OZ Optics Limited

Your solution provider for existing and next generation fiber optic components and test equipment…

- Commenced operations in 1985
- Corporate headquarters and manufacturing in Ottawa
- Manufacturing in Ottawa/Canada, Izmir/Turkey and Jiaxing/China
- Over 250 employees – 140 in Ottawa, 60 in Turkey, and 50 in China
OZ Optics Limited

Your solution provider for existing and next generation fiber optic components and test equipment…

- Seven Product Groups
  - Laser-to-Fiber Delivery Systems
  - High Power Fiber Optic Components
  - Polarization Maintaining Products
  - Attenuators
  - Opto-Electronic Packaging
  - Test Equipment
  - Fiber Optic Sensor Systems

- Over 1,000 products
- Deep and broad patent portfolio
- Robust new product development program
- ISO 9001:2008 Certified
**Management Team**

*OZ Optics is lead by an experienced team:*

- **Ömür Sezerman, Chairman, President & CEO**
  - Founder and CEO since inception (25 years)
- **Garland Best, VP of Components Division**
  - 19 years at OZ Optics
- **Gordon Youle, VP of Test Equipment Division**
  - 12 years at OZ Optics
- **Metin Sezerman, General Manager of OZ Turkey**
  - 10 years at OZ Optics
- **Bing Li, General Manager of OZ Optics China**
  - 5 years at OZ Optics
Using our strong direct sales force and distribution network, we address the following markets:

- Telecom/Datacom
- Oil & Gas
- Military & Homeland Security
- Medical & Pharmaceutical
- Industrial
- Educational
Why We Win Business

• Superior Technology
• Innovative Engineering
• Extensive experience in fiber optics (over 25 years)
• Competitive Pricing
• Exceptional Quality & Service
• Global Presence
OZ Optics has resellers and distributors in over 30 Countries and regions including:

- Australia
- Austria
- Benelux Countries
- Brazil
- Canada
- China
- Czech Republic
- Denmark
- France
- Germany
- Greece
- Hong Kong
- India
- Ireland
- Israel
- Italy
- Japan
- Norway
- Poland
- Portugal
- Singapore
- South Korea
- Spain
- Switzerland
- Sweden
- Taiwan
- Turkey
- United Kingdom
- United States

…sold to over 10,000 customers globally!
Manufacturing Strategy

- Product Design and Engineering in Ottawa
- Subcomponent Parts Manufactured in China and Turkey
- Final Assembly and Quality Assurance in Ottawa
- Components Sourced World-Wide
- Ensure Highest Quality and Lowest Cost
In-house Production Capabilities

• Experienced (over 25 years), well-trained staff
  – Optical, mechanical, electronic & software
• State-of-the-art machine shop – CNC Machines
• Thin Film Coating Facility
• Environmental Test Chambers
• Clean Room Facilities
Facilities

• Ottawa:
  • 60,000 sq. ft - Manufacturing and R&D Facilities
  • 14,000 sq. ft - Sales, Marketing and G&A
  • 15,000 sq. ft - Training, and Fitness Facility

• Izmir, Turkey:
  • 33,000 sq ft Manufacturing Facility
  • Located in a Free Trade Zone
  • Cost-Effective Manufacturing
  • High Quality Labour Pool
  • Very Low Tax Rates

• Jiaxing, China:
  • Over 20,000 sq ft
  • Low Cost Manufacturing

• Sales Offices in Georgia, California and Florida
OZ Optics – Turkey Campus
OZ China JiaXing Campus

- ZHEJIANG OZ OPTICS TECHNOLOGIES CO., LTD China, Jiaxing 314033, 289 Mu Yang Road, Jiaxing Economic Development Zone
- 2000 Square Meters of Manufacture Area
- 100 Square Meters of Clean Room – Class 1000
- 100 Square Meters of ESD Working Area
Industry Standards

• ISO 9001:2008 Certified
• Controlled Goods Directorate Registered
• Telecordia Compliance
• CE Compliance
• RoHS Compliance
Technology

