



# OZ Optics

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# Fiber Optic Distributed Strain and Temperature Sensors (DSTS)

## BOTDA+BOTDR Combo Module

**BOTDA Module**



**Combines 2 modules into 1**

**BOTDR Module**



*Photo: 3U chassis and laptop computer shown.*

### Features

- Loop or single end measurements
- Uses low-cost telecom single mode fiber
- High spatial resolution and long sensing range
- Multiple channel monitoring available

### Performance at a glance

- 0.1 m (BOTDA) / 1 m (BOTDR) spatial resolution
- 160 km (BOTDA) / 70 km (BOTDR) maximum fiber length

### Description

OZ Optics' ForeSight™ family of fiber optic Brillouin distributed strain and temperature sensors (DSTS) are sophisticated optical sensor systems employing Brillouin scattering. Distributed sensing provides a direct method of measuring the changes in strain and temperature along the entire length of an optical fiber. A new unit combining BOTDA (Brillouin Optical Time Domain Analyzer) and BOTDR (Brillouin Optical Time Domain Reflectometer) capabilities is now available. If there is a break somewhere along the fiber, this unit can be switched from BOTDA mode to BOTDR mode to continue measurements.

## Oil and Gas applications



### Oil and Gas Pipeline Monitoring

- Pipeline leakage monitoring
- Up to 100 km sensing range per channel
- High spatial resolution supports localized measurements over extended distances
- Short acquisition / response time



### Oil and Gas Well Monitoring

- Well integrity management
- Temperature, strain and pressure monitoring with proper sensing cable and installation
- Not sensitive to hydrogen which may change the attenuation of the fiber



### Refinery Efficiency Sensing

- Improve the efficiency of the refinery based on the distributed temperature profile
- Reduce downtime while ensuring safety levels
- Uses low cost telecom single mode fiber cable

## Civil Engineering applications



### Dam Monitoring

- Dam internal temperature monitoring
- Crack / sediment / deformation / seepage monitoring
- Up to 100 km sensing range per channel



### Structural Health Monitoring (SHM)

- Sediment monitoring
- Strain and crack monitoring
- Up to 100 km sensing range per channel
- High spatial resolution supports localized measurement with long range object

## Civil Engineering applications *continued*



### Geohazard Monitoring

- Landslide, subsidence and deformation of levee / ground / highway monitoring
- Can monitor trends in ground movement
- Up to 100 km sensing range per channel



### Highway Safety Monitoring

- Internal temperature / strain monitoring with proper sensing cable and installation
- Highway subsidence monitoring
- Up to 100 km sensing range per channel

## Utility and cable applications



### Overhead Power Line Monitoring

- Lightning strikes, icing and broken wires can be detected
- Up to 100 km sensing range per channel
- No additional components required along power line route
- Easy deployment



### Submarine Cable Monitoring

- Ongoing quality / status monitoring throughout the life of the cable
- May only require one fiber
- No additional components required along the route



### Quality Inspection of Fiber Optic Cable

- More sensitive to strain than OTDR
- High level quality control based on high level technology
- Can monitor the quality of power cable / OPGW with optical fiber unit

## Security, Cryostat, and Fire applications



### Border Security Monitoring

- Fast, dynamic measurement
- High precision of event location
- Can work in conjunction with a video surveillance system



### Cryostat Temperature Sensing

- Able to measure temperatures as low as 25 K
- May use low cost telecom single mode fiber
- Up to 100 km sensing range per channel
- High spatial resolution with good temperature resolution / precision



### Building Fire Detection

- Fast, dynamic, and accurate temperature measurement
- Up to 100 km sensing range per channel
- May use low cost telecom single mode fiber cable



