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APPLICATION BOOK

OSI-S

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CONTENTS

OSI-S Distributed Optical Fiber Sensing Instrument

Description

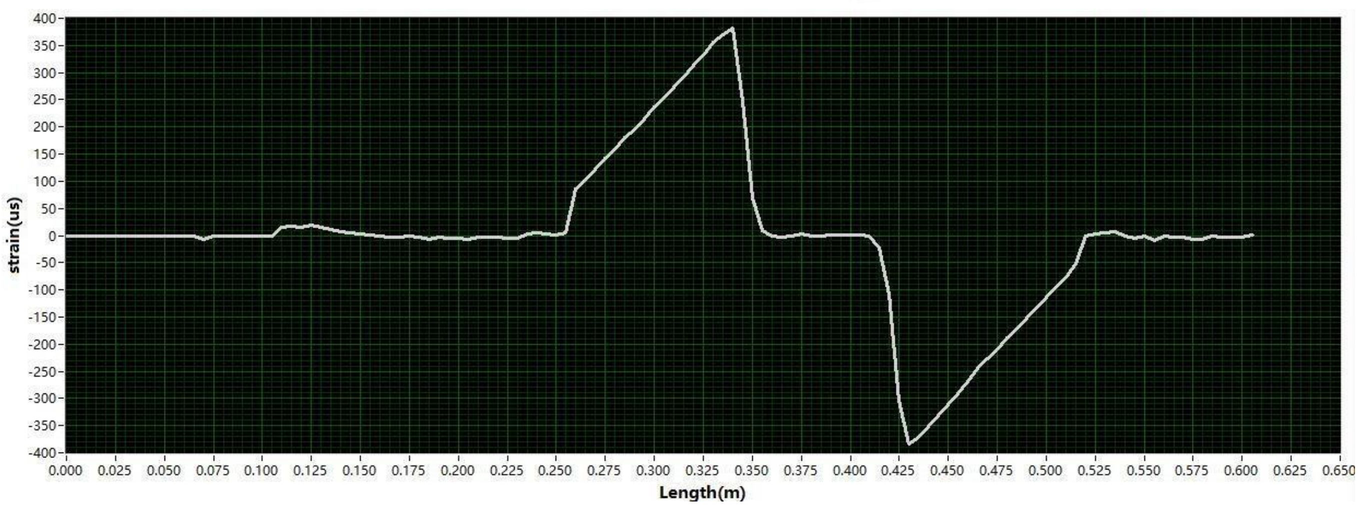
The Semicon OSI-S is an ultra-high distributed optical fiber sensing instrument. The principle is optical frequency domain reflection (OFDR). Its spatial resolution is 1mm in 50m sensing range and 1cm in 100m sensing range. The measuring accuracy of OSI-S is ±0.1℃ or ±1.0 micro strain. OSI-S can simultaneously measure more than thousands of sensing points along a single fiber. Therefore, OSI-S is an excellent tool in high resolution and high accuracy sensing application fields.

Features

- Distributed temperature and strain measurement
- Sensing range: 20m, 50m, 100m
- Supply customized service
- Sensing spatial resolution: 1mm
- Sensing accuracy: ±0.1℃ / ±1.0$\mu\varepsilon$
- 2D/3D shape sensing

Applications

- Aircraft: composite material fatigue testing
- Civil & Construction Engineering: SHM
- Power Industry: transformer temperature and strain monitoring



Products

System				
Sensing range[1]	20	50	100	m
Spatial resolution[2]	1		10	mm
Acquisition Rate[3]	4			Hz
Strain				
Strain accuracy[4]	±1.0			μ ε
Strain range[5]	±15000			μ ε
Temperature				
Temperature accuracy[4]	±0.1			℃
Temperature range[5]	-200-1200			℃
Interface				
Power	220/110V			AC
Communication interface	USB			-
Fiber connector	FC/APC			-
Size	410x375x146.5			mm
Weight	15			KG

Note:

1. For longer sensing length, please connect our sales team.
2. 1mm spatial resolution is available for all measurement range. If 1mm spatial resolution is set, the temperature and strain range would be reduced. Centimeter-level resolution is available.
3. For 0.5m measurement length with 1cm spatial resolution.
4. For 1cm spatial resolution and below 50m sensing length.
5. Based on the material properties of the sensing fiber. Acrylate is used in 0~100℃, Polymide is used in -50~300℃ and Au coated fiber can be used in -200~700℃.

