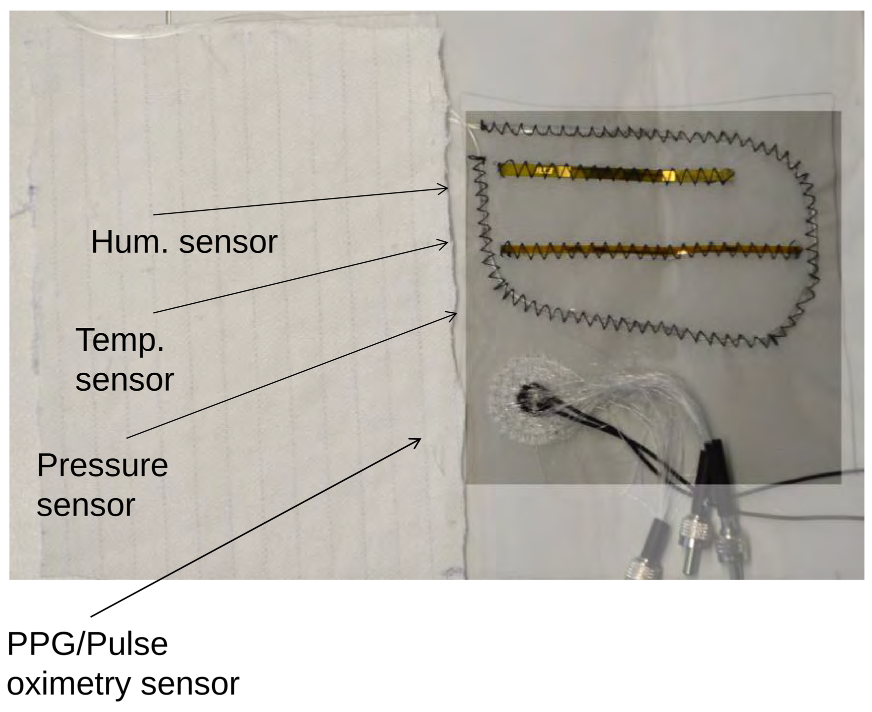
Tec InTex

EMPA

The TecInTex project aims at the development of truly wearable functional clothes. In this context, sensors based on optical fibers are designed for the continuous monitoring of biological parameters. Polymer optical fibers have been modified in order to enhance their flexibility to integrate them into textiles. Plastic optical fibres have several advantages compared to textile electronics when wearing them close to the body, e.g., comfort, ease of movements, and reduced movement artefacts. Since the electronics often involved in the proposed solutions often negatively influences the haptic of these textiles, flexible and smart fibres allow for the separation of the rigid electronics from the measured region and thus from the body

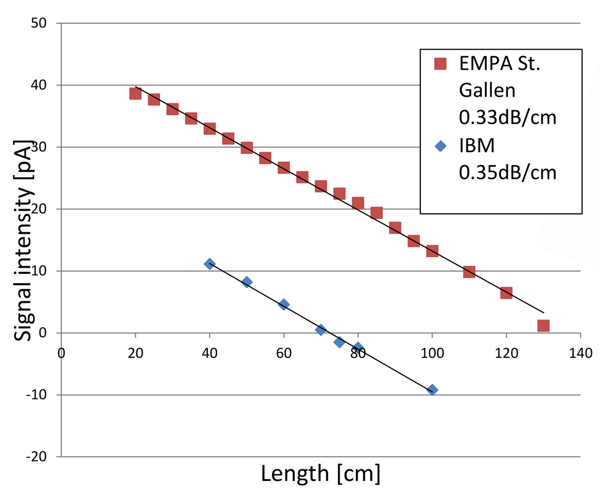
Motivation

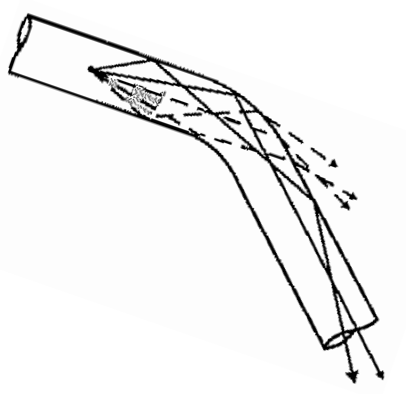
Development of textile patch with sensors to foreseen decubitus at paraplegic patients. All of those sensors have to be with great haptic in order not to cause pressure points which in turn can lead to decubitus.