We have accumulated over 25 years of corporate knowledge and experience in the field of fiber optic components and test equipment

- Numerous patents granted and filed
- Advanced proprietary processes
- Extensive library of proven and tested designs
  - Optical, mechanical, electronic & software
Technology

• OZ Optics was the first to manufacture:
  • PM Fiber Connectors & Components
  • Visual Fiber Optic Fault Locators
  • Fiber Optic Patchcords With Attenuating Fiber
    - Reduces costs and complexity
    - Eliminates fixed female to male attenuators
  • In-line Power Monitors Based on Innovative Optical Taps With Integrated Photodiodes
  • Wireless Diagnostic Equipment for Monitoring of Optical Fibers
    - Fault Finder and Smart Patchcords
  • Fiber Optic Distributed Strain and Temperature Sensors
    - Sensitive detection of corrosion in large structures
    - Fast and simultaneous measurement of strain and temperature
    - Combined sensor technology and web monitoring
Technology

- Pioneer in Polarization Maintaining (PM) Components
- Leader in Wavelength Flattened, High Power & Low PDL Components
- Leader in High Power Fiber Optic Delivery Systems
- Custom Test Equipment, Including Polarization Test Equipment and FTTH Equipment
- Widest Range in Attenuator Product Offering
- Fiber Optic Distributed Strain and Temperature Sensors for highly accurate and rapid measurement of strain and temperature
- Complete product line for OCT applications
Conventional Temperature & Strain Sensors

- **Temperature sensor:** thermocouple
- **Strain sensor:** electrical strain gauge
  - Temperature influence
  - Electromagnetic interference (EMI)
  - Humidity influence
  - Point sensor
Fiber Optic Sensors

• **Advantage of Fiber Optic Sensors**
  – Electrically insulating materials (no electric cables are required)
    — high voltage environments
  – Chemically passive, not subject e.g. to corrosion
  – Immune to electromagnetic interference (EMI)
  – Wide operation temperature range

• **Fiber Bragg Grating Sensor**
  – Strain resolution and accuracy: < 2 με
  – Cannot distinguish strain and temperature
  – Point sensor

• **Distributed Fiber Optic Sensors**
  – Raman scattering based — only temperature
  – Brillouin scattering based — both temperature and strain
Fiber Optic Sensors

- **Fiber Bragg Grating Sensor**
  - Sensor medium: Fiber Bragg grating
  - Laser source and data acquisition system: Spectrum analyzer

- **Distributed Fiber Optic Sensors (Brillouin Sensors)**
  - Sensor medium: Conventional communication fiber (SMF, LEAF)
  - Laser source and data acquisition system: Brillouin sensor system
    - **OZ Optics [Foresight™ DSTS (Distributed Strain and Temperature Sensors)]**
    - Omnisens (STA)
    - Yokogawa (AQ8603)
    - Sensornet (DTSS)
    - Neubrex (Neubrescope)
Comparison of BOTDR and BOTDA

BOTDR (Brillouin Optical Time Domain Reflector)

- Probe Laser
- Pulse Modulator
- Reference
- Heterodyne Receiver
- Digital Processor
- Weak signal
- $v_0 \rightarrow CW$
- $v_0 \rightarrow CW$
- $10^3$ photons
- at most 1 photon
- Brillouin scattered light
- $v_0 \pm v_B(v'_B)$

BOTDA (Brillouin Optical Time Domain Analyzer)

- Probe Laser
- Pulse Modulator
- Heterodyne Receiver
- Digital Processor
- High dynamic range
- $v_0 + v_B(v'_B) \rightarrow CW$
- $v_0 + v_B(v'_B) \rightarrow CW$
- $10^3$ photons
- Coherent amplification
- Brillouin scattered light
- $v_0 + v_B(v'_B)$
Working Principle — BOTDA

Sensor medium: standard telecom optical fiber

When the beat frequency $\nu$ matches intrinsic Brillouin frequency of the fiber $\nu_B$, we will get maximum of Brillouin spectrum.