Tunnel Surrounding Rock Deformation Monitoring

During the excavation process of geotechnical engineering, the interaction between internal rock and peripheral rock, deformation and instability of surrounding rock are all important factors affecting construction effect and safety. In a geo-mechanical model test, a shallow-buried, large-diameter and circular tunnel excavation using cross rock pillar method, the distributed optical fiber sensing technology is used to carry out continuous strain monitoring of different sections of the whole model to analyze the deformation and stability of surrounding rock.

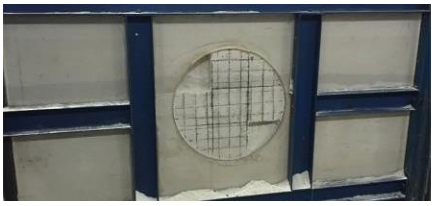


Figure 1 Experimental sand model

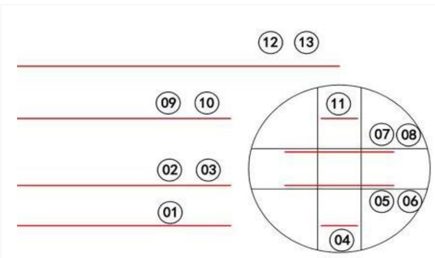


Figure 2 Layouts of optical fiber

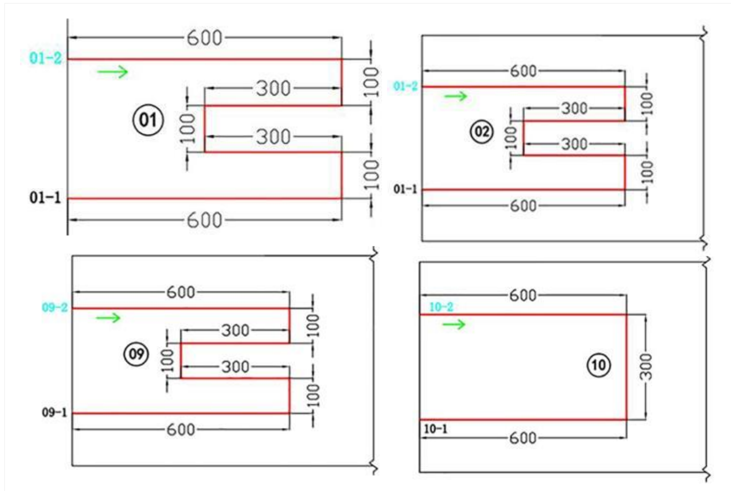


Figure 3
Sectional views of layouts of No.1、2、9 and 10 optical fiber

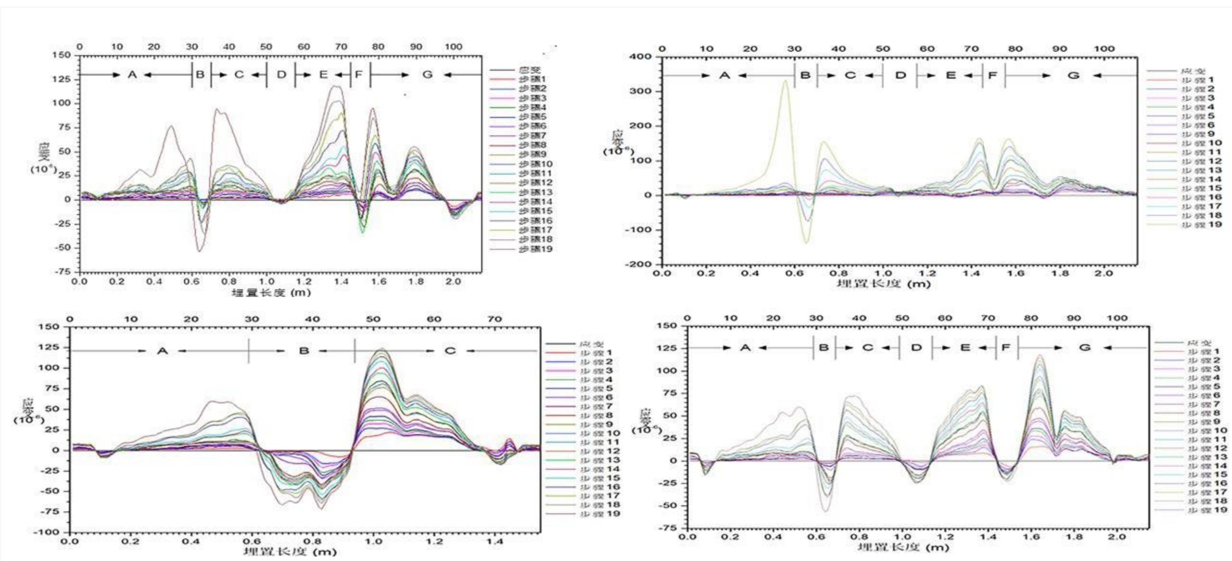


Figure 4 Test results of optical fibers

All fibers are mainly laid in the coating around the tunnel to be dug (Fig. 2, Fig. 3) and measured by OCI-1500. The test results of four sensing fibers of 01, 02, 09, and 10 are extracted (Fig. 4): the distribution of different fibers in the same position is basically the same in the process of increasing strain; the strain distribution trend measured by a single fiber, and the distance between fibers and tunnel are also closely related. The results confirmed that the sensing system has a good reflection of the strain distribution of the sand around the tunnel during the excavation process.

Crack Measurement On Concrete Beam

During the use of the bridge, due to adverse effects such as environmental load, fatigue effect, material aging and corrosion, etc., its structure will inevitably cause damage and cracks, resulting in a series of safety hazards.

