Fiber Bragg Grating Sensor Technology and Products for Subsea Applications

NAGANO KEIKI
Subsea EXPO 2017
Content

• Corporate Overview
• Fiber Bragg Grating Sensor Technology and Products for Subsea Applications
Founded 1896
First Asian Pressure Gauge Factory

400+ Mio $ Revenues*
2,140 Employees*

No.1 Global Share in Pressure Gauge

Conversion rate $ 1 = \ 100 (31.03.2014)
Performance and Core Businesses (FY 2013)

- Measurement devices: 12%
- Pressure sensors: 25%
- Automotive: 10%
- Other: 10%

Revenue Mio $ (FY 2011 – 2013)

- 2011: 395
- 2012: 367
- 2013: 408

- Pressure gauges: 53%
NAGANO KEIKI Global Network

- Baesweiler (Germany)
- Dresden* (Germany)
- Al Jubail* (Saudi Arabia)
- Gandhinagar* (Gujarat, India)
- Suzhou (China)
- Sunnyvale (CA, U.S.)
- Stratford (CT, U.S.)
- Maracaibo* (Venezuela)
- Mexico City (Mexico)
- Sao Paulo (Brazil)

Key facilities (Nagano, Japan)

- Ueda measurement Instrument Plant
- Maruko Electronic Instrument Plant
- NKS Technical Solutions Center

*Joint ventures
Global Standard Products and Services

ISO9001 • ISO/TS16949 • ISO14001 certificated

International MRA certificated, providing Global Standard Calibration Service

GC15
Precision digital pressure gauge

PD66
Dead weight tester
Innovations for Customer’s Safety and Success

- Explosion proof
- High accuracy & stability
- EMC / EMI
- Ultra high pressure

FA / Industrial Machines

Power Plant / Process

Energy Saving / HVAC

Semiconductor Process

Water Supply / Plant Factory

Food / Medical Care

Aerospace / Aircraft / Ships

Automotive / Rails / Machinery
Content

• Corporate Overview

• Fiber Bragg Grating Sensor Technology and Products for Subsea Applications
Basic Principle of FBG Sensor

Grating pitch = Wavelength of reflected light

When grating pitch changes due to strain / temperature change, reflected light (wavelength) changes depending on a grating pitch
Basic Principle of Wavelength Change

- **Grating pitch**
- **Stretch**
- **Shrink**

FBG reflected wavelength

- Wide wavelength
  - **Wavelength**

- Narrow Wavelength
  - **Wavelength**
Expanding Applications of FBG Sensing

**Transport**
- Strain
- Vibration
- Acceleration

**Social Infrastructures**
- Strain
- Vibration
- Acceleration
- Displacement
- Inclinations

**Composite Materials**
- Strain
- Delamination

**Equipment Diagnosis & Maintenance**
- Strain
- Pressure
- Temperature
- Air Escape (crack)
- Corrosion
FBG Sensing - Advantages

Safety

- No electricity at the sensor: Perfect explosion proof.
- Not affected by lightning: No replacement, long life.

Functionality

- Long distance sensing (several km – dozens of km)
- Multi-sensing in a single fiber: Temperature / Pressure / Strain / Acceleration / etc.

Immunity/Durability

- Not affected by electromagnetic wave: Can be used in a strong electromagnetic field
- Operable at high temperature
**FBG Data Logger** PF 20

**Specifications**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling Frequency</td>
<td>1kHz</td>
</tr>
<tr>
<td>Wavelength Range</td>
<td>1530-1560nm</td>
</tr>
<tr>
<td>Wavelength Stability</td>
<td>&lt;±15pm</td>
</tr>
<tr>
<td>Wavelength Repeatability</td>
<td>&lt;±3pm</td>
</tr>
<tr>
<td>Interface</td>
<td>LAN</td>
</tr>
<tr>
<td>Size</td>
<td>242 (W)×214 (D)×90 (H)mm</td>
</tr>
<tr>
<td>Operation Temperature</td>
<td>-10～50℃</td>
</tr>
<tr>
<td>Power</td>
<td>100～240VAC, 7W</td>
</tr>
</tbody>
</table>

**For Ship Installation**
- Compact
- Stand-alone Data Storage
- High Reliability

- Max 128 FBG Sensors (with 16ch multiplexer)
- High Speed Sampling (1kHz)
- Data can be stored in SD card
- Easy to operate (Touch Panel)
- Timer Function
- Network Connection
- Reasonable Price
FBG Data Logger

Sensor Installation/ Maintenance Support Functions: Install Navi

*Conversion formula for each sensor is stored in attached SD

FBG wavelength/physical value can be instantly measured by connecting the sensor.
Example of measurement system configuration

Measuring data acquisition
- Tablet-type device
  - SD card
  - Wi-Fi

Network utilization
- PC
- Network server
- Router
- PF20 FBG data logger
  - PF30 Optical multiplexer
    - Several sensor can be installed in one fiber. Each sensor performs measurement independently.
    - Strain sensor
    - Displacement sensor
    - Accelerometer
    - Level sensor

Several fibers can be connected in parallel in one system
Tanker Measurement

**FBG Data Logger**

Improve cost performance of your system

Vibration and stress measurement of the vessel

Accelerometer

Strain Sensor

Accelerometer

Stern

Hull

Stem
Other Applications
(Industrial Measurement, Infrastructure Maintenance.)

