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WAVEGUIDE SURFACE PLASMON RESONANCE SENSORS

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Guided-wave optical biosensors have great potential for use in the field of environmental monitoring. In particular, planar waveguide technologies offer the possibility of producing compact, monolithic, multisensor devices which may be connected to instrumentation using optical fibres, allowing remote operation. Optical evanescent field sensing techniques presently under investigation include grating couplers, waveguide interferometers and surface plasmon resonance (SPR) sensors. In the latter case, the surface plasmon is generally excited using a "bulk" optical component such as a prism, and equipment using this technique is now commercially available. One potential advantage of the SPR technique is that the metal film which supports the surface plasmon may also be used as an electrode for electrochemical control of sensing reactions. However, recent reports have indicated that the "bulk" SPR devices may not ultimately be as sensitive as fully guided-wave approaches such as the Mach-Zehnder interferometer [1]. An alternative to the "bulk" SPR devices which has recently emerged is the use of distributed coupling between a dielectric waveguide and the surface plasmon mode in a metal-coated waveguide [2]. This has the advantage of combining greater design flexibility and the potential for monolithic integration with the well-established technique of SPR. However, at present no adequate model for the performance of these devices exists.

In this paper we present a rigorous model for the optical power transmittance of these sensors. The model allows determination of the modulation in output power due to the adsorption of a thin organic layer onto the metal surface, which in turn leads to a measure of sensitivity. The performance of such devices requires detailed analysis of the waveguide modes supported by a metal-clad waveguide, of their excitation by an input waveguide, and of the resultant power coupled into an output waveguide. The number of modes in the structure and their complex effective indices are first numerically evaluated using the argument principle method (APM). The coupling of power from a monomode input waveguide across a step discontinuity into each mode of the metal-clad region is determined using appropriate overlap integrals. The modes are then allowed to propagate over the length of the metal-clad region, incurring losses due to the imaginary parts of their effective indices. Finally, the total power coupled from these modes into the output waveguide is determined to yield the input/output characteristic of the sensor.

This model is used to determine the change in transmitted power when a thin layer is adsorbed to the sensor surface, as a function of the waveguide and metal film parameters. The sensitivity of these devices may be optimised by adjusting the composite waveguide design, and design curves for sensors based upon glass waveguides coated with thin gold films immersed in water will be presented. Practical, sensitive, waveguide surface plasmon sensors for an aqueous environment, optimised for specific sensing films, are predicted using this design tool.

[1] W.Lukosz, *Biosensors & Bioelectronics*, **6**, 215-225, (1991).
[2] H.Kreuwel et al., *Proc. 4th Euro. Conf. Integrated Opt.*, 217-220, (1987).

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