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Development of a System Concept for Miniaturized Cardiovascular Multi Sensor Implants

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Abstract

Long-term monitoring of hemodynamics can be achieved by an implantable and telemetric multi sensor system. A concept to realize a system with high miniaturization level is presented. The requirements regarding a multifunctional transponder ASIC (Application Specific Integrated Circuit), which should combine signal processing, telemetric communication and additional sensors in one chip, are introduced. Capacitive pressure sensors showing low power consumption were tested with laboratory setups with respect to the integration in this concept. First results were achieved and discussed concerning two potential assembly technologies for the integration of a pressure sensor. Finally, novel hermetic sealing and implant encapsulation technologies are proposed for further implant miniaturization.

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Keywords: pressure sensor; monitoring of hemodynamics, multi sensor system, telemetric power and data transmission, implant encapsulation

1. Introduction

Long-term monitoring of physiological parameters in cardiovascular areas becomes more and more important along with an increasing number of patients suffering from heart diseases, e.g. hypertension. Controlling of hemodynamics allows the early detection of critical conditions and facilitates diagnosis, even before clinical symptoms may occur (see Figure 1). Thereby, hospitalization can be avoided and therapy can be optimized which results in more comfortable patient treatment [1]. For the controlling of hemodynamics (for example in pulmonary artery) a high precision pressure measurement is indispensable for accurate detection of physiological changes in

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blood pressure [2]. Side effects like patient's position, mechanical shocks, temperature or energy level deviation may lead to inaccurate or faulty pressure measurements. These negative effects can be accounted by monitoring of disturbances with additional sensors, whereby a compensation of the measured pressure value can be performed.

A multi-functional ASIC is responsible for sensor signal processing, power management and communication. The complete sensor system operates without any integrated energy sources, since energy and signal transmission are performed telemetrically by an integrated antenna within the circuit board.

The presented approach of a cardiovascular multi sensor implant is conceived for applications within blood vessels, which results in special requirements concerning geometrical dimensions and shape. This challenge of a very high miniaturization level is supposed to be solved by smart implant design and a novel encapsulation technology.

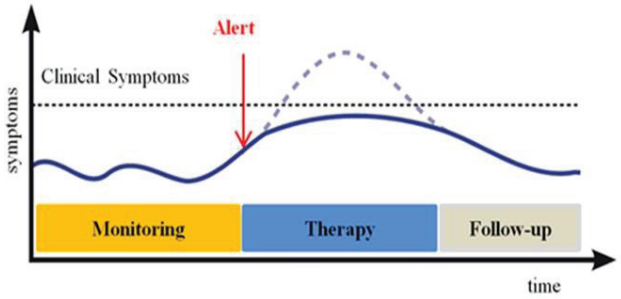

Fig. 1. Early detection of critical conditions and start of therapy before clinical symptoms may occur [according to 1]

2. Multi sensor system

Implementation of a multi sensor system for in-vivo applications results in the challenge of a very high miniaturization level. Therefore, approaches for combining several functionalities in one chip and novel encapsulation technologies have been developed. The basic assembly and packaging concept of the multi sensor implant is presented in Figure 2. (a). Micro Electro Mechanical Systems (MEMS), for example a pressure sensor, the multi-functional ASIC, which contains further sensors, and additional components are assembled on a circuit board. On addition, the integration of the antenna for telemetric communication and power supply into the circuit board, such as shown in Figure 2. (b), is supposed to support a further miniaturized design of an implant.

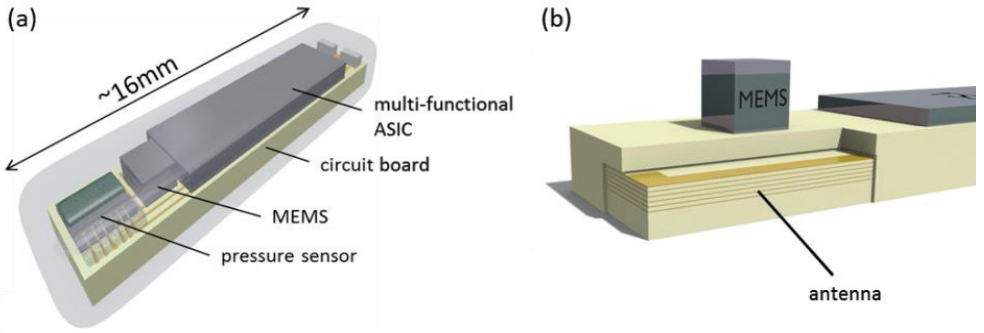

Fig. 2. (a) A highly miniaturized assembly and packaging concept of the implant that contains an integrated antenna for telemetric communication into the circuit board (b).