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Solidly Mounted Resonator (SMR) Sensors for Biomedical Applications †

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Abstract: Biosensors play a key role in medical diagnostics, and acoustic wave technology such as solidly mounted resonators (SMRs) applied to this field is one of the latest developments with great potential. This study seeks to explore the potential application of SMRs to detect and quantify prostate-specific antigen (PSA) for the screening and diagnosis of prostate cancer. The primary results show promising frequency shift of SMR sensors coated with Polydimethylsiloxane (PDMS) to different liquids. The SMR frequency is 1.082, 1.084 and 1.088 GHz, respectively, to air, deionized water and toluene (liquid) presence. These sensors have great potential as an accurate, low-cost method for measuring PSA and biomarkers for cancer and other diseases.

Keywords: solidly mounted resonator (SMR); biosensor; medical diagnostics; liquid biosensing

1. Introduction

Prostate cancer is the second most prevalent cancer in men worldwide. According to the UK cancer research, in the UK male population, 1 in 6 will be diagnosed by prostate cancer [1]. Annually, there are an estimated 1.6 million new cases of prostate cancer and approximately 666,000 deaths [2]. Prostate-specific antigen (PSA) is a biomarker that, when elevated, indicates a greater risk of prostate cancer. However, there is currently no screening program in place in the United Kingdom to identify patients at risk of prostate cancer [3]. There are several methods of testing the level of PSA in the blood and urine; however, there are limitations to these tests relating to the accuracy, cost and time required for each test. The theory behind using Film Bulk Acoustic Resonator (FBAR) sensors as liquid biosensors was demonstrated over a decade ago by Weber et al. in 2006. They highlight the ability of these acoustic sensors to detect changes in the mass of up to 2.3 ng/cm^2 [4].

2. Materials and Methods

The system concept uses two SMRs, one with a biological coating to detect PSA, another without as a reference, and uses the difference between the signal to calculate the mass of antigen on the surface of the coated SMR. These sensors have been used primarily for gas sensing in the Microsensors and Bioelectronics Laboratory (MBL), and therefore liquid testing is the first step in adopting this sensor for liquid biosensing. The SMR sensor is mounted on a printed circuit board PCB oscillator board based on a pierce oscillator. PDMS was chosen as a polymer coating due to its ability to detect volatile organic compound (VOC) in a gaseous state [5]. The PDMS solution was prepared by combining uncured PDMS and curing agent in a 10:1 ratio by weight. This preparation was dissolved in hexane to 3.5% w/w using 600 µL of PDMS preparation and 30 mL of hexane. The polymer mixture was solvated at room temperature for 24 h using a magnetic stirring plate.

3. Results

Initial testing was carried out using a single drop of deionized water and toluene on the sensing area of the single SMR device. The initial frequency of the SMR device after coating with PDMS was 1.082 GHz in the presence of air. This value changed to 1.084 GHz after dropping deionized water on the surface of SMR. In the presence of toluene, the frequency changed to 1.088 GHz, see Figure 1.

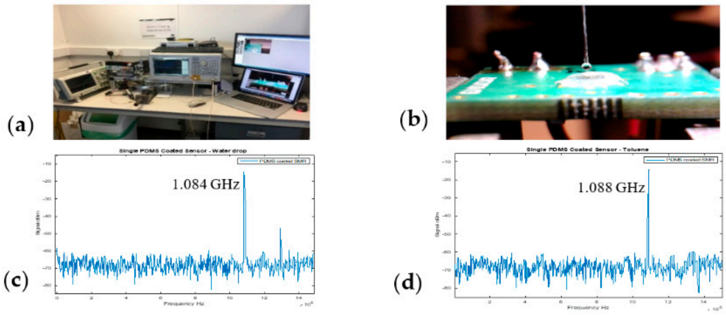

Figure 1. (**a**) Experimental setup; (**b**) typical image of dropping liquid on solidly mounted resonator (SMR) device; (**c**) response of SMR device to water; and (**d**) response of SMR device to toluene.

4. Conclusions

In this paper, we report the possibility of using SMR devices for the liquid phase and the results to indicate that the SMRs with a PDMS coating are capable of detecting changes in liquids from deionized water to toluene. The frequency shift between these two liquids is 4 MHz. Further work is required to test the system with reference and sensing SMR with different concentrations of toluene.

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Conflicts of Interest: The authors declare no conflict of interest.

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