- **Infrastructure monitoring**
  - Solar battery
  - SD card
  - Tablet-type device
  - Office

- **Natural disaster monitoring**
  - FBG Displacement sensor
  - FBG Inclinometer sensor
  - FBG Rain gauge

- **Monitoring in power-generating plant**
  - Office
  - Generator
  - Optical cable

- **Monitoring of tank status**
  - Factory, office etc.
  - Optical cable
  - Dangerous place
  - PF20
  - FBG Level sensor
  - Temperature sensor
FBG Acceleration Sensor (High Range)

<table>
<thead>
<tr>
<th>Product Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurement Range</td>
</tr>
<tr>
<td>Frequency Range</td>
</tr>
<tr>
<td>Shock Resistance</td>
</tr>
<tr>
<td>Operating Temperature</td>
</tr>
<tr>
<td>Dimensions</td>
</tr>
<tr>
<td>Weight</td>
</tr>
</tbody>
</table>

Electromagnetic Compatibility (EMC) Electric Insulation

- Electromagnetic-resistance, lightning-resistance, explosion-proof, and electrical insulation.
- High-voltage (25kV) usage
- Strong electrical insulation between sensor and measurement equipment

Installed on the pantograph of inspection train
FBG Acceleration Sensor (Low Range)

- **Measurement Range**: ±1 G
- **Frequency Range**: 0–150 Hz
- **Shock Resistance**: 1,000 G
- **Operating Temperature**: −20–60 °C
- **Dimensions**: 80 × 50 × 35 mm
- **Weight**: About 1kg

**Long-term Reliability**
**Long-Distance Transmission**
**Lightning Resistance, Noise Resistance**

**Monitoring of high-way viaduct**

- Monitoring of traffic vibrations
- Strong noise resistance – On-vehicle wireless
  Strong electromagnetic field
Strain Sensor (Long Gauge)

Long-term Reliability
Long-Distance Transmission
Lightning Resistance
Multi-point Measurement

Maintenance of concrete bridges

- Installation labor-saving by series connection and multi-point simultaneous measurement
- Direct fixing on the concrete surface by anchor bolts.
- Monitoring strain or crack (occurrence and development) on the structure.
- Monitoring of number of passing vehicles, weight, and speed

<table>
<thead>
<tr>
<th>Product Specification</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurement Range</td>
<td>±2500 μ strain</td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>-20 – 60 °C</td>
</tr>
<tr>
<td>Dimensions</td>
<td>350 × 70 × 35 mm</td>
</tr>
<tr>
<td>Weight</td>
<td>About 1kg</td>
</tr>
</tbody>
</table>
FBG Water Level Sensor (Immersion Type)

<table>
<thead>
<tr>
<th>Product Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurement Range</td>
</tr>
<tr>
<td>Measurement Accuracy</td>
</tr>
<tr>
<td>Operating Temperature</td>
</tr>
<tr>
<td>Dimensions</td>
</tr>
<tr>
<td>Weight</td>
</tr>
<tr>
<td>Material</td>
</tr>
</tbody>
</table>

Lightning Resistance  
No Power Feeding  
Multi-point Measurement

- No lightning protection necessary, and not damaged by lightning or induced lightning.
- Monitoring of land conservation infrastructure like rivers, dams, soil-erosion barriers, and coasts.
- Liquid level in a tank, water or sewerage level monitoring
- Monitoring of river dikes.

Monitoring of river dikes (Image)
Displacement Sensor (Rod Type)

- Installed 8 FBG displacement sensors for 5,260m tunnel in Shanghai, China.
- Continuous monitoring of the joint deviation.

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<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Measurement Range</td>
<td>0−50 mm</td>
</tr>
<tr>
<td>Measurement Accuracy</td>
<td>±0.5 %F.S.</td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>−20 − 60 °C</td>
</tr>
<tr>
<td>Dimensions</td>
<td>370 × 75 × 35 mm</td>
</tr>
<tr>
<td>Weight</td>
<td>About 1kg</td>
</tr>
</tbody>
</table>

Multi-point, Long-term Stability
Long Distance Transmission
No Power Feeding
FGB Tilt Sensor

Long-term Stability
Long-Distance Transmission
No Power Feeding
Lightning Resistance

- No lightning protection necessary, and no power feeding.
- Monitor culvert shape change because of land subsidence
- Continuous monitoring for 5 months.

Product Specification

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurement Range</td>
<td>±3 °</td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>−20 − 60 °C</td>
</tr>
<tr>
<td>Dimensions</td>
<td>130 × 90 × 50 mm</td>
</tr>
<tr>
<td>Weight</td>
<td>About 1kg</td>
</tr>
</tbody>
</table>
We provide reliable sensor technology

- Surface strain of engine / transmission / etc.
- Pressure / Temperature / Vibration / Strain inside engine room / metal mold / etc.
- Vibration / Inclination monitoring
- Strain of steel / plastic / composite component

FBG Sensing Technology

- **Harsh environment**
  (high temperature / strong electronic field / explosion proof)
- Multi-point
- Long distance

Very useful in subsea applications!
Thank you for your attention!

FOR THE FUTURE
WITH SENSING TECHNOLOGY

NAGANO KEIKI