Therefore, to accurately position the cracks and analyse the deformation law of cracks under load are important for comprehensive assessment of the safety of bridge structures. In a concrete beam load test, the OCI1500 measurement system was used to study the deformation law of crack under different loads.

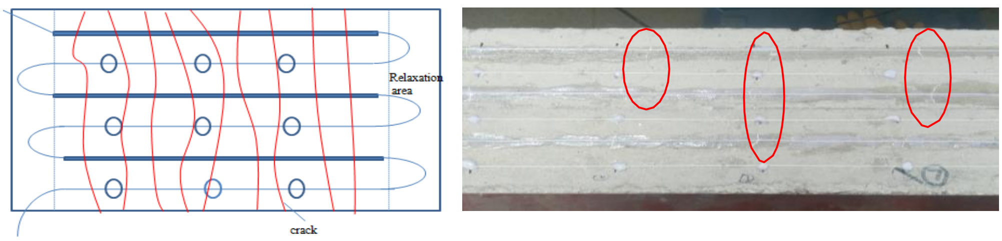
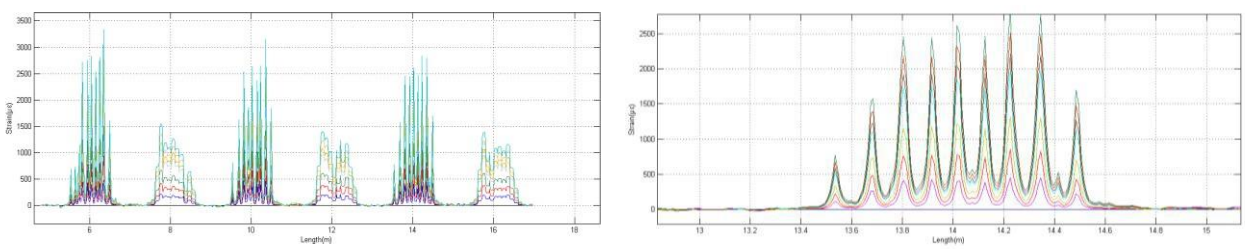


Figure 1 Fiber layout on the test beam

The fiber used in the test was a common tight-fitting fiber, which was glued to the surface of the test beam and a total of 6 channels were laid. Three of them are dispensed by glue, three of them are entirely fixed by glue and on the each side is a fiber relaxation zone (Fig.1). The load is applied upwardly from the central position below the test beam. 7 different loads were set and measured by OCI1500 for the strain of the test beam.

Figure 2 Test beam

Figure 3 shows the test results of the strain at each point of the test beam under different loads. The position of the 6-channel sensing fiber is clearly reflected in the figure. The three sections with larger strain are fully-glued fixed fibers and the three sections with smaller strain are dispensed fixed fibers. Under different loads, the nine peaks appearing at the same position of each fully-glued fixed fiber correspond to the crack on the beam. As the load increases, the peak value increases, indicating that the crack continues to extend.



（a） （b）

Fig. 3 Strain measurement results of test beams at different loads under different loads (a) and details of crack location (b)

Pipe Clay Soil Deformation Monitoring

In the pipe clay soil deformation monitoring test, cohesive soil was added to the test box, four sensing fibers were buried and finally the box was left for three months to form a test model.