$\nu_B$ changes linearly with the strain and temperature exerted.

$\nu_B = \nu_{B0} + C_T(T - T_0) + C_\varepsilon(\varepsilon - \varepsilon_0)$

Brillouin Spectrum
Working Principle — BOTDA

$T$ and $\varepsilon$ are variables; to differentiate these two variables, we need Brillouin peaks in the spectrum.
OZ Optics Foresight™ DSTS

Block diagram of DSTS

- Laser 1
- EOM
- Pulse Driver
- Data Acquisition System
- Photodetector
- Phase-Locked Loop
- Pump
- Isolator
- Polarization Controller
- Variable Attenuator

Real product

BOTDA

Circulator

Photo-detector

Sensing fiber

www.ozoptics.com
Foresight™ DSTS Wins Silver Award

Silver Level Winner

was issued on June 13, 2007 in the Best of Sensors Expo 2007 which was held in Rosemount, Illinois, USA
Foresight™ DSTS Wins Frost & Sullivan Award

FROST & SULLIVAN

2009 BEST PRACTICES AWARD

NORTH AMERICAN FIBER-OPTICS BASED STRUCTURAL HEALTH MONITORING SYSTEMS TECHNOLOGY INNOVATION AWARD
Foresight™ DSTS

Has Been Granted
USA Patents#:
7499151 on March 3, 2009
and
7599047 on October 6, 2009
Merits of OZ Optics Foresight™ DSTS

• Coherent amplification of Brillouin scattering signal ⇒ longest measured range (100km round-trip)
• Narrowest Brillouin spectrum (∼ 45MHz ) ⇒ highest resolution of strain and temperature
• OZ Optics special low loss fiber components and electronic processing ⇒ high stability of system
• With proprietary techniques, Brillouin frequency is extracted accurately ⇒ highest accuracy in measuring strain and temperature separately or simultaneously
• New technology ⇒ quick measurement of strain and temperature (as low as 1 second)
Competitive Analysis

• **OZ Optics Foresight™ DSTS**
  - Spatial resolution/accuracy: 10cm/5cm
  - Strain/Temperature accuracy: $\pm 2\mu\varepsilon/0.1^\circ C$
  - Strain/Temperature resolution: $0.1\mu\varepsilon/0.005^\circ C$

• **Omnisens (BOTDR/A)**
  - Spatial resolution/accuracy: 50cm/10cm
  - Strain/Temperature resolution: $2\mu\varepsilon/0.1^\circ C$
  - Strain/Temperature accuracy: $\pm 30\mu\varepsilon/NA$

• **Sensornet (BOTDR)**
  - Spatial resolution/accuracy: 1m/NA
  - Strain/Temperature resolution: $20\mu\varepsilon/1^\circ C$
  - Strain/Temperature accuracy: NA

• **Yokogawa (BOTDR)**
  - Spatial resolution/accuracy: 1m/5cm
  - Strain/Temperature resolution: $1\mu\varepsilon/NA$
  - Strain/Temperature accuracy: $\pm 100\mu\varepsilon/1^\circ C$

• **Neubrex (BOTDA)**
  - Spatial resolution/accuracy: 10cm/5cm
  - Strain/Temperature resolution: NA
  - Strain/Temperature accuracy: $\pm 25\mu\varepsilon/1^\circ C$

• **Frequency uncertainty**
  - Foresight: 5kHz $\Rightarrow$ Strain/Temperature resolution: $0.1\mu\varepsilon/0.005^\circ C$
  - Others: 100 kHz $\Rightarrow$ Strain/Temperature resolution: $2\mu\varepsilon/0.1^\circ C$
# Comparison between OZ Foresight™ DSTS and Raman based instruments

