



OF ETH

Optical Fibre Sensors Embedded into technical Textile for Healthcare

FP6 Instrument: STREP

Thematic priority: 2.4.11: Integrated biomedical information for better health

Proposal/Contract no.: **FP6 - 027 869**

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Start date of project: 01/03/2006 (M01)

Duration: 42 months

Project Coordinator

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Publishable executive summary

1 - Project details

- Instrument: STREP
- Identifier : FP6-027869
- Project start date : 1st March 2006
- Duration : 42 months
- Total cost : 3.5 M€
- Commission funding : 2.3 M€

Consortium:

N°	Participant name	Short name	Country	Role
1	Multitel	MUL	Belgium	CO
2	Centre Scientifique et Technique de l'Industrie Textile Belge	CEN	Belgium	CR
3	Shishoo Consulting AB	SHI	Sweden	CR
4	TAM Télésanté	TAM	France	CR
5	Centre Hospitalier Régional Universitaire de Lille	ITM	France	CR
6	Bundesanstalt für Materialforschung und Prüfung	BAM	Germany	CR
7	Advanced Optics Solutions Gmbh	AOS	Germany	CR
8	Fiberware Generalunternehmen für Nachrichtentechnik GmbH	FIB	Germany	CR
9	Technische Universität München	TUM	Germany	CR
10	ELASTA Ind	ELA	Belgium	CR
11	Tytex A/S	TYT	Denmark	CR

CO: Coordinator / CR: Contractor

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2 - General context and objectives

Healthcare monitoring is a general concern for patients requiring a continuous medical assistance and treatment. In order to increase mobility of such patients, a huge effort is pursued worldwide for the development of wearable monitoring systems able to measure vital physiological parameters such as respiration movements, cardiac activity, pulse oxymetry, temperature of the body. Technical or smart textiles that incorporate many different sensors play a growing role in these developments as they are well suited for wearability and can ensure comfort to the user.



While most developments up to now have been focused on the use of electrical sensors, the aim of OFSETH is to take advantage of pure optical sensing technologies for extending the capabilities of medical technical textiles for wearable health monitoring.

OFSETH research will focus on how silica and polymer optical fibres can be used for sensing vital parameters while being compatible with a textile manufacturing process.

Optical fibre sensors have already demonstrated great capabilities for many applications where distance, electromagnetic compatibility (EMC), risk of explosion, need for distributed measurement,... limit the use of standard competing technologies. Up to now however, their use as embedded sensors in technical textiles for medical applications has not been fully explored, despite their expected positive impact.



In this context, OFSETH will notably investigate how measurements of various vital parameters such as cardiac, respiratory rates and pulse oxymetry can be performed through pure optical devices and techniques, such as fibre Bragg gratings (FBG) sensors and near infrared spectroscopy (NIRS), among others, and which could also, in a longer term, suit for non-invasive pH or glucometry measurements. The feasibility of such sensors using polymer optical fibre (POF) instead of standard glass (silica) fibre for an easier integration into the textile will be investigated, with a special focus on POF FBGs.

In parallel, OFSETH will explore all suitable techniques for processing optical fibres together with textile yarns, for the realisation of medical textiles with embedded optical sensors. Specific developments of weaving and knitting techniques as well as custom design of optical fibres shall be necessary in order to obtain a textile manufacturing compatible process that does not damage the optical fibres nor degrade their sensing properties.

In the frame of OFSETH, prototypes of fibre based sensors integrated into textiles will be developed and compared with standard sensors when tested onto simulators. A complete monitoring textile with embedded monitor shall then be produced and used for clinical evaluation with patients and healthy volunteers.

OFSETH expects to achieve a breakthrough in healthcare monitoring applications where standard (non-optical) monitoring techniques show significant limits. In particular and as short and mid-term results, OFSETH developments will be assessed for monitoring the vital parameters of sedated or anaesthetised patients under medical resonance imaging (MRI), where there is a need for safe, reliable and fully EMC compliant monitoring systems and therefore an interest for the promising properties of pure optical sensing solutions.

The wearability and comfort of the system will then be assessed as it is an additional goal of OFSETH to enlarge the capabilities of the technique to ambulatory healthcare monitoring and SIDS (Sudden Infant Death Syndrome).

