ESC499Y1: Thesis Proposal (modified at Interim)

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The Fabrication and Testing of a Multi-Mode Plasmonic Biosensor

A plasmon is a quantized unit of plasma vibration much like the phonon for mechanical excitations. Plasmonics is the study of these vibrations, particularly those arising from the coupling of light to free electrons in metals. An example would be the excitation of Surface Plasmon Polaritons (SPPs): by using light at the resonance frequency (matching k-vectors) any free electrons can be made to oscillate as a whole. SPPs are essentially guided surface waves (directed parallel to the metal interface) akin to light inside a fiber optic cable. This coupling of light to electrons in metals is inherently interesting since it allows for the breaking of the diffraction limit for the localization of light, thus allowing for light at higher wavelengths to resolve sub-wavelength features. Resonant excitations of SPPs known as 'Surface Plasmon Resonance' (SPR), are sensitive to variations in refractive index of the materials and as such could be very useful in bio-sensing applications.

An extremely useful feature of the SPR technique is the ability to detect extremely small variations *near* the interface: an affinity SPR sensor. This can especially be useful when dealing with bio-molecules since "concentrations of analytes of interest in biological samples are in the femtomolar-to-nanomolar range" but "time required for analysis can be impractically long". However, this can be significantly expedited by using a flow-through geometry where the analyte solution is passed over the sensing surface [1].

Strictly speaking, in using the affinity sensor one simply aims to extract information regarding a thin bio-layer (adlayer) formed whilst using the flow-through geometry. However, the information required is coupled to other extraneous factors that cannot be separated as is. This arises from the evanescent-like nature of the SPP wave and its appreciable interaction with media beyond the thin adlayer (such as the analyte solution itself). To this end a novel approach was suggested using a dielectric grating-based SPR (DGSPR). The DGSPR basically involves exciting 3 SPR modes instead of 1, hence gathering more data which could be used to decouple the useful information from the extraneous factors, consequently resulting in more accurate sensor measurements. The proposed DGSPR's design has been optimized and the finalized design simulated [2].

This thesis project will be aimed at fabricating the DGSPR design. The fabrication will be done using electron beam lithography with attention being given to proximity effect correction (PEC) [3]. PEC is done at the software end of the lithography process and using this method simple gratings, with smooth walls, may be etched onto the metallic surface. The actual etching will be done using a DRIE method (with KOH being used if required). This method will create a master mold that can be used in nano-imprint lithography to generate the modified Kretschmann configuration to couple the incident light to the metal surface [1], [2].

The project is aimed at: getting the mold to have the optimum dimensions, understanding what experimental considerations are involved in production, and coming up with ad-hoc methods of resolving the same (if needed). A working mold should allow for a working prototype which should in turn allow for the quick and easy diagnosis of a variety of diseases including AIDS (perhaps by monitoring CD40 membrane expression [4], [5]). Such a device would have great use in the diagnosis and treatment of disease in countries such as Africa and India, where testing and monitoring for disease is usually unaffordable and time consuming for the general masses.

References

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