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# A Stretchable and Flexible Platform for Epidermal Electronics

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**Abstract:** The society is aging and therefore there is a need for new mobile and reliable health monitoring systems. An idea of such wireless, stretchable and mobile health monitoring platform has been developed. It consists of a wireless stretchable, biocompatible sensor tag placed on the skin and an RFID reader collecting and evaluating all the data, which are then shown on the display.

## Introduction

The measurement of various physiological parameters of the epidermis has been already the object of studies over 80 years ago [1]. A large number of works on solid wafer–based measurement techniques may be found in the literature, for example the use of a glucose watch was proposed [2]. Most of the described sensors never reached the market because of problems related to the robustness of the electrical contacts to the epidermis, miniaturization issues, and lack of full portability. Attributes like small size, lightweight, and biocompatibility are very hard to achieve in a single device. The most recent studies have been focusing on stretchable membranes, which may fulfill all the above-mentioned requirements (Fig. 1).

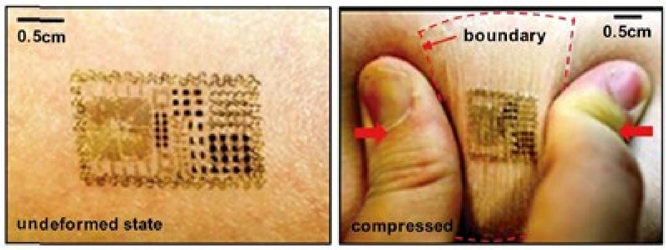


Fig. 1 Electronic epidermal system [3]

The field of electronic systems on flexible substrates has been emerging in recent years with the development of systems on foil for different functionalities such as circuits, displays and sensors. The latter include the development of sensors for temperature [4] or pressure [5]. The application range of flexible sensing systems for on-body applications range from pressure, temperature, humidity, strain, ECG sensors [3] to body movement.
Our approach aims at developing a wireless mobile sensor platform consisting of the wireless stretchable tag placed on the skin/wound, which could communicate wirelessly with the mobile device. The system should be reliable and user friendly.

## Methods

We have designed, produced and tested a wireless, stretchable and flexible health monitoring tag featuring connectivity with mobile applications. The tag contains medical sensors and an RFID antenna. It has been successfully tested with a commercial temperature sensor and an impedance-based sensor for human fibroblasts. In the following we describe each component of the development platform in detail.

### A. Stretchable wireless tag

We have built a stretchable wireless tag made up of a thin Cu layer and commercial electronic Surface Mounted Devices (SMD). The electronic circuit is encapsulated within two layers of stretchable, flexible and transparent polymers. The tag has a size of 25mm x 50mm x 5mm, and it is lightweight and biocompatible. Furthermore, it adheres to the skin by itself using van der Waals forces, so that it can be easily located onto the epidermis. The tag can accommodate various sensors and sense bio-signals from the human body. It is a passive device working only when the RFID reader is close to it and provides electrical power. The maximal distance for the power transmission is up to 50mm (Fig. 2). We tested it successfully with commercial rigid sensors as well as flexible temperature sensors developed in house. We are also working on more complex applications like wound monitoring. As a proof of concept, in order to understand the biological implications during wound healing, we focused on human fibroblast cell lines and studied the influence of external parameters on their growth behavior. We then performed in-vitro experiments on cell culture samples, measuring changes in their frequency-dependent impedance with variation in cell layer density (Fig. 3).

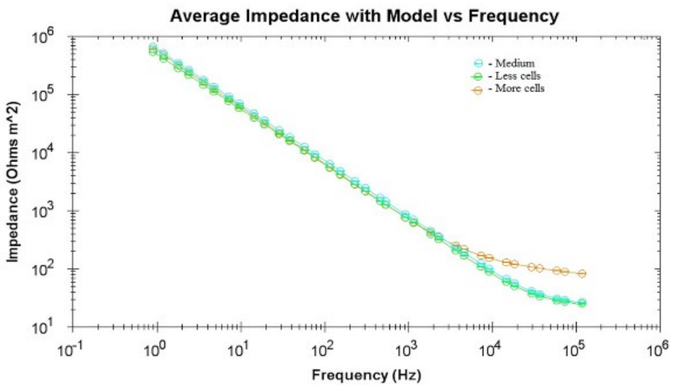


Fig. 2 Power transfer between the tag and the reader

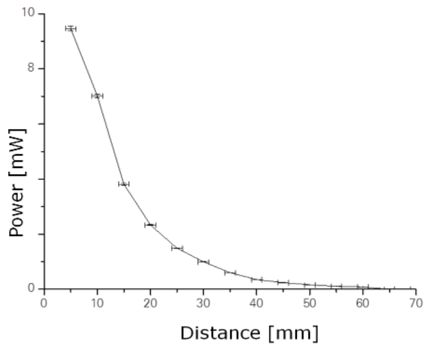


Fig. 3 The dependence between the amount of the cells and the impedance of the gold electrode – qualitative data

### B. RFID reader FOR PC

Regarding the RFID reader, we designed and built on a printed circuit board a wireless receiver working at the frequency of 13.56 MHz (Fig. 4a) and connected by cable with a computer. It can power the sensors located on the skin and collect medical signals from the tag through the wireless communication channel. The maximal sensing distance between the antenna (of size 30mm x 50mm) on the sensor tag and the receiver antenna is 30 mm. The reader collects the data, which are amplified, filtered, and, most importantly, processed for the extraction of features of interest.

### C. Applications

We developed a basic application to be operated on a PC which may recast the outputs of the signal processor in a patient-friendly way and show them on the display of the computer, as shown in Fig. 4b. The application provides also the possibility to save data, and, if necessary, to send them to the physician.

## Summary and Outlook

In summary, we have developed and built a first implementation of a wireless health monitoring stretchable sensor platform, consisting of a flexible and stretchable tag, an RFID reader and a PC-based application for data collection and further processing.


Fig. 4 (a)RFID reader for PC ; (b) PC program for the sensor platform

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