Chapter 69
Optical Fiber Technology for eHealthcare

Nélia Jordão Alberto
Instituto de Telecomunicações, Portugal

Lúcia Maria Botas Bilro
Instituto de Telecomunicações, Portugal

Paulo Fernando da Costa Antunes
Instituto de Telecomunicações, Portugal & Universidade de Aveiro, Portugal

Cátia Sofia Jorge Leitão
Universidade de Aveiro, Portugal

Hugo Filipe Teixeira Lima
Universidade de Aveiro, Portugal

Paulo Sérgio de Brito André
Instituto de Telecomunicações, Portugal & Universidade de Aveiro, Portugal

Rogério Nunes Nogueira
Instituto de Telecomunicações, Portugal

João de Lemos Pinto
Universidade de Aveiro, Portugal

ABSTRACT

In the last years, optical fiber based sensors and systems for ehealthcare attracted the attention of the scientific community. Over this chapter, optical fiber technology is presented, referring the different types of optical fibers, its main characteristics, and advantages over other sensing methodologies. In addition, optical fiber based sensors and sensing techniques are discussed and several works reported in the literature are reviewed showing that they are a valuable technique to improve healthcare service to the community and as a potential solution to answer different problems. The final section of the chapter consists of the description of three applications of optical sensors in healthcare, namely monitoring of human joint movement, measuring strain of biological tissues, and characterization of medical materials.

INTRODUCTION

The quality of human life is dependent, among others factors, of his health. Healthcare represents the principal means by which people try to improve the overall quality of their daily lives. The purpose of healthcare is to provide diagnosis, treatment, and prevention of diseases or conditions that contribute to that goal. Over the years, the scientific community has focused efforts to implement new methodologies to allow a faster and early detection of diseases, which make treatments less invasive, and to develop new

DOI: 10.4018/978-1-5225-5484-4.ch069

materials, drugs and equipments to help in the medical practices. The optical fiber technology has been widely explored and used in different research areas, including food and oil industry, civil and aerospace engineering. The intrinsic characteristics of the optical fiber make it one of the most promising technologies to be used in healthcare. The optical fiber provides immunity to electromagnetic interferences, electrical isolation, chemical stability, reduced weight and flexibility to adhere to curved structures, as for instance bone anatomical structures. Additionally, optical fiber is biocompatible, and several sensors can be integrated in the same optical fiber, providing a mechanism for distributed monitoring. Hence, a significant increase on the number of works reporting the application of optical fiber sensors in healthcare has been obtained (Bilro et al., 2010; Kanellos et al., 2010; Liao et al., 2008). The present work intends to provide an overview of optical fiber sensor applications in healthcare. Over this chapter, the working principle of some optical fiber sensors is presented. Different sensing schemes are considered, and the description is complemented with examples of the application of this technology in healthcare. Particular attention is given to the monitoring of human joint movement, measurement of biological tissues strain and the characterization of medical materials with optical fiber.

OPTICAL FIBER TECHNOLOGY

Optical fibers are mostly known as a transmission medium in data networks. They consist of a glass or plastic material through which light pulses are sent to represent data that is intended to convey. Their development was largely due to the development of optical communication systems. These systems have been undergoing significant growth since 1960, at the time of the laser discovery. Then, there were preliminary experiments to transmit information through light beams propagated in the atmosphere, but quickly was verified that the variability of the atmospheric environment was a limiting factor, requiring other means that would guide the light signals. Optical fibers are the central element in optical communication systems, although currently their applications are not limited to a transport channel and can also be used as sensors.

There are mainly two types of optical fiber: Glass Optical Fiber (GOF) and Plastic Optical Fiber (POF). They are flexible waveguides, manufactured from dielectric materials, almost transparent to the operation wavelength. The cross section of these is generally circular and in their most basic form, divided into three concentric layers, namely the core, cladding and coating. The propagation of the optical signal is carried out mainly in the fiber core. However, if the fiber was only formed by the core, although the total internal reflection occurs, the light would be lost due to absorption phenomena or due to frustrated total internal reflection when in contact with the core interface. For these reasons, the core is surrounded by the cladding, which is also a transparent layer, characterized by a refractive index lower than the core index. The coating provides mechanical protection to the optical fiber.

The POF has some important advantages over the GOF. Specifically, the typical larger diameter, 0.25 mm to 1 mm, allows the use of connectors with low accuracy, reducing the total cost associated with a POF system. In this sense, the POF can be a disruptive technology (Polishuk, 2005). This assertion is supported by the growing number of papers on POF sensors. The properties of the POF polymers, usually Poly(Methyl MethAcrylate) (PMMA), clearly differ from the properties of silica and therefore provide additional benefits associated in large part to the fact that the Young's modulus is about twenty five times lower than that of silica.