Figure 1 Formed test model

In the test, the jack applies thrust to the central clods step by step, and a displacement gauge is placed on one side of the clod to measure the displacement of the clods, and the strain is measured by Semicon OSI-S.

The measurement result of one of the optical fibers is shown in the figure below:

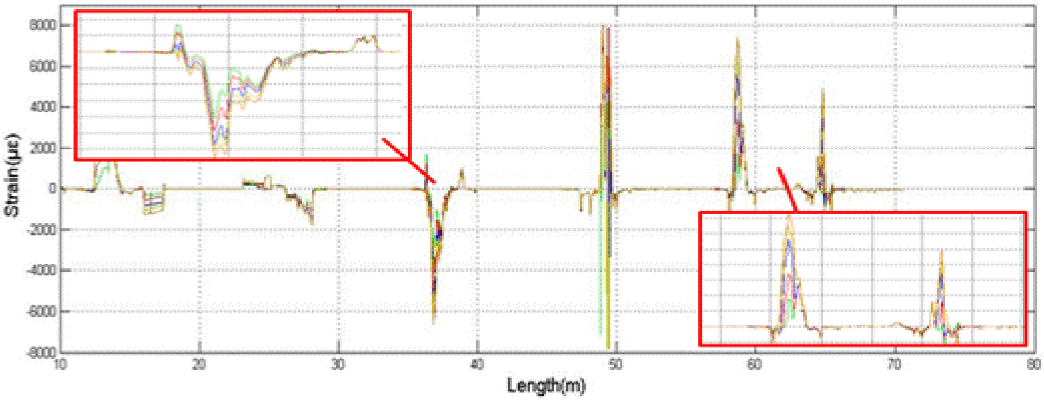


Figure 2 Measurement results

At each stage of loading, the strain distribution measured by the fiber is basically the same. The strain at different positions is related to the strained condition of the soil. The thrust law of the pipe soil under the state of horizontal displacement can be explored according to the real measured value.

Measurement Of Cantilever Strain By OFDR Technology

The length and width of the cantilever beam are 30 cm and 5 cm. Polyimide coated optical fibers are laid on the cantilever beam. OSI-S is used to measure the distributed strain. Optical fibers are laid along the upper and lower surfaces of the cantilever beam, as shown in Figure 1.

In the process of the experiment, 10, 20, 50, 70, 100, 150, 200 g weights were used to load the cantilever beams from light to heavy, then from heavy to light.

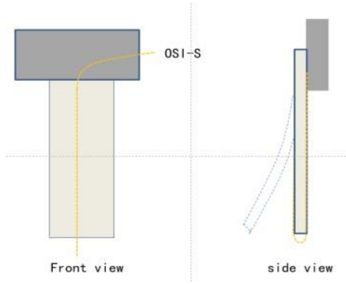
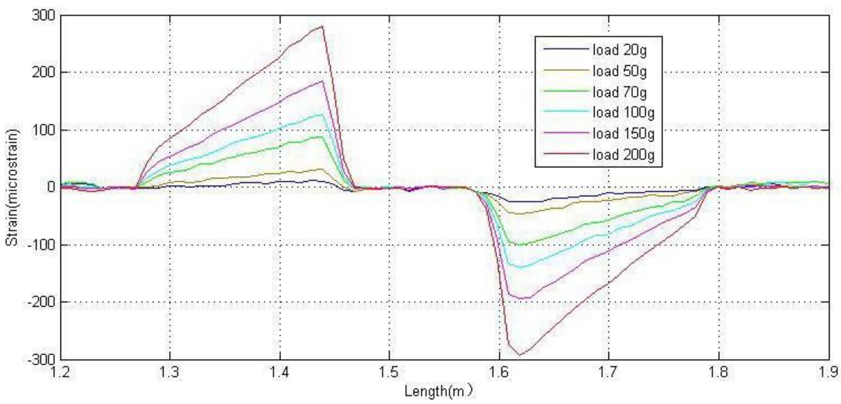


Figure 1 Fiber layout in the cantilever beam

Fig. 2 shows the strain distribution of the cantilever beam under different loads which detected by OSI-S. It can be seen that the strains at each point of the cantilever beam are linearly distributed, and the distance-strain curves are symmetrically distributed at the junction of the upper and lower surfaces. As the loads increasing, the curve becomes smoother, which is mainly due to the decrease of residual stress and the improvement of measurement stability.



