Optical Fiber Sensors for Medical Applications

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Abstract:

The inherent physical quality of optical fiber joint with its flexibility in distant sensing makes it smart equipment for biomedical uses.

With worldwide residents that are both budding and breathing longer, the global healthcare provider are progressively more looking to highly developed biomedical instrumentation to facilitate more competent patient analysis, monitoring, and cure. In this situation, biomedical sensing uses of optical fiber are of budding significance. The same time, current advances in modestly invasive surgery require smaller throwaway sensing catheters.

Keywords: *Optical fibre, medical application, technology, biomedical.*

Introduction

Endoscopic imaging application of optical fiber are well recognized, but the inherent physical feature of optical fibers also makes them enormously gorgeous for biomedical sensing. Fibers without jacket can be inserted straight into nozzle and catheters; so that their employ can be both simply enveloping and extremely limited to a small area—and fiber-optic sensors completed with them can carry out distant multipoint and multi-parameter sensing. Optical fibers are resistant to electromagnetic interference, chemically inert, nontoxic, and fundamentally safe. Their make use of will not reason interference with the conservative electronics establish in medical theaters. And, most significantly, the resistance of fibers to electromagnetic and radio frequency signals makes them perfect for real-time use throughout diagnostic with Magnetic Resonance Imaging, computed tomography, A positron emission tomography, or Single-photon emission computed tomography systems, as well as throughout thermal ablative treatments relating RF or microwave radiation.

Creating high-accuracy telecentric lenses for machine vision systems: A key component of a machine vision system is its telecentric lens, which offers the best possible "vision" for the machine. Learn what telecentric lenses are and how to create high accuracy telecentric lenses for machine vision systems.

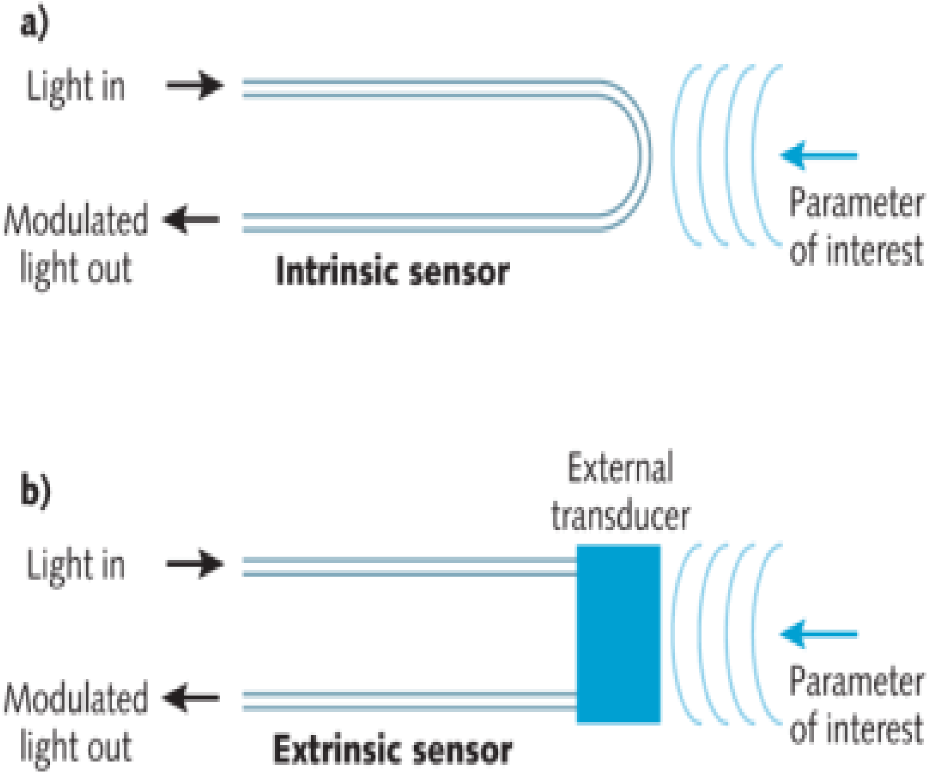

FIGURE: Two fundamental types of optical fiber sensors. Extrinsic sensors (a) a transducer, whereas intrinsic sensors (b) do not.

Fiber-optic biomedical sensors

Optical fiber sensors consist of a light source, optical fiber, exterior transducer, and light detector. They detect the modulation of one or more of the properties of light that is guided inside the optical fiber such as intensity, wavelength, or polarization. The modulation is created in a straight and repeatable style by an exterior perturbation caused by the physical factor to be considered. The measured of notice is inferred from changes detected in the optical characteristics.

