African Strategy for
Fundamental and Applied Physics

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Quantum Plasmonic Sensing

This letter of interest is aimed at promoting research in plasmonic quantum biosensing. It is also aimed at encouraging more funding to this field of research. Plasmonic nanosensors have become a powerful tool for biosensing applications [1,2]. This is because they are able to overcome the limitations of conventional optical sensors in terms of sensitivity, flexibility and photostability [3]. As the field has grown new detection schemes have been developed and are being incorporated into a wide variety of biological and medical applications. The key driving force behind research in plasmonic nanosensors is the improvement of their sensitivity. Some of the strategies which are being considered in the improvement of sensitivity include sensing based on target induced local refractive index changes, colorimetric sensing based on localised surface plasmon resonance (LSPR) sensing, and the amplification of sensitivity based on nanoparticle growth [2].

While SPR-based plasmonic nanosensors are available commercially, the SPR instrumentation in use today is limited by the resolution they can achieve. Such limitations lead to problems in applications, for example in studying the drug kinematics for drugs used to treat various HIV-1 virus mutations it is important that the sensitivity be higher than currently available in commercially available SPR-based nanosensors. In order to overcome this, researchers need to look deeper into the physics of the sensor and consider more fundamental resources of optics, i.e., quantum mechanical resources [4,7].

The resolution limitations of currently available SPR-based nanosensors can be overcome by the study of the quantum nature of light. In particular, the preparation of light in the squeezed states that make use of the uncertainty principle can enhance the resolution [5,6], as well as entangled multi-photon states [7,8]. The potential enhancement in the sensing performance of plasmonic devices using quantum optical resources has been inspired by recent efforts to show that both quantum and plasmonic resonance features can be combined to give many beneficial properties [9-11].

The main goal of quantum SPR bio-sensing is to show how the use of quantum states of light in biosensing with surface plasmon resonance (SPR) gives an enhancement over using classical states. Here we focus primarily on a bio-sensing SPR setup known as the Kretschmann configuration in which surface plasmons are excited using a bulk prism and a gold coated microscope slide. The excitation is performed by means of an evanescent field arising from total internal reflection from the backside of the sensor surface.

It has been shown theoretically that using quantum states of light such as the Fock state, two mode squeezed vacuum and two-mode squeezed displaced state improve the precision in the estimation of kinetic parameters measured from the sensorgrams produced by the Kretschmann configuration [12]. In [12] a theoretical application of quantum bio-sensing was looked at in an immobilized Bovine serum albumin (BSA) interaction with anti-BSA and as well a theoretical application of quantum sensing was considered for a binding reaction between a phosphate-buffered saline (PBS) solution that contains Bovine carbonic anhydrase and its inhibitor benzene-sulfonamide.

An experimental implementation of the Kretschmann configuration with light from a single-photon source which shows an enhancement in sensitivity was also conducted [13]. The spontaneous parametric down conversion process to generate our single photons which we use to study the binding kinetics of BSA on a gold slide. Further research is necessary in quantum plasmonic sensing.

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Potential impact
Biosensors have a wide range of applications in biology, medicine and industry. They can be used in fields from fundamental biological studies to clinical diagnosis applications [1]. Related applications of biosensors include the maintenance of food safety and environmental monitoring. Research in the field of nanosensing using SPR has led to the development simple, easy-to-use measurement devices for a diverse range of biological and medical applications [2]. Healthcare is the most important area for applications. The maintenance of health is an important technological objective for science and technology, and diagnosis is an essential prerequisite for treatment and prevention of disease [2]. The integration of nanoscale ultrasensitive biosensors with other medical instruments will open the door to new and emerging medical fields, including point-of-care diagnostics and ubiquitous healthcare.

In the developing world, i.e., most African countries, including South Africa, there is a desperate need for robust diagnostics. Infectious diseases account for around a quarter of worldwide deaths. South Africa in particular is faced with diseases of poverty such as HIV/AIDS and tuberculosis, which kills millions of people each year according to the World Health Organisation.

[1] L. Guo et al, Strategies for enhancing the sensitivity of plasmonic nanosensors, ScienceDirect, 213-239 (2015).
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Primary Category

Optics & Photonics

Secondary Category

Biophysics

Subgroup categories

LightSources—DynamicAndTime-resolvedTechniques

Did you / will you submit this LOI to another category?

NO

Additional Information

NONE

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