Figures 2 Distance-strain curve

Figure 3 and Table1 are the measurements of the strain at the maximum deformation of the cantilever beam in the experiments. From the tables and figures, it can be seen that the maximum strain of the cantilever beam is linearly related to the external loads. The fitting value is R2=0.9998.

The deviation of single measurement at the same position is very small, which shows that the equipment has great repeatability and high measurement stability.

load/g	First relative deviation /%	Second relative deviation /%
20	0.0293	0.3797
50	0.0099	0.7173
70	0.0116	0.7704
100	0.0106	0.0236
150	0.0004	0.4225
200	0.0028	0.0837

Table 1 Relative deviation

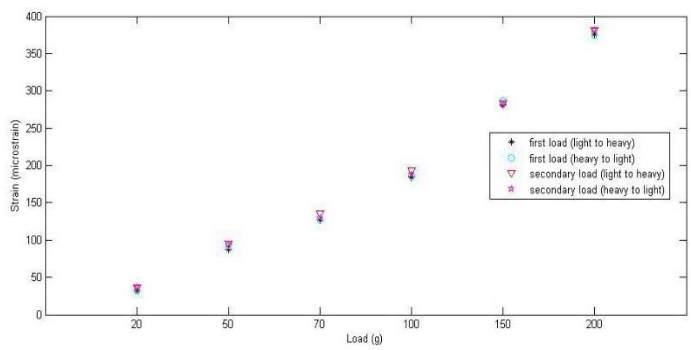


Figure 3 Maximum strain at cantilever beam under different loads

Strain Measurement On Steel Girder Trusses

As a truss with high strength, uniform material and easy installation, steel girder truss is often used as the main load-bearing structure for industrial engineering and civil buildings, such as roofs, bridges and pylons. Due to the long-term load, the deformation of the truss beam will directly affect its fatigue life and ultimately affect the stability of the civil structure. Therefore, under the load conditions, the study of the deformation law of steel girder truss is very important.

The OFDR technique was used to measure the strain of the steel truss. The test steel girder truss is made up of two trusses and has a length of 4 m. Each truss is made up of equilateral angle steel. Polyimide fiber and ETFE tightly-packed fiber are laid on one of the trusses, as shown in Figure 1. Polyimide fibers were attached to the positions 1, 2, 3, 4, and 5, and ETFE tightly-packed fibers were attached to the 6th, 7th, and 8th positions for a total of 8 segments. Each segment of fiber is approximately 30 cm in length. The load is applied to the entire steel truss beam by the load-bearing beam. The strain of the steel truss beam is measured by OSI-S under each load and the spatial resolution is 1 cm.

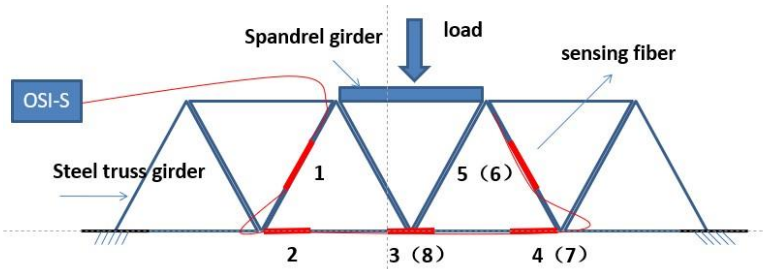


Figure 1 Fiber layout on the truss girder


Figure 2 Steel truss girder

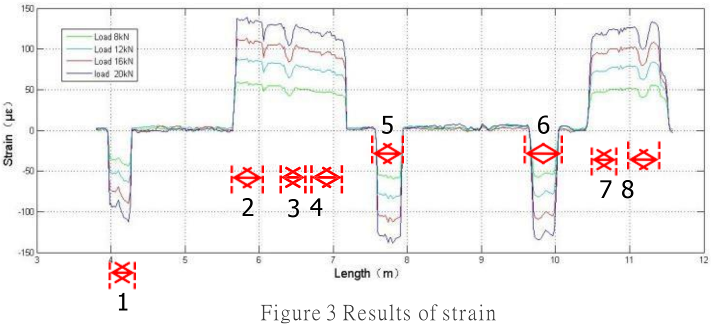


Figure 3 Results of strain

The strain measurement results of the steel truss under each load are shown in Figure 3. Under different loads, the strain distribution on the truss is basically the same. The inclined truss beams (1, 5, 6) bear compressive stress, the transverse truss beams (2, 3, 4, 7, 8) bear tensile stress and the strain distribution of segment 1 and segment 5(or 6) is symmetrical.

