A Novel Cross-Reference Dual-Window SPR sensor based on single silica optical waveguide

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Abstract – We reported the design and development of a dual-window SPR sensor, which is based on Ge-doped Silica waveguide structure. By employing the WDM concept, a single waveguide can detect two or more kinds of samples in different ranges of wavelengths. The silica waveguides with low refractive index are good for lower SPR spectrum range in liquid. The two channels silica waveguide SPR sensors had been successfully fabricated and tested with two solutions, whose refractive indices are 1.361 and 1.418, respectively. The resultant spectrum has two resonant peaks at 626.41nm and 751.8nm, respectively.

INTRODUCTION

As the development of biochips is expecting to continuously growing with the maturation of several key technologies, the drives for integrated and portable analytical solutions are on the horizon for many applications. Integrated optics and waveguide technologies offer possible solutions for these emerging needs. Even though, surface plasmon resonance (SPR) biosensor with resonant wavelength detection based on integrated optical waveguide had been reported by J. Dost âlek et.al.[1], they typically used one sensing area for sample measurement of intensity changes or interference. The wavelength division multiplexing (WDM) concept in optical communication has not been employed in SPR sensors on single silica optical waveguide yet. By employing the WDM concept, we report the result of detecting two kinds of samples in different ranges of SPR resonant wavelengths on a single waveguide. Each area can have their own resonant wavelength in spectrum where the SPR occurred at and all sensed samples can be detected at the same time.

MATERIALS AND METHOD

The waveguide were fabricated with silica wafer whose refractive index is 1.469 and then doped with Ge by using Plasma Enhanced Chemical Vapor Deposition (PECVD) to give a refractive index around 1.492. Optimal process parameters have been acquired during pre-fabrication studies to understand the relationship between the resultant refractive index and its controlling variables, such as doped concentration, spatial variation and annealing temperature. Three types of ridge waveguides are designed and fabricated with different claimed features. In this paper, we will focus on the report of a long straight waveguide whose length is 3 cm and width is 1 cm with two opening windows (figure 1) for possible cross referencing between samples. The SPR sensing areas are formed by depositing thickness of 1nm Cr and 50nm Au on opening areas of fabricated waveguides. The effect of various window sizing is tested with 200um, 250um and 500um length of sensing area. The measurement is done by using a spectrophotometer (Ocean Optics, SD-2000) with a while light source. The schematic diagram of measurement system is shown as in the figure 2 (a) and the holder for fluidic handling is shown in figure 2 (b). The performance of these fabricated WGSPRSs is tested by using different refractive index solutions, which are prepared by mixing different glycerol and water ratio. The concentration ranges from 20%, 30%, 40%, 50% to 60% and whose measured refractive indices are 1.361 、1.376 、1.391 、1.405 and 1.418, respectively.

Results and Discussions

The two channels SPR sensors had been designed (Fig.1 a, b) and fabricated (Fig.1c) successfully in the report. The sensors had two 500um length sensing areas which for two different samples. The experimental results on one channel WGSPRSs clearly demonstrated their successes as a SPR sensor. The resonant wavelength, where SPR occurs, in different solutions can be easily observed with a spectrophotometer after spectral signal processes (figure 3a). The resultant peak position changes with the refractive index of the solutions, which is shown as in the figure 3b. The different lengths of sensing areas will have effects on the resonant loss of reflective intensity at the SPR occurred wavelengths, which results in better sensitivity and accuracy due to increasing of surface interactive area. When two different samples were dropped on the two sensing areas respectively, the output spectrum had shown the two depth peaks (see Fig. 3c). This result

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demonstrated the two-channel SPR sensors are valid and the WDM concept can be used on the multi-channel SPR sensors. The successful demonstration of two-channel WGSPRSs provides the necessary background for high throughput applications.

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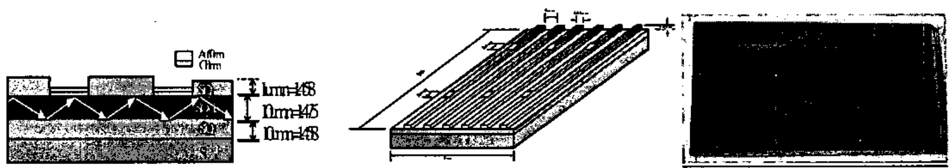

Fig. 1: The design and fabricated SPR integrated waveguide sensor

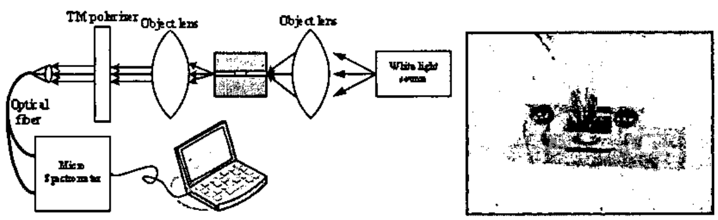

Fig. 2 (a) Schematic diagram of measurement system. (b) Sample holder.

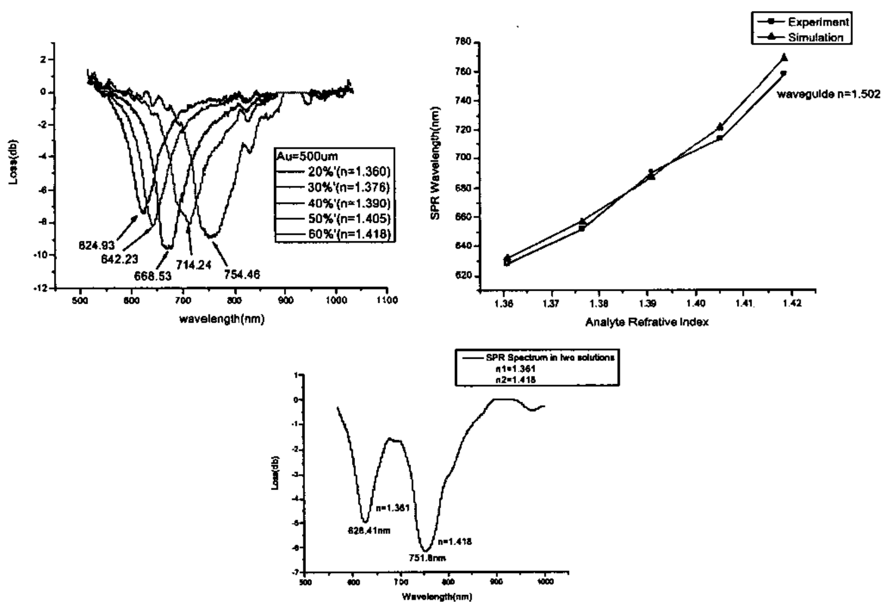

Fig. 3 (a) Resonant position changes with concentration range from 20%-60% of glycerol. (b) calibration curve of resonant wavelength vs. refractive index. (c) Dual-window SPR sensor with different refractive index of 1.361 and 1.418 results in 636.41 and 751.8 nm resonant peaks.