Waveguide-Based Resonance Sensor Design

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Abstract - **We describe optical sensors based on the waveguide resonance phenomenon which allow for label-free detection of thin layers of varying refractive index. We present a design for sensor which can perform real-time analysis.**

Keywords - **Waveguide resonance, Prismatic structure, Sensor.**

I. Introduction

Nowadays, optical sensing is a very promising and powerful technology, which is finding widespread ranges of applications, such as environment, security, health. For example, the increased demand of in situ diagnostic tools requires the development of small, reliable and cheap sensing devices.

Waveguide sensor systems have been the subject of a large number of investigations over the last two decades. The concept of evanescent field sensing was initially reported by Lukosz and Tiefenthaler in 1983 [1]. While using thin, high refractive index SiO_2-TiO_2, waveguides with incoupling gratings, they discovered variations in incoupling angles due to changes in the effective refractive index of the guided modes due to variations in humidity. Subsequently, these authors proposed and demonstrated application of this observed effect toward chemical, and biochemical sensing.

II. Waveguide-based resonance sensors

The waveguide-based resonance (WR) configuration is similar to SPR's Kretschmann configuration, but differs in that WR relies on coupling of incident light through a prism with a high-index dielectric layer, rather than a metal surface, Figure 1. This replacement combines the simple structure of SPR systems with the enhanced sensitivity of waveguide structures to produce sharper resonance peaks than SPR, thereby increasing the sensitivity of the technique [2, 3].

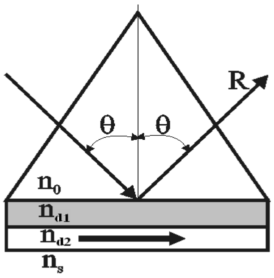

Fig.1 Structure of the waveguide-based resonance sensor

As light passes through the prism to a low-index medium, it couples with the high-index resonant layer, thereby allowing total internal reflection to occur at the boundary of the sensing layer.

Similar to SPR, resonance only occurs when the angle of the incident light and the resonant modes in the high-index layer are phase-matched, resulting in strong reflection at the output.

As an example, let us consider the waveguide sensor system that includes prism with refractive index 1.76, layers with refractive indices 1.52 and 1.38 respectively. Thickness high-refractive index layer has been selected 0.8μm, low-refractive index layer has been selected λ/(2n). Water was selected (1.33) as surround medium. The spectrum characteristic of this system is presented on fig. 1. The calculations have been provided by matrix method.

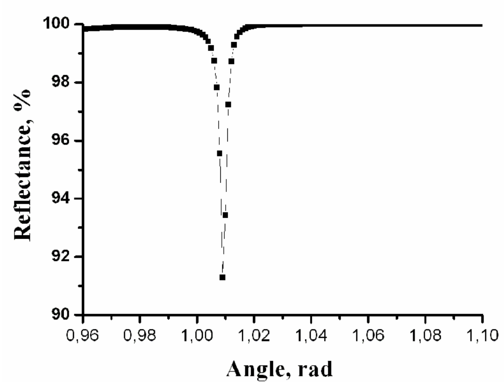

Fig. 1. Reflectance as function the angle of incidence beams on prismatic structure.

Any change in the refractive index of the surroundings at the surface corresponds to a change in the angle of light that satisfies resonance condition.

III. Conclusion

Identical to SPR, WR can be used to monitor many different molecular interactions of macromolecules and has parallel capabilities in terms of surface modifications. Due to the extreme sensitivity to small variations in the refractive index of the probed medium this prismatic structure is ideally suited for a variety of applications.

References

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