As the load increases, the strain at each position increases. The measurement results of different optical fibers at the same position are basically the same, indicating that both of the polyimide fiber and the ETFE tightly-packed fiber can perform very good strain measurement.

Metal Embedded Optical Fiber Temperature Measurement

In machinery, aerospace, electric power and other industries, the need of metal surface temperature monitoring is very common, such as power cable lines, high temperature steam pipes and so on. Through temperature monitoring, other physical quantities marked by temperature could be analyzed.

Figure 1 shows the temperature test using the constant temperature oil bath pot. Temperature measurement is carried out by OCI1500 and the layout of optical fiber is embedded type. Nine temperature test points are set.

Figure 1
Oil bath pot with a pure copper sample in it.

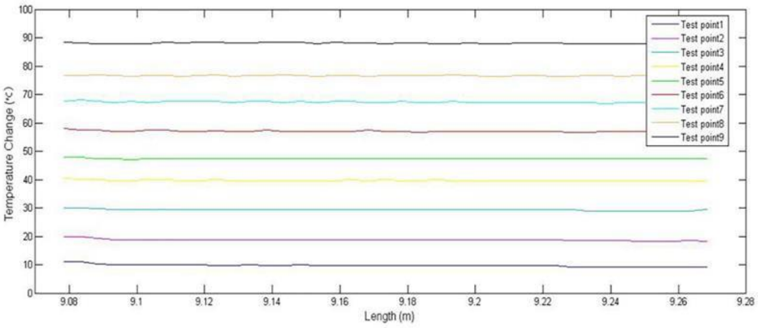


Figure 2
Measurement result of OCI1500

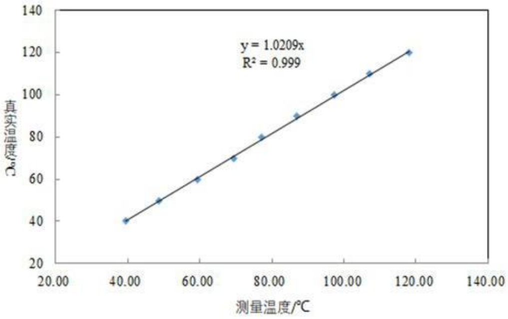


Figure 3 Temperature fitting curve

Temperature /℃	40.2	49.8	59.7	69.6	79.8	89.9	99.7	109.6	119.7
Relative deviation / %	0.6456	0.1363	1.3749	2.0471	1.1500	1.2377	0.4624	0.7353	0.6264

Table 4 Measurement deviation

The result that temperature fluctuations are small along the optical fiber during measurement indicates the effectiveness and rationality of embedded optical fiber measurement. The maximum relative deviation between average of each measured temperature and actual temperature is less than 2%(Figure 2、3、4).The measurement system is of high stability and the accuracy can reach ±0.1℃ .

Temperature Accuracy Experiment Of OFDR

OSI-S is an ultra-high distributed optical fiber sensing instrument. The principle is optical frequency domain reflection (OFDR). It has the characters of high spatial resolution and high accuracy. The measuring accuracy of OSI-S is ±0.1℃ or ±1.0 micro strain. We design experiments to verify the accuracy of the device's measurement temperature.

Sensing optical fiber is 20m which was placed in an oil bath. The initial temperature of the oil bath was set to 30℃. Set temperature to 30.1℃ and 30.3℃ and wait for the temperature of the oil bath to be stable , Then measure the temperature of sensing fibers by OSI-S. The result is shown in figure 1.

