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# Refractive index measurement in sucrose solution and beverage using surface plasmon resonance sensor based on hetero-core structured fiber optic

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**Abstract**

The surface plasmon resonance (SPR) sensor was fabricated by depositing silver thin film on the surface of hetero-core structured fiber optic. The SPR sensor based on hetero-core structured fiber optic was applied to measure refractive index of sucrose solution and fruit juices. The sensor part was immersed in sucrose solution and/or juice and the propagating light spectra were measured. It was shown that the fiber optic SPR sensor showed a good agreement with that measured by conventional refractometer.


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*Keywords* : Hetero-core structured fiber optic ; Surface plasmon resonance ; Refractive index ; Beverage

## 1. Introduction

Sugar is one of main ingredients to give sweetness to foods and drinks. Therefore measurement of sugar content is of importance in agriculture, food and beverage industry [1]. In sugar content measurement, traditional and/or digital handheld refractometers have been used. These methods are based on refractive index measurement of the solution. Recently surface plasmon resonance (SPR) sensors have been utilized in many field such as molecular biology, chemical analysis and medical diagnosis because SPR signal is very sensitive to refractive index near the sensor surface. Especially, fiber optic SPR sensor have been studied because of simpler configuration than Kretschmann prism configuration.

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In fiber optic SPR sensors, unclad fiber optic, tapered fiber optic and U-shape fiber optic are used [2]. We have been studying hetero-core structured fiber optic and its application to chemical sensors. In this study, we investigate refractive index measurement in sucrose solution and beverages using SPR sensor based on hetero-core structured fiber optic.

## 2. Material and Methods

Fabrication of hetero-core structured fiber optic was described elsewhere [3]. In brief, a short length of singlemode fiber optic (Core 3µm/Cladding 125µm) was inserted and spliced in multimode fiber optic (Core 3µm/Cladding 125µm) by using arc fusion splicer (Fujikura Ltd, Japan). Hetero-core structured fiber optic SPR sensor (HC-SPR sensor) was fabricated as follows; Silver thin film of 40 nm thickness was deposited on the hetero-core part by utilizing vacuum deposition technique, followed by preparing self-assembled monolayer of octadecanethiol on the surface of silver thin film. The sensor was immersed in various concentration of sucrose solution and/or beverages, and the propagating light spectra were measured at room temperature.

## 3. Result and Discussion

Fig.1 shows the schematic diagram of the SPR sensor based on hetero-core structured fiber optic (HC-SPR sensor). The propagating white light in the core of the multimode fiber (MMF) leaks into the cladding of the inserted singlemode fiber (SMF) at the fusion-splicing junction because of the difference of the core diameter, resulting in the generation of cladding mode waves in the core of SMF. When the total reflection takes places at the interface of cladding/surroundings of the SMF, evanescent wave generates. When silver thin film is deposited on the surface of the SMF, it absorbs the evanescent wave, resulting in decreasing the reflection light. Therefore, the propagating loss takes place.

Figure 2 show the propagating loss spectra of theHC- SPR sensor at various sucrose concentration and the correlation between peak wavelength and sucrose concentration, respectively. According to increasing of sucrose concentration, the shift of the peak wavelength to the long wavelength side was observed. This result indicates that HC-SPR sensor could measure refractive index.

In sugar content measurement, degrees Brix (°Bx) is used as a unit traditionally. 1°Bx is 1% sucrose by mass in solution. That is, the refractive index of the solution indicating 1°Bx is same as that of value of 1 % sucrose solution. Therefore, Fig.2 indicates that HC-SPR sensor would be able to measure °Bx of beverages. Fig.3 shows the comparison between HC-SPR sensor and a conventional refractometer in measuring sucrose concentration in eleven kinds of fruit juices. X axis indicates refractometer value and Y axis indicates HC-sensor value, respectively. These date were calculated from the refractive index of the sample solutions. This result shows the good agreement between the fiber optic SPR sensor and the conventional refractometer was obtained.

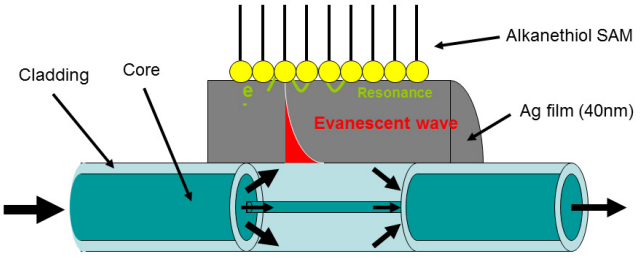

Fig.1 Schematic diagram of SPR sensor based on hetero-core structured fiber optic sensor.

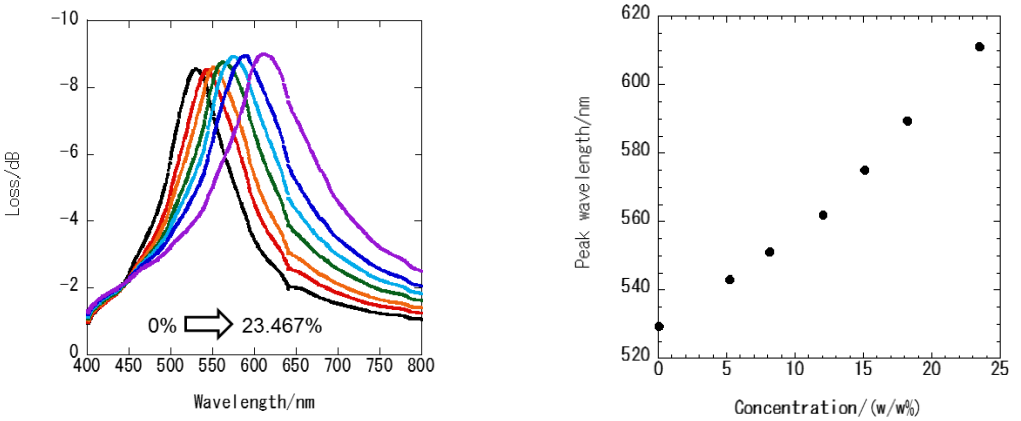


Fig.2 The propagating loss spectra of hetero-core structured fiber optic SPR sensor at various sucrose concentration (left), and the correlation between the peak wavelength and sucrose concentration (right).

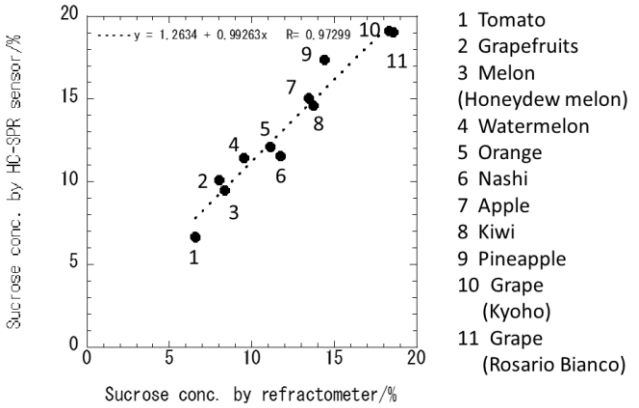


Fig.3 The comparison between the fiber optic SPR sensor and a conventional refractometer.

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