<table>
<thead>
<tr>
<th></th>
<th>Raman based</th>
<th>OZ Foresight™ DSTS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Maximum distance</strong></td>
<td>20 km</td>
<td>100 km round-trip (physical distance 50 km)</td>
</tr>
<tr>
<td><strong>Fiber Type</strong></td>
<td>Multimode</td>
<td>Single mode standard telecom</td>
</tr>
<tr>
<td><strong>Response time @ 20km, 2C</strong></td>
<td>More than 10 minutes</td>
<td>2 Seconds</td>
</tr>
<tr>
<td><strong>Configuration</strong></td>
<td>Single end</td>
<td>Loop / double end, single end is also available</td>
</tr>
<tr>
<td><strong>Measurement base and accuracy</strong></td>
<td>Intensity based, require calibrations, sensitive to changes in attenuation</td>
<td>Frequency based, after setup, no calibrations required, not sensitive to changes in attenuation</td>
</tr>
<tr>
<td><strong>Dynamic range</strong></td>
<td>3-4 dB, may fail to measure when attenuation increases</td>
<td>25-30 dB, allows better immunity to attenuation, wider measurement range and longer use of installed fiber</td>
</tr>
<tr>
<td><strong>Measurement types</strong></td>
<td>Temperature only</td>
<td>Temperature and strain</td>
</tr>
<tr>
<td><strong>Measurement resolutions</strong></td>
<td>Comparable @ over 10 minutes</td>
<td>Comparable @ several seconds</td>
</tr>
</tbody>
</table>
Competitive Analysis

Omnisens, 18”x11”x20”

Yokogawa, 18”x10”x20”

Neubrex, 18”x11”x20”

Sensornet

Foresight_F

Foresight_R

Feature Highlights:
- High spatial resolution: 10cm
- High measurement accuracy
- Strain: ±250 με
- Temperature: ±1 °C
Merits of OZ Optics Foresight™ DSTS

- Real-time fault point detection
Merits of OZ Optics Foresight™ DSTS

- The only one with very sensitive feature
Quick measurement (2 second for 80km)
Quick measurement (2 second for 80km)
High accurate measurement in 5 minutes for 100km
High accurate measurement in 5 minutes for 80km
High accurate measurement in 5 minutes for 80km
Simultaneously measure strain and temperature
Friendly GUI
Friendly GUI
OZ Optics Foresight™ DSTS Benefits

Total System Solution Provides:

• Reduced operating expenses
  – Centralized monitoring

• Reduced danger of catastrophic failure
  – Real-time continuous monitoring
  – Corrosion and leak detection
  – Crack detection

• Optimized field engineering resources
  – Automated dispatch with GPS coordinates
OZ Optics Foresight™ DSTS Features

• Patent pending sensing cable for both communications and simultaneous measurement of temperature and strain
• Real-time fault point detection
• Rapid strain and/or temperature detection
• Yield high resolution data along the entire fiber length
• High spatial resolution
• High temperature and strain resolution
• High temperature and strain accuracy
• Up to 100 km round-trip sensing range
Applications

- Oil and Gas Pipeline Monitoring
- Dam Monitoring
- Oil and Gas Well Monitoring
- Bridge and Building Monitoring
- Power Line Monitoring
- Border Security Monitoring
Metal/Polyimide Coated Hermetic Fibers

Coating materials and maximum sustainable temperatures

- UV-cured acrylate: 100°C
- UV-cured dual acrylate: 150°C
- Polyimide: 400°C
- Copper+polyimide: 400°C
- Aluminum: 450°C
- Copper alloy: 600°C
- Gold: 700+°C
Polyimide Jacketed Loop Back Fiber Probe
Polyimide Jacketed Armor Cabled Fiber Probe
High Voltage Underground Cable with Fiber
Brillouin Sensor Monitoring of Telecom Fibers

- Detects minor events that are too small to be seen by OTDRs.
- Can replace OTDRs for monitoring fibers.
- OZ Optics’ BOTDA includes OTDR capability.
- Can be used to monitor new or existing fiber installations.
- Permits performance monitoring of fibers above or below ground.
- Avoids unnecessary replacement of old fibers, saving millions of dollars in installation costs.