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## Specifications

|             |                                                                                  | BOTDA module               |                                                                                                                         |             | BOTDR module |
|-------------|----------------------------------------------------------------------------------|----------------------------|-------------------------------------------------------------------------------------------------------------------------|-------------|--------------|
| Performance | Number of Channels                                                               |                            | 2 to 25 <sup>1</sup>                                                                                                    |             |              |
|             | Sensor Configuration                                                             |                            | Loop fiber                                                                                                              |             |              |
|             | Maximum Fiber Length                                                             |                            | 160 km <sup>2</sup>                                                                                                     |             |              |
|             | Spatial Resolution                                                               |                            | 0.1 to 50 m                                                                                                             | 0.5 to 50 m | 1 m to 50 m  |
|             | Spatial Step                                                                     |                            | as low as 5 cm                                                                                                          |             |              |
|             | Dynamic Range                                                                    |                            | 30 dB                                                                                                                   |             |              |
|             | Temperature Sensing Range (depending on cable material)                          |                            | -270°C to +2100°C                                                                                                       |             |              |
|             | Temperature Resolution                                                           |                            | 0.005°C <sup>4</sup>                                                                                                    |             |              |
|             | Temperature Accuracy (2σ)                                                        |                            | ± 0.1°C                                                                                                                 |             |              |
|             | Strain Range (depending on cable material)                                       |                            | -3% to +4%                                                                                                              |             |              |
|             | Strain Resolution                                                                |                            | 0.1µε <sup>4</sup>                                                                                                      |             |              |
|             | Strain Accuracy (2σ)                                                             |                            | ± 2µε                                                                                                                   |             |              |
|             | Fault Point Detection                                                            | Acquisition Time           | 1 second per thousand scans                                                                                             |             |              |
|             |                                                                                  | Sensing Range (round trip) | 100 km                                                                                                                  |             |              |
|             | Simultaneous Measurement of Strain and Temperature (using patented cable design) | Temperature Resolution     | 0.005°C <sup>4</sup>                                                                                                    |             |              |
|             |                                                                                  | Temperature Accuracy (2σ)  | ± 0.1°C<br>(whole sensing range for BOTDA)                                                                              |             |              |
|             |                                                                                  | Strain Resolution          | 0.1µε <sup>4</sup>                                                                                                      |             |              |
|             |                                                                                  | Strain Accuracy (2σ)       | ± 2µε<br>(whole sensing range for BOTDA)                                                                                |             |              |
|             |                                                                                  | Sensing Range              | 50 km                                                                                                                   |             |              |
|             | Measured Variables                                                               |                            | Strain, Temperature, Brillouin spectrum                                                                                 |             |              |
| General     | Communication & Connections                                                      |                            | Ethernet port, USB                                                                                                      |             |              |
|             | Output Signals                                                                   |                            | Software alarms via TCP/IP, SPST, SSR relays (optional)                                                                 |             |              |
|             | Data Storage                                                                     |                            | Internal hard disc (128GB or more)                                                                                      |             |              |
|             | Data Format                                                                      |                            | Database, text files, MS Excel, bit map plot                                                                            |             |              |
|             | Optical Connections                                                              |                            | FC/APC <sup>6</sup>                                                                                                     |             |              |
|             | Laser Wavelength                                                                 |                            | 1550 nm band                                                                                                            |             |              |
|             | Operating Temperature                                                            |                            | 0°C to 40°C, <85% RH, Non-condensing                                                                                    |             |              |
|             | Power Supply                                                                     |                            | 115 or 230 VAC; 50–60Hz; max 300W                                                                                       |             |              |
|             | Dimensions (L x W x H)                                                           | 3U Chassis                 | 390 mm x 344 mm x 133 mm (not including computer) <sup>7</sup>                                                          |             |              |
|             | Weight                                                                           | 3U Chassis                 | <12 kg (not including computer)                                                                                         |             |              |
| Features    | Measurement Modes                                                                |                            | Manual, remote or automatic unattended measurements                                                                     |             |              |
|             | Data Analysis                                                                    |                            | Measurement analysis, multiple trace comparison with respect to selectable baseline, measurement trends, graphical zoom |             |              |
|             | Alarms & Warnings                                                                |                            | Automatic alarm triggering, configurable alarm settings (gradient, threshold, etc.)                                     |             |              |
|             | Remote Operation                                                                 |                            | Remote control, configuration and maintenance via TCP/IP                                                                |             |              |
|             | Watch Dog                                                                        |                            | Long term operation 24/7 guaranteed by automatic recovery and continuous self diagnostics                               |             |              |

<sup>1</sup> 2 channels or 4 channels are provided within the sensor unit. Additional channels can be added by using an external optical switch.