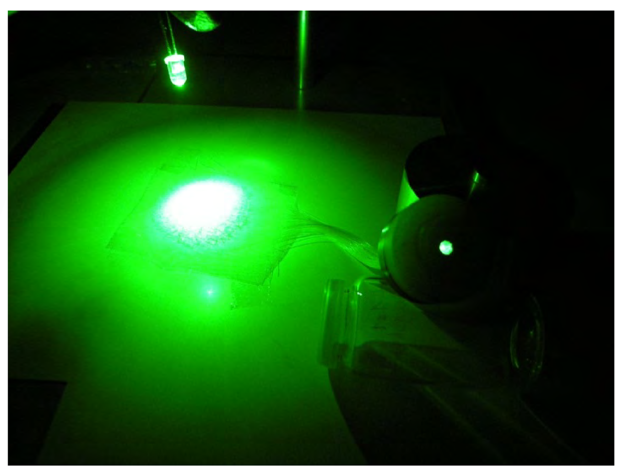
Optical Fibers for Pulseoximetry

The fibers that will be used are produced at EMPA St. Gallen and have enhanced flexibility and mechanical strength and are therefore ideally suited for embroideries. When the fiber is bend the critical angle can be exceeded and the light will be out/in coupled from/to the optical fibers.

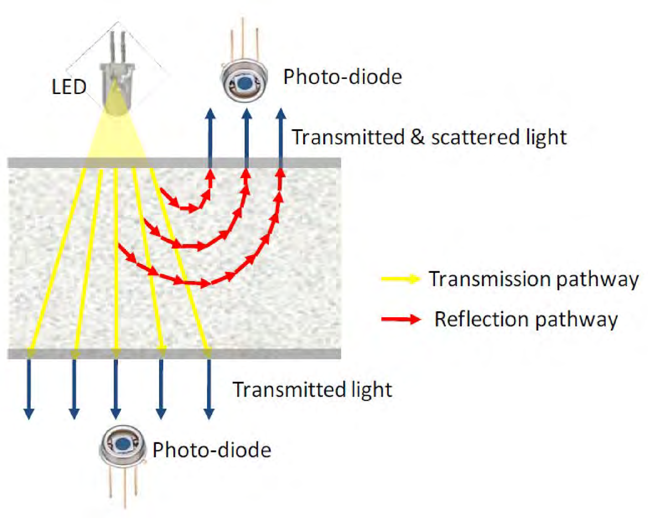


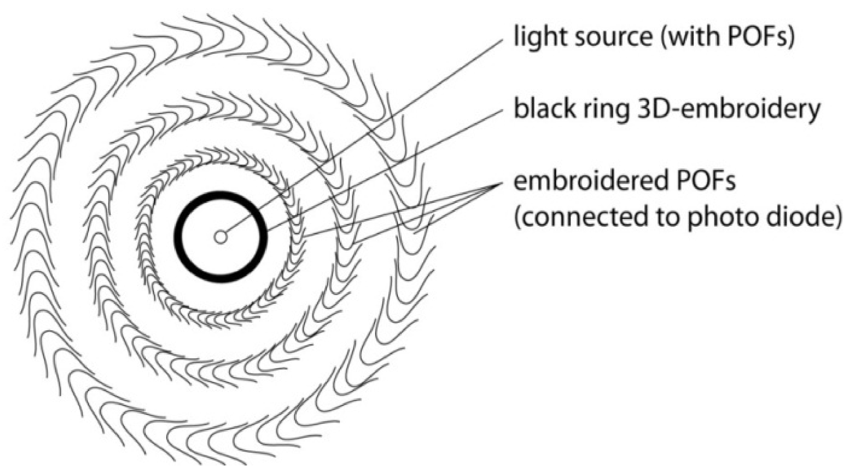


Mark G. Kuzyk, Polymer Fiber Optics, Fig 4.5 (a), p. 102