3 - First year main achievements

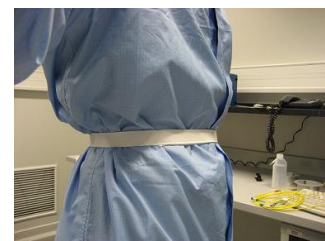
During the first year, the work has focused on:

- Training the consortium members to the various technologies that will be used in the project
 - o The overall objective of this task has been to ensure that there is a deep common knowledge of the scientific and technical tasks of the OFSETH project among all its participants. This has been achieved by the development of a comprehensive training and educational plan consisting of four short courses including lab or hospital tours and demonstration activities on healthcare, health monitoring systems, optical sensors and textiles.

- Developing precised specifications with regards to the targeted applications
 - o From the broad range of possible applications, a set of feasible, clinically useful and technically realizable technologies have been defined. Together with clinicians, a precise description of the expected functionalities and then clinical benefits has been given. Two study cases have been selected:
 - Sedated patient under MRI requiring continuous monitoring of cardiac, hemodynamic and respiratory activity. Here, no reliable monitor is available on the market today
 - Ambulatory patient, we aim to explore how our solution can fit for ambulatory applications, and especially prevention of SIDS, for which no reliable and cost effective system has been proposed up to now
 - o For both study cases, a report detailing all information relevant to the useful signals and parameters and including a description of the acquisition methods, technical specifications and constraints has been created. The associated report details the requirements for optical sensors for MRI, where focus is given on wearability of the whole monitoring system, through integration of the sensors into wearable textiles, making it compatible for ambulatory monitoring and prevention of SIDS.
 - o For the first study case (sedated patient under MRI), a complete analysis has been performed by the medical partners in order to design a textile fabric that would suit the requirements of the medical staff (“dressing time”, compatibility with resuscitation procedures, etc.). A harness-like monitor was designed accordingly.
 - o Finally, a preliminary description of the system validation procedure was also done.

- Developing knowledge about integration of optical fibres into various types of textile fabrics
 - o Several designs as well as textile processes have been investigated by the textile partners, including weaving, wrap and weft knitting, crochet, and stitching and the respective advantages and capabilities of each process have been estimated with regards to the required applications.
 - o In parallel, the partners with a fibre optics background evaluated the performances of various types of optical fibres, including silica glass and polymer fibres, when being embedded. The comparison has focused on different fibre geometries and coating materials.

- Designing respiratory motion sensors based on fibre optics
 - o Because monitoring of respiratory activity of sedated patients relies on impedancemetry measurements between the ECG electrodes, the measure is not reliable in the MRI environment
 - o Three techniques for sensing respiration rate from optical fibres embedded into medical textiles have been investigated, based on intensity measurements, spectral measurements from a FBG sensor, and reflectometry measurements in the time domain, and the feasibility of the three techniques was demonstrated
 - o In parallel, a feasibility study regarding the possibility to



use a FBG sensor made in a POF fibre has been conducted, but with no concluding results at this stage due to the lack of available single-mode polymer fibre on the market.

- Designing a pulse oxymetry (SpO₂) sensor with an optical fibre termination
 - Commercially available oximeters usually consist in a NIRS measurement device based on red and infra red emitting diodes coupled with a single photodetector. Because metallic parts as well as an electric cable still remain in the sensing part, skin burns can occur during the MRI examination.
 - We started investigation of possible solutions for making the sensor fully EMC compatible, thanks to a remote illumination and interrogation through optical fibres. First prototypes of suitable fibres were developed and will soon be evaluated.
 - In parallel, a complete interface with data acquisition and processing was developed. It allowed investigating the best location for a reflectance SpO₂ sensor.

- Disseminating the project approach and results to the community
 - Some efforts were devoted to dissemination actions within the European textile, sensor and biomedical communities. Numerous papers were presented/submitted to industrial and/or R&D events, such as Textile Trends (Berlin – Feb07), EWOFS (Napoly – July07). More dissemination events will take place in the coming months
 - In parallel, a public website has been set-up at www.ofseth.org. It especially contains useful information about the applications and the hospital environment constraints.