<sup>2</sup> For fiber lengths longer than 100 km, only the first 100 km has a valid Brillouin spectrum.

<sup>3</sup> -270°C to 1500°C and -3% to +3% is optional.

<sup>4</sup> This value is estimated/calculated from the uncertainty of laser beat frequency (5 kHz), and temperature and strain coefficients of fibers.

<sup>5</sup> Measurement condition: 1 km SM fibers with unstrained condition at pulse width of 10ns, average time of 60000, frequency sweep span of 300 MHz with frequency step of 5 MHz, standard deviation (2σ) of 100 consecutive data on temperature/strain distribution waveform.

<sup>6</sup> Adaptors and patch cords are available for mating with other types of optical connectors.

<sup>7</sup> Dimensions do not include carrying handle. Air vents on sides of unit must not be obstructed.

The ForeSight™ Brillouin based DSTS design enables focus on the variable of most concern. For instance, concrete fracture detection may require tight spatial resolution and high precision.

The measurement time of the DSTS BOTDA module can vary from **1 second** to **10 minutes** based on the requirements dictated by the application. The sample table below reflects some common requirements: better than  $\pm 0.5^{\circ}\text{C}$  and  $\pm 10\mu\epsilon$  precision. All table measurements were completed in less than 1 minute and 40 seconds.

The table is not a restriction of what can be achieved. Variations in the four areas of concern can be accommodated. For instance, the measurement of temperature/strain for 50 km sensing fiber, 2 m spatial resolution, with a precision of  $0.2^{\circ}\text{C}/4\mu\epsilon$  is attainable, but will increase measuring time to 3 minutes and 45 seconds. Another comparison of the interaction of fiber length, spatial resolution, accuracy of temperature/strain, and measurement time: 100 km sensing fiber, 6 m spatial resolution can be  $0.4^{\circ}\text{C}/8\mu\epsilon$  when measuring time is 4 minutes and 38 seconds, however the same 100 km can have a precision of  $0.1^{\circ}\text{C}/2\mu\epsilon$  when spatial resolution is increased to 50 m with a measuring time of 3 minutes and 48 seconds.