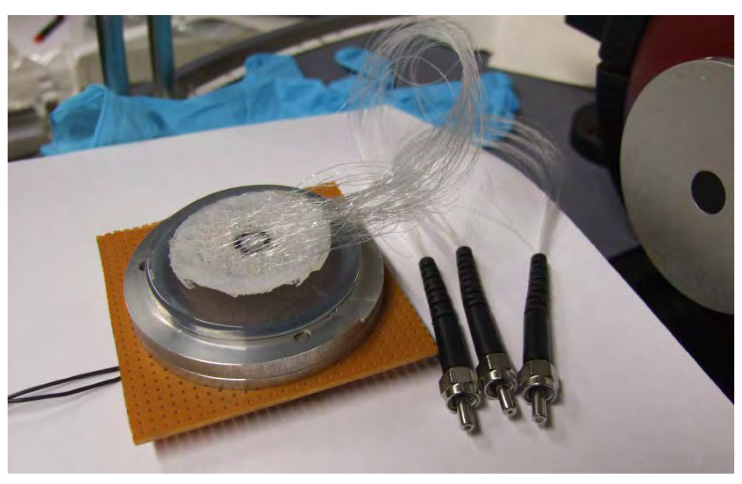


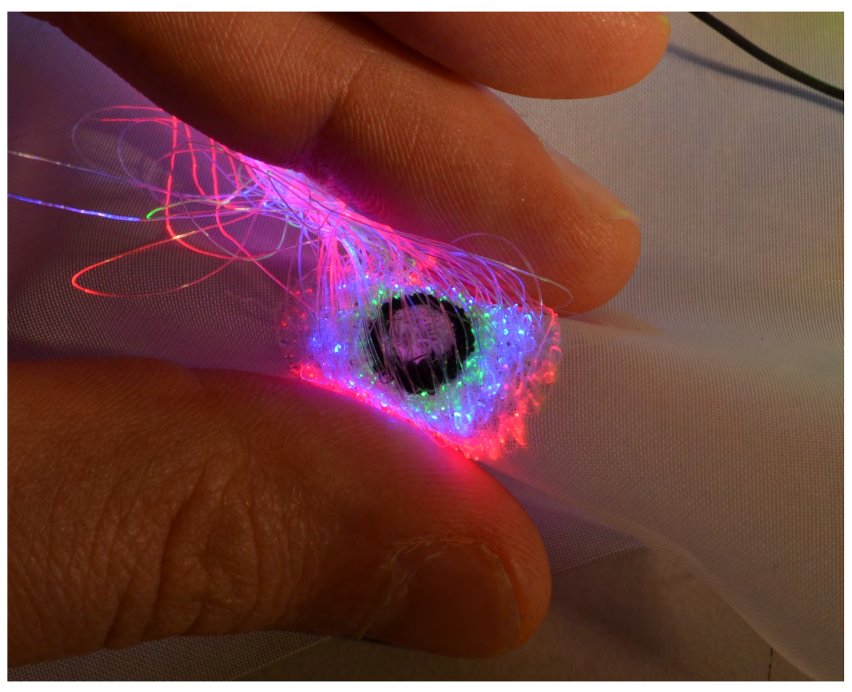
Perfusion measurement for wound healing monitoring relies on the difference in light absorption in the tissue. Measuring the light at different distances can deliver information about the tissue at different depths. Stitched flexible Polymeric Optics Fibers (fPOFs) can act as light source and detector.





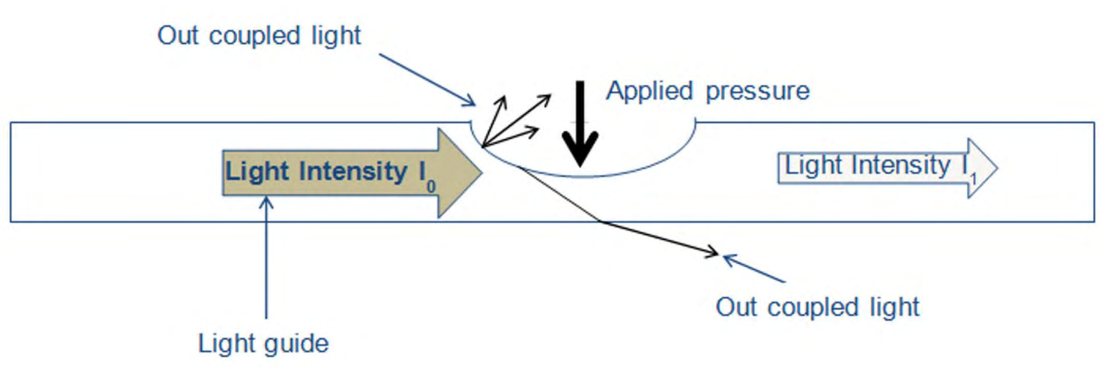
Set-up for light coupling efficiency measurements – LED plus a tissue model