Yogokawa’s results from AT&T’s old telecom fiber, very broad Brillouin spectrum, which results in bad resolution and accuracy.

OZ’ results from AT&T’s old telecom fiber, very narrow Brillouin spectrum, which results in high resolution and accuracy.
40 micro-meter crack detectable

Crack detection in University of California, Irvine, Dr. Maria Feng, 19th International Conference on Optical Fiber Sensors, Perth (Australia, 14-18 April 2008).
Applications of Foresight™ DSTS

Crack detection in University of California, Irvine, Dr. Maria Feng, 19th International Conference on Optical Fiber Sensors, Perth (Australia, 14-18 April 2008).

[Graph showing strain vs position for Crack A and Crack B]
Applications of Foresight™ DSTS

Pipeline corrosion monitoring in Canmet Materials Technology Laboratory, NRCan, Ottawa, NACE International — Corrosion 2008 Conference and Expo, New Orleans (Louisiana, USA 16-20 March, 2008).
Applications of Foresight™ DSTS

Pipeline corrosion monitoring in Canmet Materials Technology Laboratory, NRCan, Ottawa, NACE International — Corrosion 2008 Conference and Expo, New Orleans (Louisiana, USA 16-20 March, 2008).
Applications of Foresight™ DSTS

- Pipeline buckling detection in TransCanada Pipeline Ltd, Calgary, and C-FER Technology, Edmonton
Applications of Foresight™ DSTS

• Power line/OPGW monitoring in Hydro-Quebec, Montreal

1.5 cm outer layer crack

Aluminum Clad Steel Wire
Central Stainless Steel Tube
Optical Fibres
Aluminum Alloy Wire

Strain (με)

Position (m)

Control region
1.5 mm bending
sensor system

Stress region A including 1 m jump and point B in the middle of A.

Loose region C

Spiral box

Loose regions & stress region

90 m, 2 loose regions & stress region

0.0 kN
34 kN
127 kN

Peak
50 MHz
124 MHz

Applications of Foresight™ DSTS

• Concrete beam/Highway monitoring on HW40/University of Sherbrooke, Dr. Brahim Benmokrane
Via internet, GPS locator, wireless, service calls, SMS messages
OZ Optics Monitoring System Architecture

Diagram showing the architecture with Internet, DSTS Field Instruments connected to Web Server and Database Server, and devices like Mobile Phone, Wireless Laptop, and Web Browser connected to the Internet.
The Cost of Catastrophic Failure

- **Example: Druzhba Pipeline July 2006**
- **Small 50 cubic meter leak results in:**
  - Interruption of $100M/day pipeline
  - Global spike in oil prices
  - Report of environmental catastrophe
  - Months of investigation and ecological monitoring
- **Single point of failure in 3,000 km pipeline**
The Cost of Catastrophic Failure

• Example 2: Nigerian Pipeline July 2006
• Accidental leak
• 180,000 barrels / day shutdown
• $180,000 \times $74 = $13M per day
• 10-day shutdown = $130M
• Brillouin operation << $1/m/year
• Single production shutdown far exceeds lifetime sensor operating costs.
Acknowledgements

- University of California, Irvine, Dr. Maria Feng
- University of Ottawa, Dr. Xiaoyi Bao
- University of Sherbrooke, Dr. Brahim Benmokrane
- TransCanada Pipelines Limited (TCPL)
- C-FER Technologies
- Canmet Materials Technology Laboratory, NRCan
- Hydro-Quebec
The OZ Optics Commitment

OZ Optics is committed to providing a complete solution, lab evaluation, and field trial to meet your structural health monitoring requirements.
Your solution provider for existing and next generation fiber optic components, test equipment, and sensor systems...

For sales information please contact us at: 613-831-0981 x 3370 or 1-800-361-5415

or email us at: Sales@ozoptics.com