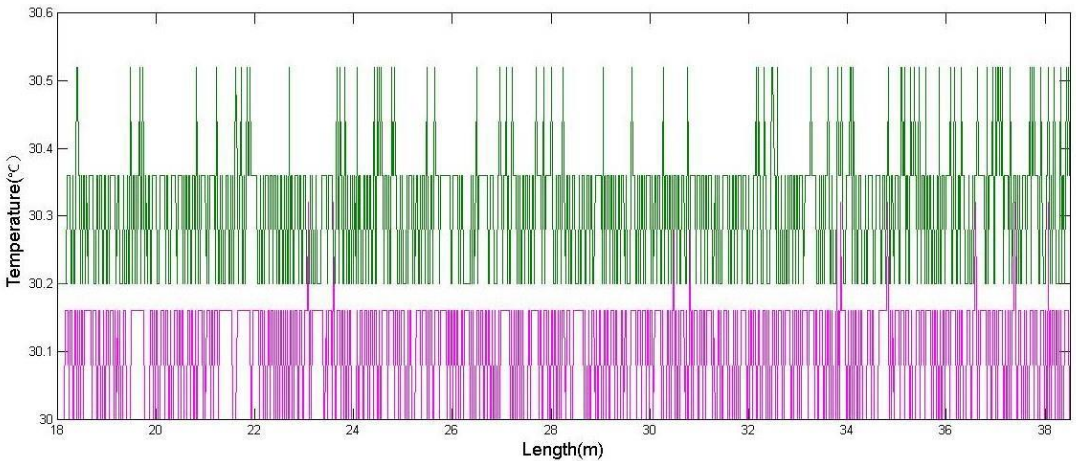


Figure 1 Result of temperature

The red line is the result of the temperature distribution of the sensing optical fiber when the oil bath temperature is 30.1℃. The green line is the result of the temperature distribution of the sensing optical fiber. When the oil bath temperature is 30.3℃.

When the actual temperature is 30.1℃, the temperature of the sensing optical fiber fluctuates between 30.0℃ and 30.3℃, the average is 30.11℃. When the actual temperature is 30.3℃, the measured temperature fluctuates between 30.2℃ and 30.5℃, the average is 30.32℃. The above results show that OSI-S has high accuracy of temperature measurement. With many times of measurement and verification, the accuracy of OSI-S temperature measurement can reach ±0.1℃.

Automotive Structural Testing

Before the design of the automobile structure is finalized, a comprehensive safety test should be carried out to examine whether there are structural defects in the driving process that cause major damage to the vehicle body and directly threaten the personal safety of the passenger. In the extreme cases of emergency braking and collision, OSI-S is used to measure the strength and strain of the door frame of vehicle, and to anlyzse the rationality and safety of the structure of door frame.

The fiber is laid along the front and rear door frames, as shown in FIG. 1.