Optic fiber sensors can be intrinsic or extrinsic. In an intrinsic sensor, the light resides in the fiber and the parameter of attention affect a property of the light propagating during the fiber by acting directly on the fiber itself. In an extrinsic optical fiber sensor, the perturbation acts on a transducer and the optical fiber just transmit light from the sensing position.

A lot of diverse optical fiber sensing mechanisms have been used previously for industrial applications[1, 2,] and a number of biomedical applications[3-5] amid which are fiber Bragg gratings, Fabry-Perot cavities or external fiber Fabry-Perot interferometer sensors, evanescent wave, Sagnac interferometer, Mach-Zehnder interferometer, micro-bending, photo-elastic etc. The most common are based on external fiber Fabry-Perot interferometer sensors and fiber Bragg gratings sensors. Spectroscopic sensors which are based on light absorption and fluorescence are also used. Biomedical optical fiber sensors can be considered into four chief types: physical, imaging, chemical, and biological.

Physical sensors measure a range of physiological parameters, such as human body temperature, blood pressure (BP) and muscle dislocation. Imaging sensors cover both endoscopic tools for internal study and imaging, as such as modern techniques such as optical coherence tomography and photo-acoustic imaging, where internal scans and visualization can be made non-intrusively. Chemical sensors rely on spectroscopic, fluorescence and indicator technique to recognize and compute the being there of specific chemical compounds and metabolic variables such as pH, blood oxygen, or glucose level. They sense exact chemical species for diagnostic purposes, and observe the body's chemical reactions and action. Biological sensors to be inclined more composite and rely on biologic detection reactions, such as enzyme-substrate, antigen-antibody, or ligand-receptor — to recognize and measure specific biochemical molecules of notice.

In optical fiber sensor development, the basic imaging sensors are the most developed. Fiber-optic sensors for dimension of physical parameters are the after that for the most part prevalent, and the slightest developed area in terms of doing well products is sensors for biochemical sensing, although many optical fiber sensors concepts have been established.

Table 1: Classification of biomedical sensors by type showing various biomedical parameters of interest

Physical	Chemical	Biological	Imaging
Body temperature	pH	Antigens	Endoscopy
Blood pressure	pO_2	Antibodies	Optical coherence tomography (OCT)
Blood flow	PCO_2	Electrolytes	Photodynamic therapy (PDT)
Heart rate	Oximetry (SaO_2, SvO_2)	Enzymes	
Force	Glucose	Inhibitors	
Position	Bile	Metabolites	
Respiration	Lipids	Proteins	
Shape sensing			

Requirements and applications

Biomedical sensors here sole design challenges and exacting trouble connected to their interface with a biological living being. Sensors should be secure, dependable, extremely stable, biocompatible, agreeable to sterilization and autoclaving, not prone to biologic negative response, and not need calibration. Sensor covering is a particularly crucial aspect since the tool should be tiny - mainly those for implanting or indwelling purposes as shown in Fig. 2. The tools also should be as uncomplicated as possible.

Uses for biomedical optical sensors could be divided into two types as *in vivo* or *in vitro*. *In vivo* gives to application on a full, living organism - such as a human patient; *in vitro* gives to measuring exterior of the body - like as laboratory blood tests. From the perception of how optical sensors are applied to a patient, they can be classified as non-invasive, contacting, minimally invasive, or invasive. Biomedical optical sensors can be used in humans, in animals, or other living organisms and depending on the intended use, can be for diagnostic, therapeutic, or rigorous care in clinical uses; research and preclinical growth; or laboratory testing (see Table 1).

FIGURE. Sensors intended for implanting or indwelling applications must be very small such as this micro-miniature fiber-optic pressure sensor shown on a fingertip.

Latest product developments:

One of the near the beginning fiber-optical biomedical sensors, Camino Labs (San Diego, CA), in 1984 come into the medical market an intracranial pressure sensor that has since develop into one of the most usually used intracranial pressure monitoring systems in the world. The tools are based on a potency modulating optical fiber system relying on a tiny bellows as the transducer.

Earlier sensor pioneers are Luxtron (Santa Clara) with its fluor-optic temperature sensor and FISO (Quebec City, QC, Canada) which has situated itself as a mainly significant supplier of medical fiber-optic pressure and temperature sensors. FISO's sensors are based on EFPI tools interrogated with white-light interferometry. Among a new generation of companies are

Opsens, Neoptix (both in Quebec City, QC, Canada), and Samba Sensors (Västra Frölunda, Sweden). By far, the most familiar medical optical fiber sensor on the market is temperature and pressure monitor, but a handful of other diverse sensors and instruments does be present as given in Table 2. As low costs and modern sensing techniques are developed, it's likely that the number and diversity of biomedical optical fiber sensos will increase.

