UNIVERSITY OF EXETER

Phase Differential Surface Plasmon Imaging

by

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A thesis submitted in partial fulfillment for the degree of Doctor of Philosophy

in the

Engineering, Mathematics and Physical Sciences

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Submitted by Ciaran Stewart, to the University of Exeter
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in August 2010

I certify that all material in this thesis which is not my own work has been identified
and that no material has been previously been submitted and approved for the award of a
degree by this or any other University

Signature: ....

"I not only use all the brains that I have, but all that I can borrow. "

Woodrow Wilson

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Abstract

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Surface Plasmon Resonance (SPR) has been utilised in various forms in sensors for many years. It is usually based on angular or wavelength interrogation of the reflectivity minimum found with Transverse Magnetic (TM) light. However, as the SPR is traversed there is also a very rapid change in the phase of the reflected TM light there being no such change in the Transverse Electric (TE) light. Presented in the thesis a new SPR sensor has been developed that exploits this rapid change in optical phase. Linearly polarised light of mixed TM/TE polarisation is passed through a polarization modulator, which adds a small amplitude modulation to the polarisation. This modulated light is incident on a gold film 40 nm thick evaporated onto the base of a SF2 prism in the Kretschmann-Raether, configuration. The coupling of the TM polarised light to the SPR is dependant on the properties of the dielectric medium adjacent to the gold film. The SPR shifts when this sensed medium undergoes a change in refractive index (or index or thickness if it is a bound analyte layer). This in turn causes a change in the reflected elliptically polarised light. The change of the resultant modulated polarisation dither is interrogated through the use of a phase sensitive detectors. Initially a simple photo diode coupled with a lock-in amplifier was used to monitor the modulated signal. This was expanded into an imaging technique by using two cameras (64 by 64 pixels) fabricated with the equivalent of a lock-in amplifier on each of the 4096 pixels. The spatial map of the modulation amplitude gives an optical phase differential image. By imaging in this way it is possible to produce a multi channel differential sensor.

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