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FlusiTex RTD 2013

FNSNF

Fabrication of Fluorescence Sensors in a Textile Dressing for Non-invasive Lifetime Imaging-based Wound Monitoring

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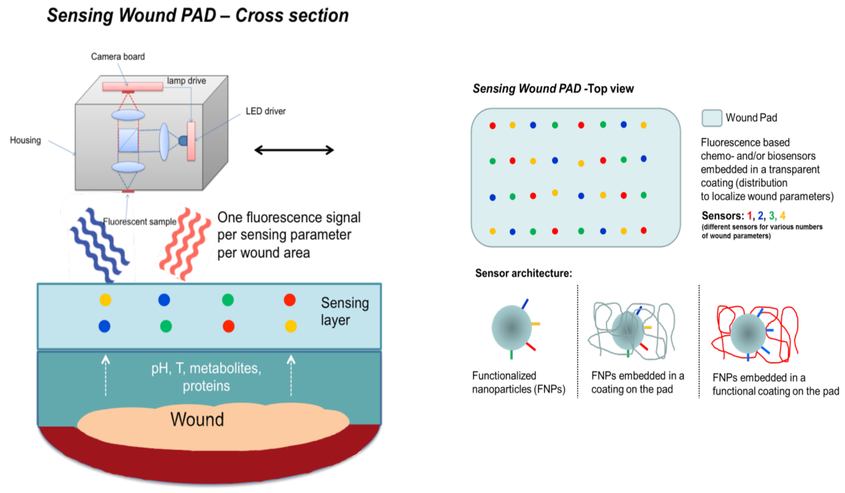
Motivation

Wound healing is a complex process, which, under normal circumstances does not require constant monitoring. However, when wounds are associated with chronic infections and/or underlying diseases such as diabetes, immune compromising diseases, paralytic patients (decubitus), or large skin defects due to trauma (fractures, osteomyelitis) or burns, a much more significant threat is presented to the patient that can result in death. Monitoring the wound healing process is difficult and is primarily based on subjective, qualitative judgment by the clinician. A more objective monitoring system that not only allows monitoring of the local milieu at the wound site, but also detects early changes before clinical symptoms occur, is highly desirable. Such a system will provide the clinician with an objective tool that allows decisions to be made using evidence-based medical data.

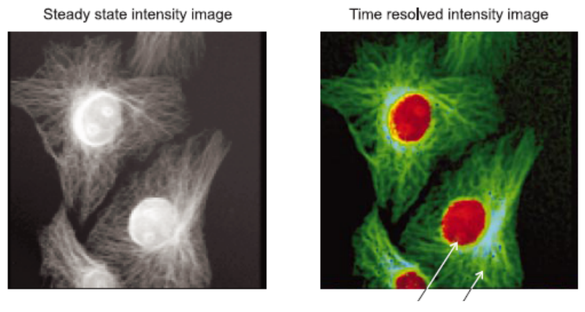
Approach

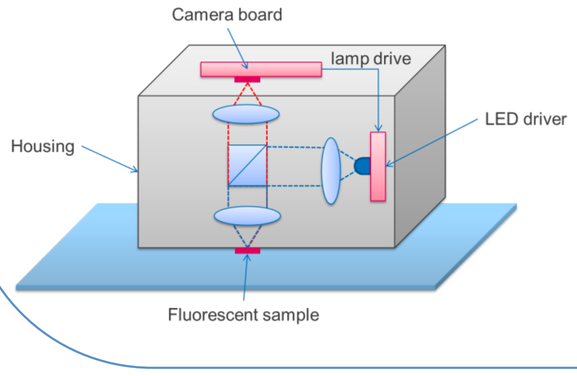
FlusiTex is developing a textile based sensing system to monitor wound healing. We combine fluorescence based chemical and biochemical recognition methods with advanced optical readout methods. The coatings will be integrated in a fabric in order to monitor wound healing, where different physical, chemical and biological parameters will be detected simultaneously.



Fluorescence Life-time Imaging

Fluorescence lifetime imaging microscopy (FLIM) has been applied since the early 1990s for the mapping of pH, ion concentration, oxygen content, etc., in living cells, tissues and model organisms. The use and value of FLIM for medical diagnostic applications, histology, high-throughput pharmacological compound screening, as well as product authentication has been demonstrated. We are developing a compact, robust system for real-time wide-field fluorescence lifetime imaging in the ns-µs range (frequency domain). We are working on adapting the lock-in pixel technology to meet the requirements of fluorescence lifetime imaging on the wound pad.

