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Article / Book Information

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Title(English)	A Study on Optical Fiber Sensor Using Dielectric Multilayer Films Deposited on Optical Fiber End
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種別(和文)	論文要旨
Type(English)	Summary

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論 文 要 旨

THESIS SUMMARY

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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

In this thesis, we propose and demonstrate the high speed refractive index (RI) sensor using a Fabry-Perot cavity with distributed Bragg reflector mirrors fabricated on the fiber end surface, which serves as an optical band pass filter on fiber end (BOF). This thesis consists of 6 chapters.

In Chapter 1: "Introduction", we review the history of optical fiber sensors and survey the conventional RI sensors based on fiber optics. Then, the detailed structure of the BOF and operation principle is explained. We also overview the recent progress of the BOF-based sensors as temperature and pressure sensor.

In Chapter 2: "Design of the BOF structure", the design of BOF structure by using a given sensor specifications is proposed. We show the detailed structure of the BOF that a Fabry-Perot cavity with distributed Bragg reflector mirrors is fabricated on the fiber end surface being based on dielectric multilayer thin films. The operation principle is clarified in the simulation using the characteristic-matrix technique, as shift in its center frequency of the reflected light is studied as a function of RI. The design procedure of the BOF for a given sensor specifications is also proposed by using the simulation method. We show the three kinds of case studies about the design of BOF structure following the proposed design procedure of BOF based on the given sensor specifications.

In Chapter 3: "BOF-based refractive index (RI) sensor", we experimentally demonstrate a novel fiber-optic RI sensor based on BOF. We make the actual BOF structure based on the design results of the first case study to confirm the appropriateness for the design method. We experimentally show that the center frequency of the reflected light spectrum changes in proportion to the RI of six kinds of liquids attached to the fiber end. Its coefficient of +0.62 nm/RIU (refractive index unit) agreed well with the design results. We also showed that this sensor is applicable to the RI measurement of two kinds of solids. In addition, we compare the experimental results with the designed result and the user requirement. It shows that the experimental result is in good agreement with the design result and satisfies the user requirement.

In Chapter 4: "High speed RI measurement with BOF-based sensor", we enhance its measurement speed by use of a high-speed demodulator where the optical wavelength information is converted into electrical voltage using the linear slopes of the reflection spectra. The response time of the sensor, which is influenced by the dynamic behavior of the sample liquid, is found to be as short as several tens of micro-seconds. We also compare its RI sensitivity with that of a simple Fresnel-based RI sensor. We also

confirm the minimum required volume for RI measurement as small as 0.03μl, which cover the whole sensing area of BOF surface.

In Chapter 5: “BOF-based ultrasonic (US) sensor”, we propose the BOF-based US sensor for mega-hertz ultrasonic-wave detection in water. We demonstrate a trial to apply the BOF-based sensor to mega-hertz ultrasonic-wave detection in water. Ultrasonic waves at 1.56 MHz are experimentally detected with a good SNR. The sensitivity of the sensor at this frequency is 3.43×10^{-4} MPa^{-1}. This value implies that the stress induced by ultrasonic waves to the BOF has significant contribution to the ultrasonic sensitivity of the BOF. We also experimentally investigate the distance response and the directional response of the BOF.

In Chapter 6: “Conclusion”, we summarize this study and present the future study.

In this study, we propose the design procedure of BOF structure to satisfy the user’s requirements based on the given sensor specifications and experimentally demonstrate a novel fiber-optic RI sensor based on BOF. In addition, we enhance the measurement speed as short as several tens of micro-seconds and confirm the minimum required volume for RI measurement as small as 0.03μl. Finally, we apply the BOF based US sensor for mega-hertz ultrasonic-wave detection in water and verify its sensitivity and directivity.

This BOF has a lot of advantages when it is used as refractive index as follows: high spatial resolution, high speed measurement, high sensitivity and applicability not only liquids but to solids. As a result, we expect that the RI sensing based on BOF can overcome the drawbacks of conventional RI sensors. We believe this BOF-based sensor will be of great use in wide range of biochemical, chemical, and engineering applications in the future.