Table 2: Examples of commercial fiber-optic biomedical sensors by type

Parameter	Company
Temperature	Fiso, LumaSense, Neoptix, OpSens, RJC
Pressure	Fiso, Maquet, OpSens, Samba Sensors, RJC
Coronary imaging	InfraRedx
Oxygenation	ISS
Pulse oximeter	Nonin
Blood flowmeter	ADInstruments
Shape/position	Hansen Medical, Intuitive Surgical, Luna, Measurand, Technobis
Force	EndoSense
EKG/EEG	Srico

The latest expansion efforts are shape-sensing systems that use arrays of Fiber Bragg Gratings disposed along multimode and single mode fibers. The Fiber Bragg Gratings will transfer peak wavelengths in response to the strain and curvature stress formed during bending. The fiber arrays help to determine the accurate position and shape of medical tools and robotic arms used during MIS. Pursuing by Companies such type development are Hansen Medical (Mountain View, CA), Intuitive Surgical (Sunnyvale, CA), Luna Innovations (Roanoke, VA), Measurand (Fredericton, NB, Canada), and Technobis (Uitgeest, the Netherlands).

New optical fiber sensors product in precertification trials is the Endo-Sense (Geneva, Switzerland) TactiCath force-sensing catheter. Fiber Bragg grating sensors are mount on the tip of an intra-aortic catheter that also serve as a laser-ablation delivery probe for the treatment of atrial fibrillation. The Fiber Bragg grating sensors examine the force exerted against the heart wall by the stress induced on them as shown in Fig. 3. Force control is necessary for deliver suitable laser ablation pulses required to create lesions that are induce in the heart walls to decrease irregular electric activity.

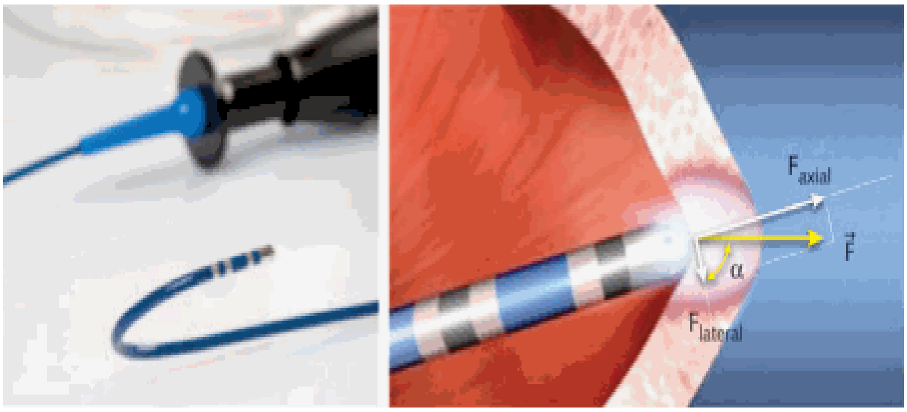

FIGURE. A fiber-optic intra-aortic force sensing catheter probe enables real-time monitoring of the force exerted against the heart wall by the catheter.

Outlook:

The market represents a biomedical sensing is a lucrative and growing opportunity for optical fiber sensors, mainly for huge volumes of throwaway probes. The requirement for large number of patient monitoring tools combine with a fashion toward modestly invasive surgery, which itself require a range of minimally invasive medical tools as well as one time use, disposable sensors of tiny size that can be included into catheters and endoscopes - an perfect fit for optical fiber sensors. There is an indisputable opportunity for optical fiber sensors as electromagnetic interference - compatible sensors to monitor vital signs during use of MRI, as well as RF treatments.

BCC Research (Wellesley, MA) estimate the US market for patient monitoring tools to be cost \$3.6 billion in 2007 and to reach \$5.1 billion in 2013. In a recently report, growth rate of 11.6% from 2017 through 2022 to reach \$35.0 billion by 2022.The throwaway sensors and other consumables, portion of the market were approximate to be \$2.6 billion in 2007 and to reach ~\$3.4 billion in 2013. The optical fiber sensors share of this global market is small and approximate to be at around \$100 million. The potential is marvellous and optical fiber biomedical sensors offer capability and description that cannot be or else obtained. The higher cost remains a barrier, however, as does the lengthy development cycles and required regulatory process. Optical Fiber Sensor design and growth is not unimportant, and proper material selection, design, biocompatibility, patient safety and other points must be taken into account.[6] However, there are already a number of successful products in the market and more to come.

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