論文 / 著書情報
Article / Book Information

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Title(English)	Proposal and performance improvement of slope-assisted Brillouin optical correlation-domain reflectometry
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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 ）

Distributed strain and temperature sensing based on Brillouin scattering in optical fibers has been gathering a lot of attention for several decades as a promising technique for structural health monitoring of civil infrastructures, such as buildings, bridges, dams, and railways. To date, a variety of methods have been implemented to acquire the information on Brillouin gain spectrum (BGS) distributions, from which the magnitude and position of strain (or temperature change) can be derived. Among them, Brillouin optical correlation-domain reflectometry (BOCDR) has been extensively studied since it is the only scheme with single-end accessibility and high spatial resolution. However, one of the important drawbacks of standard BOCDR is its limited sampling rate due to the necessity of acquiring the whole BGS to obtain the Brillouin frequency shift (BFS) values (corresponding to strain and temperature).

In this thesis, to overcome this drawback and to achieve real-time distributed measurements with intrinsic single-end accessibility, a new configuration of BOCDR assisted by the slope of the BGS—named slope-assisted (SA-) BOCDR—is proposed. Then, some experiments are performed to clarify its detailed operation and to improve its performance from a variety of aspects, such as stability, sensitivity, strain dynamic range, and robustness. Finally, as a first step toward practical applications, some pseudo-field tests are conducted using a silica-fiber-embedded composite structure.

Chapter 1: "Introduction" overviews the background of optical fibers and optical fiber sensors and then explains the principle of Brillouin scattering for sensing applications. In addition, conventional Brillouin-based fiber-optic distributed sensors are briefly reviewed. The purpose of this thesis is also presented including the necessity of high-speed BOCDR.

Chapter 2: "Proposal of slope-assisted (SA-) BOCDR" states the principle of SA-BOCDR. Instead of observing the whole BGS, this system detects the spectral power at a certain frequency on the BGS, which leads to a higher sampling rate. Furthermore, unlike standard (frequency-based) BOCDR, newly developed SA-BOCDR can provide loss distribution along the sensing fiber, because it operates based on power information. The basic operation of the system is verified through simultaneous distributed measurement of strain, temperature, and loss with a high sampling rate.

Chapter 3: "Characterization" presents the detailed operation of SA-BOCDR with some unique features. After investigating the system output of SA-BOCDR both theoretically and experimentally, a "beyond-nominal-resolution" effect is well clarified, which enables us to detect hotspots even shorter than the nominal spatial resolution. Then, using this effect, shortest-ever strained and heated sections along silica and polymer optical fibers are detected. Subsequently, the sensitivity dependencies on experimental conditions such as the incident power and spatial resolution are clarified. Finally, a long-distance measurement with a >10-km range is also demonstrated.

Chapter 4: "Performance improvement" provides the experimental results for the enhancement of stability, sensitivity, strain dynamic range, and robustness. First, by using trench-index-type low-loss fibers, loss-insensitive operation is demonstrated. Subsequently, using polarization-maintaining fibers, distributed measurements with high sensitivity and stability are also demonstrated with no need of polarization scrambling. The strain dynamic range is then enhanced by investigating its trade-off relation to the spatial resolution. Polymer optical fibers are finally employed to enhance the robustness of the system.

Chapter 5: "Pseudo-field test" shows the practical usefulness of SA-BOCDR by presenting an example of structural health monitoring using a composite structure. As a specimen, a carbon-fiber-reinforced-plastic strengthened steel plate is prepared, in which a standard silica fiber is embedded. Then, distributed strain measurements are performed while tensile and compressive strains are applied to the embedded sensing fiber using a three-point bending device. The obtained results moderately agree with the theoretical trends. Subsequently, similar experiments are carried out by applying larger strains until the sensing fiber is broken. As a result, it is shown that SA-BOCDR can indirectly predict the peeling of the composite structures by detecting the breakage of the embedded fiber.

Chapter 6: "Conclusions" summarizes each Chapter of this thesis and provides concluding remarks by discussing which of the two configurations, standard BOCDR or SA-BOCDR, should be used in practical situations.

備考 ： 論文要旨は、和文 2000 字と英文 300 語を 1 部ずつ提出するか、もしくは英文 800 語を 1 部提出してください。
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