|              |        | Spatial Resolution                 |                                    |                                    |                                       |                                    |                                    |                                    |                                    |                                    |                                    |
|--------------|--------|------------------------------------|------------------------------------|------------------------------------|---------------------------------------|------------------------------------|------------------------------------|------------------------------------|------------------------------------|------------------------------------|------------------------------------|
|              |        | 10 cm                              | 50 cm                              | 1 m                                | 2 m                                   | 3 m                                | 4 m                                | 5 m                                | 10 m                               | 20 m                               | 50 m                               |
| Fiber Length | 1 km   | $0.3^{\circ}\text{C}/6\mu\epsilon$ | $0.2^{\circ}\text{C}/4\mu\epsilon$ |                                    |                                       |                                    |                                    |                                    |                                    |                                    |                                    |
|              | 2 km   |                                    | $0.3^{\circ}\text{C}/6\mu\epsilon$ | $0.1^{\circ}\text{C}/2\mu\epsilon$ |                                       |                                    |                                    |                                    |                                    |                                    |                                    |
|              | 4 km   |                                    | $0.4^{\circ}\text{C}/8\mu\epsilon$ | $0.3^{\circ}\text{C}/6\mu\epsilon$ |                                       |                                    |                                    |                                    |                                    |                                    |                                    |
|              | 10 km  |                                    |                                    | $0.3^{\circ}\text{C}/6\mu\epsilon$ |                                       |                                    |                                    |                                    |                                    |                                    |                                    |
|              | 20 km  |                                    |                                    | $0.4^{\circ}\text{C}/8\mu\epsilon$ | $0.06^{\circ}\text{C}/1.2\mu\epsilon$ |                                    |                                    |                                    |                                    |                                    |                                    |
|              | 30 km  |                                    |                                    |                                    | $0.2^{\circ}\text{C}/4\mu\epsilon$    |                                    |                                    |                                    |                                    |                                    |                                    |
|              | 40 km  |                                    |                                    |                                    | $0.3^{\circ}\text{C}/6\mu\epsilon$    | $0.1^{\circ}\text{C}/2\mu\epsilon$ | $0.2^{\circ}\text{C}/4\mu\epsilon$ |                                    |                                    |                                    |                                    |
|              | 50 km  |                                    |                                    |                                    |                                       | $0.2^{\circ}\text{C}/4\mu\epsilon$ | $0.3^{\circ}\text{C}/6\mu\epsilon$ | $0.2^{\circ}\text{C}/4\mu\epsilon$ | $0.1^{\circ}\text{C}/2\mu\epsilon$ |                                    |                                    |
|              | 60 km  |                                    |                                    |                                    |                                       |                                    |                                    |                                    | $0.2^{\circ}\text{C}/4\mu\epsilon$ |                                    |                                    |
|              | 70 km  |                                    |                                    |                                    |                                       |                                    |                                    |                                    | $0.3^{\circ}\text{C}/6\mu\epsilon$ |                                    |                                    |
|              | 80 km  |                                    |                                    |                                    |                                       |                                    |                                    |                                    |                                    | $0.2^{\circ}\text{C}/4\mu\epsilon$ |                                    |
|              | 90 km  |                                    |                                    |                                    |                                       |                                    |                                    |                                    |                                    | $0.4^{\circ}\text{C}/8\mu\epsilon$ |                                    |
|              | 100 km |                                    |                                    |                                    |                                       |                                    |                                    |                                    |                                    | $0.4^{\circ}\text{C}/8\mu\epsilon$ | $0.2^{\circ}\text{C}/4\mu\epsilon$ |

**Typical BOTDA module measurement precision table (acquisition time  $\leq 100$  seconds)**

|              |       | Spatial Resolution                            |                                               |                                             |                                               |                                                |                                                |                                             |
|--------------|-------|-----------------------------------------------|-----------------------------------------------|---------------------------------------------|-----------------------------------------------|------------------------------------------------|------------------------------------------------|---------------------------------------------|
|              |       | 1 m                                           | 2.5 m                                         | 4 m                                         | 10 m                                          | 25 m                                           | 35 m                                           | 40 m                                        |
| Fiber Length | 1 km  | $\pm 0.8^{\circ}\text{C} / \pm 16\mu\epsilon$ |                                               |                                             |                                               |                                                |                                                |                                             |
|              | 2 km  | $\pm 1.2^{\circ}\text{C} / \pm 24\mu\epsilon$ |                                               |                                             |                                               |                                                |                                                |                                             |
|              | 5 km  | $\pm 1.5^{\circ}\text{C} / \pm 30\mu\epsilon$ |                                               |                                             |                                               |                                                |                                                |                                             |
|              | 10 km |                                               | $\pm 1.5^{\circ}\text{C} / \pm 30\mu\epsilon$ |                                             |                                               |                                                |                                                |                                             |
|              | 20 km |                                               |                                               | $\pm 1^{\circ}\text{C} / \pm 20\mu\epsilon$ |                                               |                                                |                                                |                                             |
|              | 30 km |                                               |                                               |                                             | $\pm 1.5^{\circ}\text{C} / \pm 30\mu\epsilon$ |                                                |                                                |                                             |
|              | 40 km |                                               |                                               |                                             | $\pm 1.5^{\circ}\text{C} / \pm 30\mu\epsilon$ |                                                |                                                |                                             |
|              | 50 km |                                               |                                               |                                             |                                               | $\pm 1.75^{\circ}\text{C} / \pm 35\mu\epsilon$ |                                                |                                             |
|              | 60 km |                                               |                                               |                                             |                                               |                                                | $\pm 1.25^{\circ}\text{C} / \pm 25\mu\epsilon$ |                                             |
|              | 70 km |                                               |                                               |                                             |                                               |                                                |                                                | $\pm 2^{\circ}\text{C} / \pm 40\mu\epsilon$ |

**Typical BOTDR module measurement precision table**

Results listed above are based on 100 continuous measurement using a single mode sensing fiber with zero strain. Averaging a greater number of scans can provide better precision but it will require longer measurement time.

