Aptamer modified low-cost fibre optic surface plasmon resonance sensor

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We present a low-cost fibre optic surface plasmon resonance (SPR) sensor that is based on a silver coated plastic cladded silica glass fibre and can be modified with aptamers to detect various analytes.

1 Introduction

SPR is known as the gold-standard for label-free biosensors that can be used to monitor analytes via highly sensitive changes of the refractive index. However, due to their size and cost, SPR-based biosensors have only been applied in laboratory environments to date. In order to overcome this limitation we present a low-cost aptamer-modified fiber optic SPR sensor. Aptamers can be used as alternative synthetic bioreceptors exhibiting long-term stability, pH- and temperature-resistance, and cost-effective synthesis [1]. Consequently, the sensor system can be applied in the future as a robust and cost-effective sensor for in-field use.

2 Low-cost fiber optic SPR Sensor

The fiber optic SPR sensor has been realized by using a 400 µm plastic cladded silica (PCS) glass fibre and an easy-to-implement silver coating technique. First the plastic cladding of the 400 µm PCS fibre has been removed by using a razor blade and the glass fibre core has been cleaned subsequently by using acetone and distilled water. Afterwards the glass fibre core has been coated with silver by using the Tollents reagent to obtain the SPR sensor. The fabricated fibre optic sensor is shown in Fig. 1. The sensor has been interrogated by using a white light source and a StellarNet EPP2000 spectrometer. The operation of the sensor has been evaluated by using different refractive index (RI) solutions, as illustrated in Fig. 2.

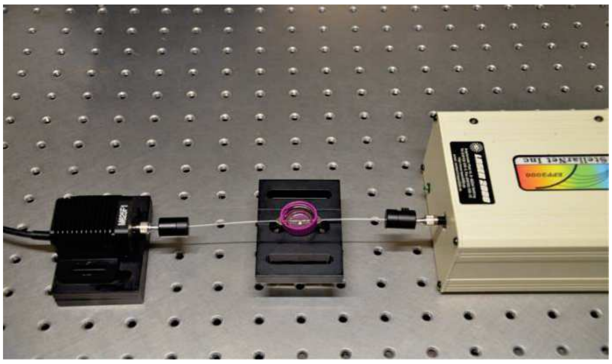

Fig. 1 *Picture of the developed SPR sensor system.*

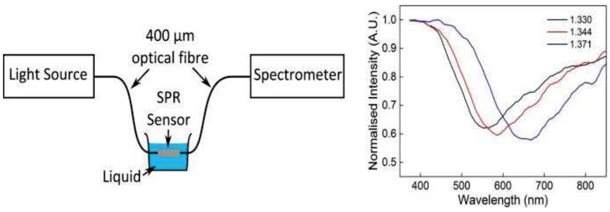

Fig. 2 *Schematic representation of the sensor system (left) and SPR sensor response to different RI solutions (right).*

3 Aptamer functionalization

In order to demonstrate the principle of operation the fibre optic SPR sensor was modified with aptamers directed against ethanolamin (EA) [2]. The principle of operation is based on target-induced dissociation (TID) of complementary oligonucleotides, an aptamer-based detection scheme that allows the detection of various targets including small molecules (Fig. 3) [3]. To facilitate immobilization of the aptamer, the silver coating of the SPR sensor was first modified with 11-mercaptoundecanoic acid. The amino-modified aptamer is immobilized on the sensor surface via 1-Ethyl-3-(3-dimethylaminopropyl)carbodiimide (EDC) coupling (red shift of the SPR, Fig. 4). Subsequently the aptamer was hybridized with an oligonucleotide complementary to the target binding site of the aptamer (increased red shift of the SPR, Fig. 5) [4]. In the presence of EA the complementary oligonucleotide is replaced by EA (blue shift of the SPR, Fig. 6) resulting in a release of the oligonucleotide. According to the measured SPR shifts the fibre optic SPR sensor allows for detection of small molecules.

