



The Chinese University of Hong Kong

Non-confidential Abstract of Technology Disclosure

Title:

SPR (Surface Plasmon Resonance) Sensor Technologies

Inventor:

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CUHK Ref. No.:

05/ENG/189 - Optical Surface Plasmon Resonance Sensor Based on Differential Phase Interrogation and Phase Enhancement using a Fabry-Perot Cavity

05/ENG/204 - A Simple Differential Phase Imaging Surface Plasmon Resonance Sensor using Liquid Crystal Modulator

Patent Status:

Two US Patents Pending

05/ENG/189 Non-confidential abstract:

A new photonic biosensor design for detecting molecular species relevant to medical and life science disciplines has been developed. Examples of such molecules are antibody, pathogens, viruses, cells and pollutants. The commercial potential of our invention is on low-cost high throughput medical diagnostic devices.

The physical phenomenon behind the invention is called surface plasmon resonance (SPR), which can be viewed as a sheet of optically-induced energy trapped near a metallic gold surface a laser beam. Upon adhesion of target biomolecules to the gold surface, the resonance condition will change and therefore a positive identification is detected by noting a change in the optical energy reflected from the gold surface. At present a handful of SPR biosensors are available commercially as analytical equipment for studying biochemistry reaction mechanisms. They are sold at very high costs to biochemistry and medical laboratories.

Conventional SPR biosensors in the market are

single test site devices based on measuring the shift of resonance angle. In the new design, the change of optical phase associated with the SPR condition is measured. This has been proved to offer much better sensitivity.

Another important feature of the new phase-sensitive technique is the built-in capability to perform SPR measurement from a large area, which enables simultaneous data collection from multiple arrays of measurement sites. This may lead to applications similar to that targeted by fluorescent DNA chips. It is well known that the advantage of SPR is its non-involvement of any fluorescent tagging process, which significantly simplifies the preparation procedures of biomolecule species. The only drawback to date is that detection sensitivity offered by the fluorescent technique is still better in comparison to that of SPR. In this respect, the improved sensitivity and array measurement capability demonstrated from the new design will further improve the market potential of SPR biosensors.



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The present invention provides a new method of measuring optical phase information in surface plasmon resonance (SPR) sensors by using liquid crystal modulator. The operation of this SPR sensing system is based on two design principles, active phase modulation and differential phase measurement technique. In the method of the present invention, a liquid crystal modulator (LCM) is employed as a phase modulator for providing an active phase modulation, which means that we can continuously vary the polarization retardation of the input optical beam according to our requirement. The retardation modulation in term provides two independent signals from the s- and p-polarized light. Since SPR only affects the p-polarization, the phase

difference between the two signals will provide the required phase measurement. The advantages of using LCM are low cost, small size, light weight, low operation voltage, low power consumption and long life time. These advantages allow us the freedom to design compact systems for portable applications. The differential phase measurement technique also minimizes the system drift and thereby increases system performance.

Between the two signal traces, upon appropriate signal recovery processing, will provide the desired SPR phase. Since all signal traces are derived from the same optical beam our technique is a true differential phase system.

Question & Answer

Question 1: *On what specific applications has this technique been tested, and what equipment is required for the phase sensitive measurements?*

This technique has been used for measuring the salt concentration in water (for demonstrating an ultimate sensitivity limit in $\sim 10^{-8}$ regime), real-time monitoring of binding of (i) BSA antibody, (ii) H3 influenza antibody. The equipment required for building the system: personal computer with data logging head, data analysis software developed in-house, HeNe laser, liquid crystal phase modulator (may be constructed from components used in low-cost liquid crystal displays), photodetectors, piezoelectric transducer, polarizing beam splitters, common optical and electronic components.

Question 2: *What limitations are there with the phase sensitive technique over the resonance angle technique?*

The phase sensitive technique has smaller measurement dynamic range in comparison to the one that measures the resonance angle. We are currently solving this drawback by developing several techniques including optimization of sensor layer stack, use of multi-pass interferometry, and incorporation of wide angle illumination.



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Question 3: *How about improved sensitivity – can this be quantified and thereby translated into an increase in throughput rate for scanning systems?*

Until now the best sensitivity we have achieved in our laboratory is 1.9×10^{-8} refractive index unit (RIU). This is approximately 10 times better than that reported from Texas Instruments' angular SPR module, SPREETA. [Ref: T. M. Chinowsky et al, Performance of the Spreeta 2000 integrated surface plasmon resonance affinity sensor, Sensors and Actuators B: Chemical, 91(2003), 266-274.]. Our experimental sensitivity limit of BSA antibody detection is ~ 0.1 ng/ml. The main advantage of using the phase-sensitive SPR technique lies in the possibility of performing parallel detection on 2-dimensional arrays by simply capturing the interference image of the sensor surface in real-time. The angular technique requires linear detector arrays to locate the resonance angle, thereby making it much more difficult to implement SPR imaging of the sensor surface.

Question 4: *Is this a technology that would form part of a High Throughput Screening equipment, and therefore best developed in collaboration with, or licensed to industry partner?*

Because of the above reason, we anticipate that our phase-sensitive measurement approach will be readily developed into a real-time label-free bio-chip platform similar to the fluorescence-based DNA-chip available in the market. In fact, at present we have already developed a SPR phase imaging system in our laboratory for monitoring specific binding at sensor sites functionalized with BSA and H3 influenza antibodies.

For further queries, please contact:

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