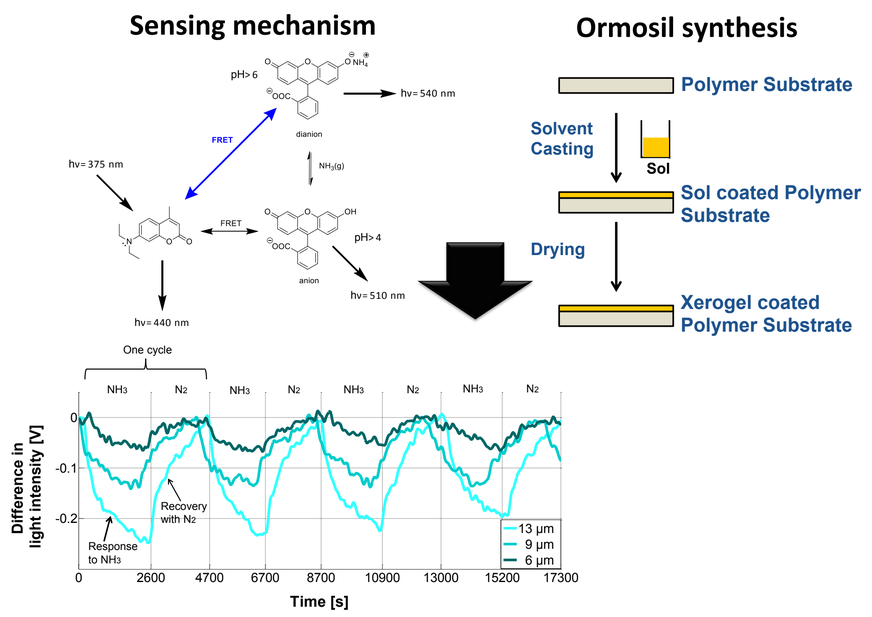




The system consists of a modulated solid-state light source (LD or LED), a CMOS lock-in imager, optical lenses and the electronic interface.

pH Sensing Layer

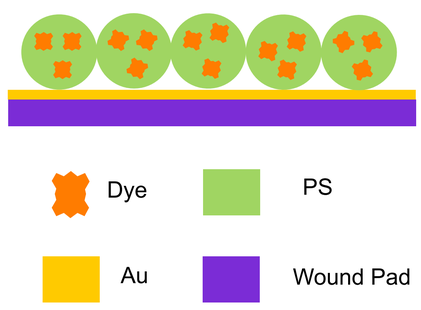
Organically modified silicate (Ormosil) claddings for textiles have been prepared at EMPA, which allows the reversible detection of gaseaous ammonia. The same cladding can be used for the monitoring of pH. The organic part of the matrix is used for attaching enzymes while the inorganic part will be designed for attaching to the wound pad.



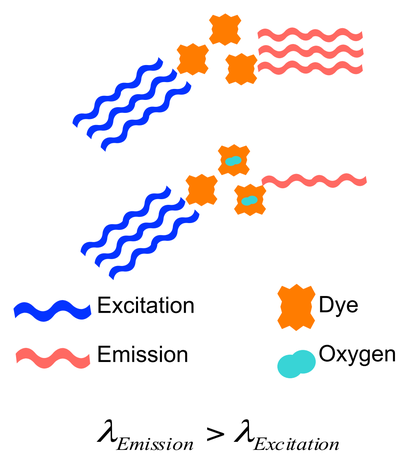
Oxygen Sensing Layer

We are using Pt(II) octaethylporphine (PtOEP) as an oxygen sensitive dye, because it has a long lifetime and the excitation/emission wavelengths are in the visible light range. The dye is embedded inside a polystyrene (PS) supporting matrix which is highly permeable to dissolved oxygen and transparent in the visible spectrum. The oxygen sensitive luminescence film will be deposited onto the wound pad and used as the sensing layer.

Microfabrication



Theory



$$\lambda_{Emission} > \lambda_{Excitation}$$

Animal Trials with the Wound Pad

Deep, fresh or chronic wounds in combination with bone trauma or selected orthopaedic procedures are one of the most challenging features for modern trauma and orthopaedic surgery. In this project, the focus is placed on wound management with deep wounds in orthopaedics. If successful, wound monitoring will be expanded to all types of open, fresh and chronic wounds, even in severe burn cases. Performance experiments of the fabricated wound pad will be carried out in animals according to Swiss legislation (TSch, TschVO 455). Standardized deep wounds (5 x 10cm) will be created at the dorsum (back) of sheep including the skin, subcutaneous fat, fascia and part of the M. longissimus dorsi. Wounds will be allowed to close with the wound sensing pad applied. Recordings of wound parameters will be documented and validated with regular wound biopsies until complete closure of the wound. Histology of wound biopsies will be performed and evaluated morphologically using immunohistochemistry to assess the stage of inflammation (cytokines, inflammatory mediators, inflammatory cells).

ETH Eidgenössische Technische Hochschule Zürich Swiss Federal Institute of Technology Zurich

EMPA Materials Science & Technology

csem

Universität Zürich[UZH]