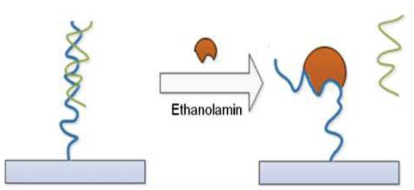

Fig. 3 *Principle of aptamer based detection (adapted from [4]).*

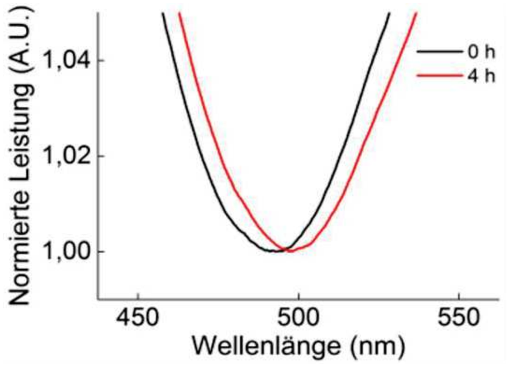

Fig. 4 *Response of the SPR: red shift due to aptamer immobilization.*

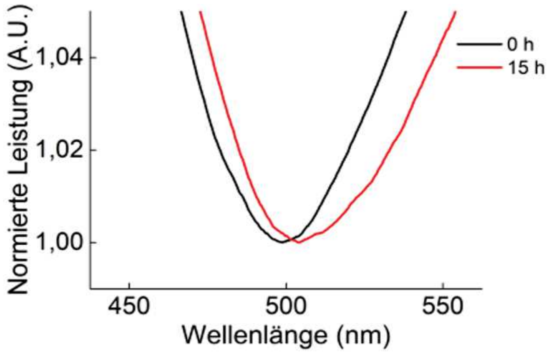

Fig. 5 *Further red shift of the SPR due to hybridization of complementary oligonucleotide.*

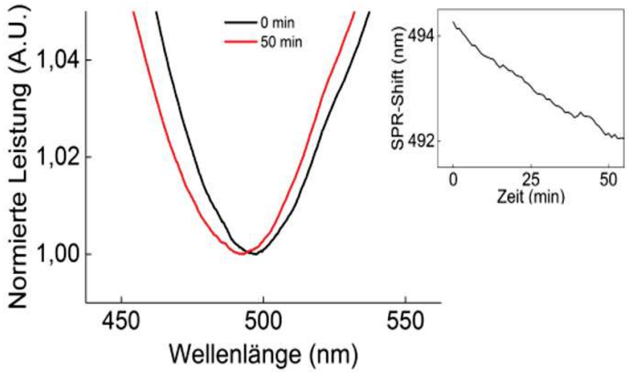

Fig. 6 *Subsequent blue shift of the SPR due to EA-induced dissociation of the oligonucleotide.*

4 Summary

A low-cost fiber optic SPR sensor has been realized by using a 400 µm PCS fibre and an easy-to-implement silver coating technique. In a model system the sensor was modified with aptamers to detect small molecules. By using other aptamers the concept can be easily transferred to detect a large variety of other analytes.

A potential application scenario could be the use of the developed SPR sensor system in combination with a smartphone. We also demonstrated in the past that the fabricated fibre optic SPR sensor can be interrogated using a conventional Huawei Ascend Y300 smartphone [5]. In the proof-of-principle study we demonstrated the use of the SPR sensor system for high sensitive refractive index sensing only (sensitivity of $5.96 \cdot 10^{-4}$ RIU/ pixel). A picture of the developed SPR sensor system for high sensitive refractive index sensing is shown in Fig. 7. Therefore, an aptamer functionalized SPR sensor in combination with a smartphone has the potential to be applied as a cost-effective sensor platform for in-field use.

Fig. 7 *SPR sensor system developed for the high sensitive refractive index sensing using a smartphone.*

References

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