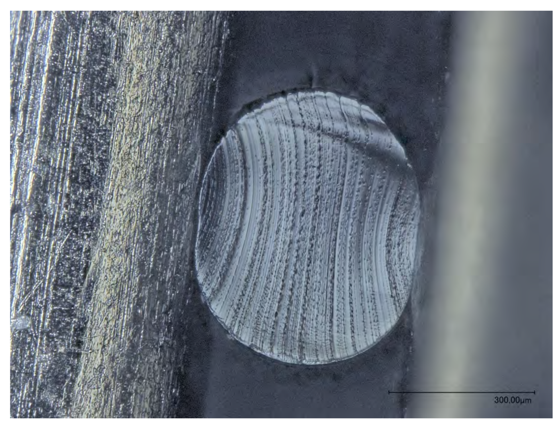




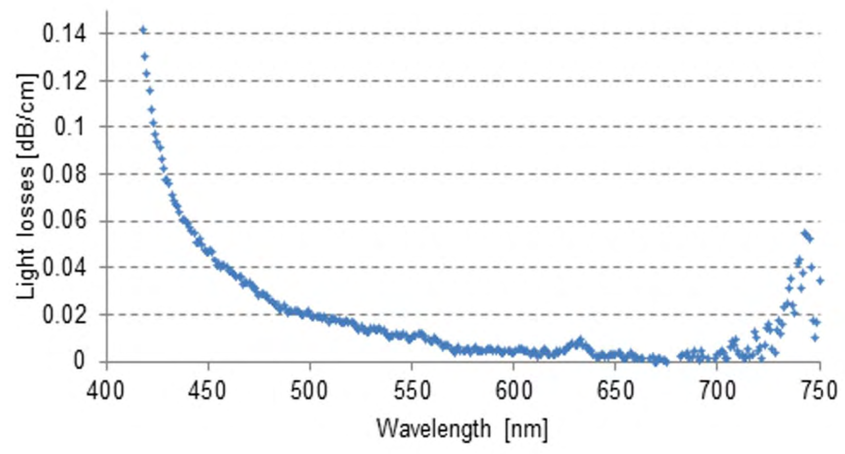
Pressure sensitive fiber

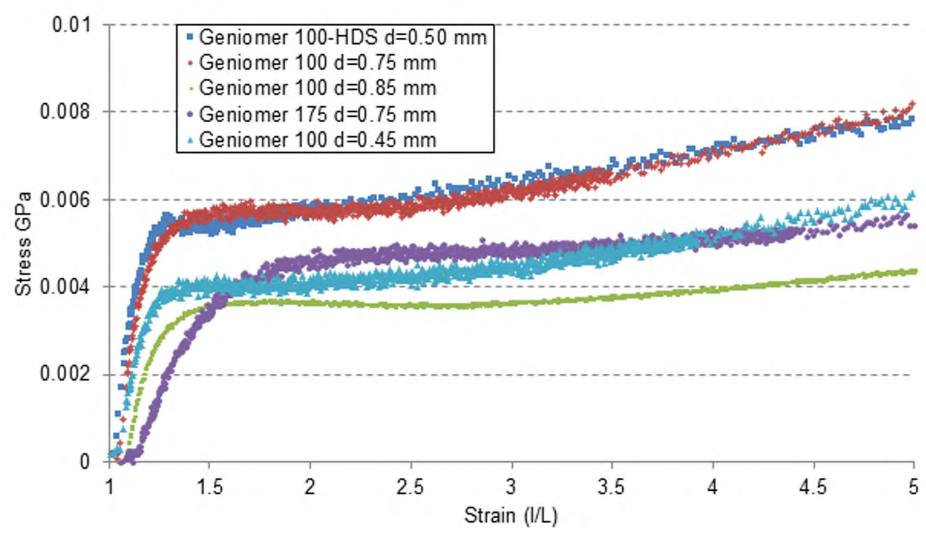
The applied force results in an elliptical deformation of the fibre cross section. From the side projection a kind of cavity was observed, as schematically illustrated. This deflection increased the out-coupling of the light in the region under pressure due to the geometrical deformation of the fibre.