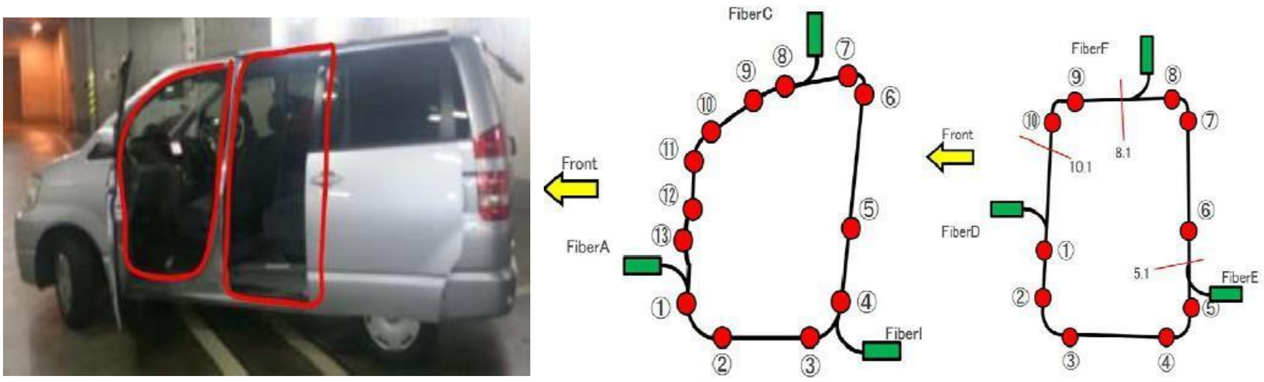


Figure 1 Fiber layout on the test beam

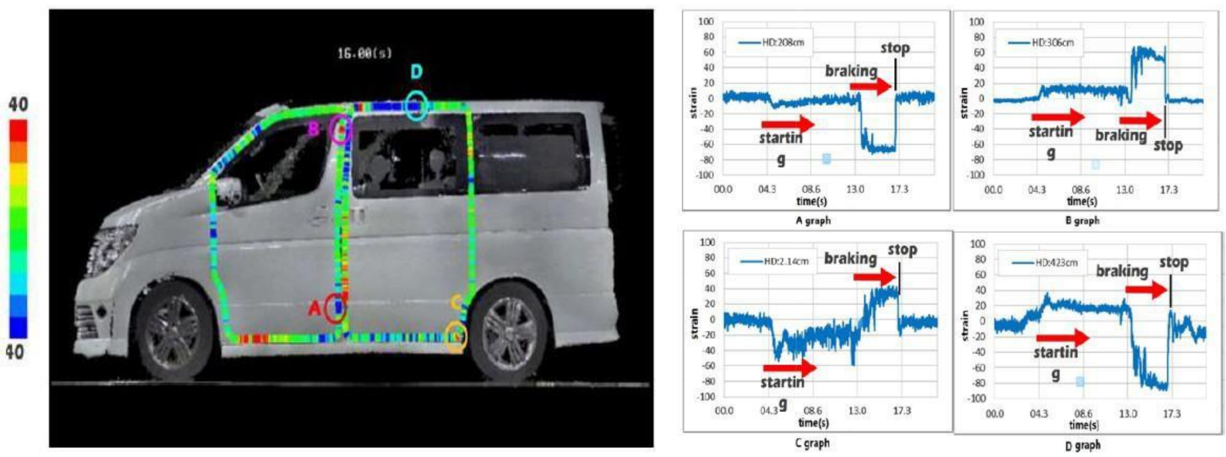


Figure 2 braking test results

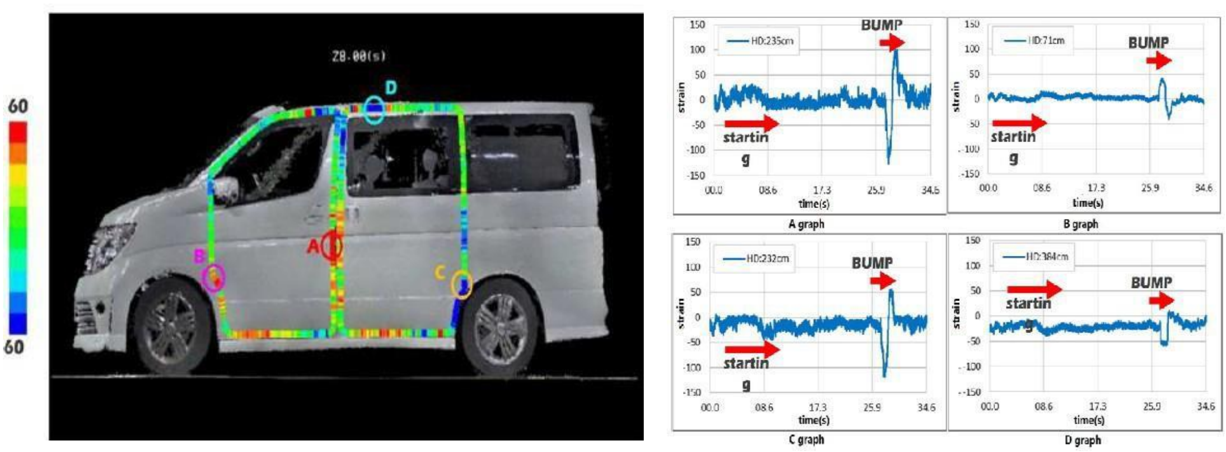


Figure 3 Collision test results

Applictions

During the whole driving process, the measurement system promptly and accurately monitoring the reaction of the door frame of each strain point.

Continuous actions such as braking, collision, and stop correspond to the strain abrupt points in the test chart one by one; in the normal driving state, the strain value of door frame returns to zero.

Multiple measurements show that the OSI-S performs very well, the structure of door frame has high stability and the design is reasonable.

ETSC Technologies Europe

ETSC Technologies Europe is a professional Photonics solution provider established in Louvain-la-Neuve since 2014.

We design and manufacture wide range of optoelectronic devices for scientific research and industrial applications in the fields of optical fiber communication and fiber sensing and also supply first-class products sourced from leading companies around the globe.

Distributeur « Solutions & Services »:
ENERFAST SARL
24 rue Jean Duplessis
78150 Le Chesnay
France
jmgrippon@gmail.com
T: +33 (0)673704959

Contact Us

Tel: +32 472 611 456
E-mail: sales@etsc-tech.be
Add: Business And Research Offices Center (BAROC) , Parc scientifique Fleming, rue Laid Burniat 3, B-1348 Louvain-la-Neuve, Belgium