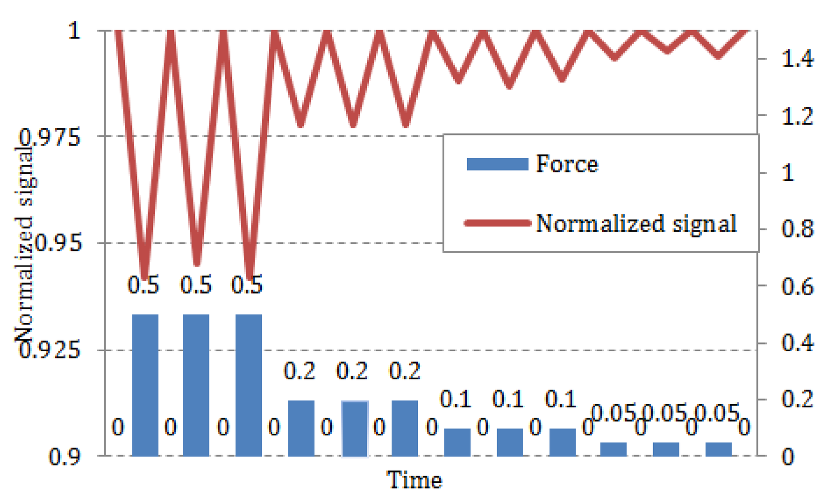


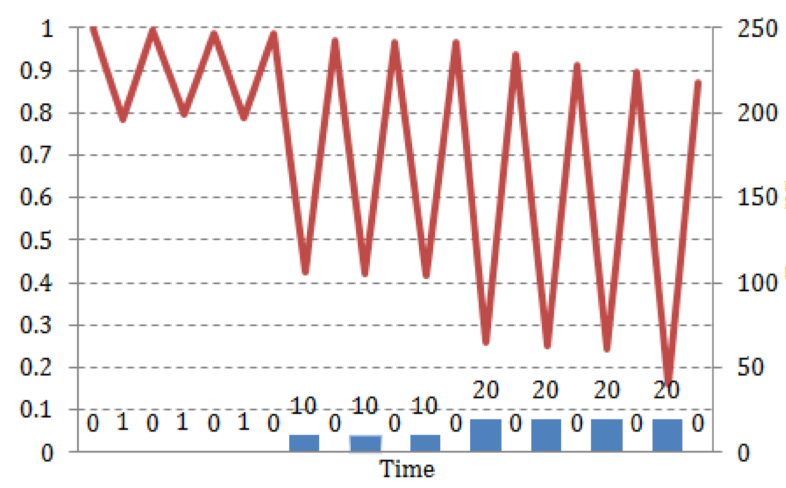
Light losses were measured with cut-back method. The signal loss varied from 0.16 to 0.25 dB/cm. The intrinsic losses were measured with a photospectrometer. Since the overall attenuation of the light pipes was much higher, the main light loss was due to extrinsic losses caused by the extrusion process (irregular fibre surface, bubbles or other inhomogeneities in the material).





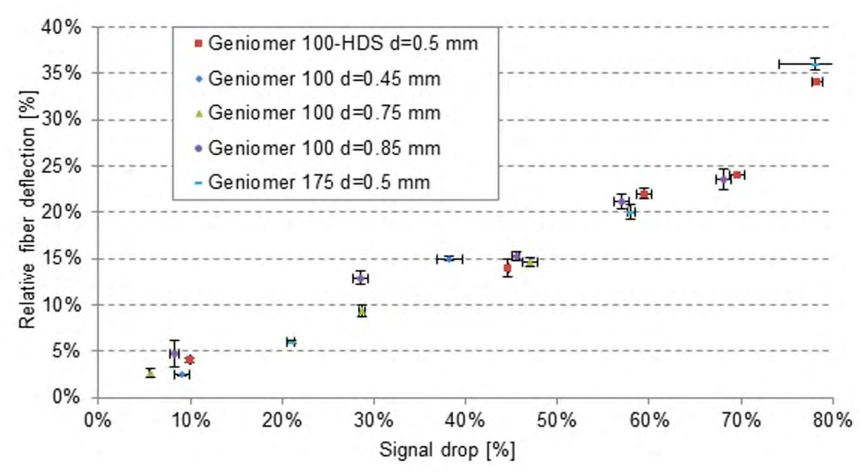
From the strain-stress curve it can be concluded that the fibre made of Geniomer 175 has the smallest elastic modulus than the fibres made of the other two Geniomers materials and thus should have the highest response for applied pressure. The Young moduli of Geniomer 100 and Geniomer 100-HDS are similar and big differences in the light transmission could not be observed while applying pressure.





Depending on the block-co-polymer material used for extrusion, the applied forces caused different responses in light transmission. This was expected due to the different young moduli. Since the light losses caused by the applied forces are associated to the fibre deflection, not only the polymer material but also the diameter of the fibre influenced the measurement range. Demonstrated measurements rage varies from 0.05 N to 40 N.

The signal drop is correlated to the fibre deflection, independently of polymer material and fibre diameter. This shows that only the deflection in force direction influences the amount of the out-coupled light and that the elastic properties of the material has only a minor influence on the signal change



Outlook

- Improving stitching pattern for better light coupling efficiency
- Improving fibers light attenuation
- Producing a "yarn" out of optical fibers
- Embossing Fresnel structures on the fibers to enhance light coupling parameters