## Ordering Information

Part Number Description: **DSTS-CT CO I-SR-MSR-AS-BOTDA/R-X-CH**

**CT** = Chassis Type of DSTS  
opto-electronics box  
3U = 3U chassis

**CO** = Computer Type  
L = Laptop (requires 3U chassis)  
X = Customer supplier computer

**I** = Internal Interface between DAQ and  
computer  
T = Thunderbolt (requires 3U chassis)  
S = Standard

**SR** = Spatial Resolution (m)<sup>1</sup>  
0.1/10  
0.1/50  
0.5/10  
0.5/50  
1/10  
1/50

For a field-ready unit, replace the chassis type, computer type, and computer interface with a single letter "F." Field ready units include a built-in computer, monitor, keyboard and mouse.

**CH** = Number of channels  
2CH = 2 built-in channels  
4CH = 4 built-in channels

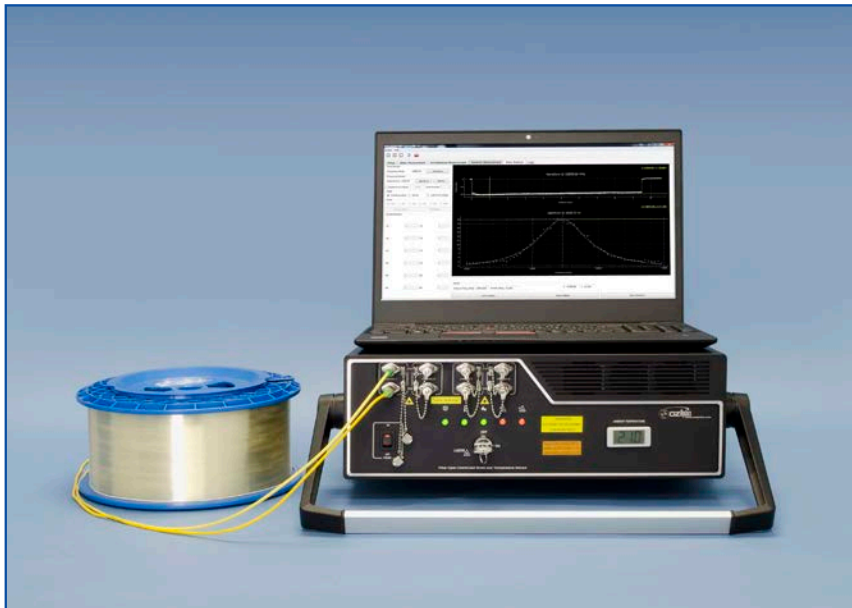
**X** = Connector Type  
3A = FC/APC

**AS** = Acquisition Speed<sup>3</sup>  
N = Normal  
H = High Speed

**MSR** = Maximum Sensing Range (km)<sup>1,2</sup>  
60  
1/60  
5/60  
100  
1/100  
5/100

### Notes:

1. Each DSTS can be configured for short haul operation, long haul operation or both. The configuration must be specified at the time of purchase. The spatial resolution indicates the best resolution at the maximum sensing range. If the DSTS is configured for both short-haul and long-haul measurements then two numbers will be listed indicating the resolutions and maximum sensing range for each operating mode. For example, suppose the DSTS unit needs to achieve 0.1 meter resolution over a 1 km range for short-haul applications, and 50 meter resolution over a 100 km range for long-haul applications. The part number will specify the spatial resolution (SR) as 0.1/50, and maximum sensing range (MSR) as 1/100. The SR and MSR parameters refer to the BOTDA module only.
2. Maximum sensing range is 60 km or 100 km for long haul operation. Alternately, if the 0.1 m spatial resolution is chosen, a maximum sensing range of 1 km is displayed for that resolution (for short haul operation). Maximum sensing range is described as 60, 1/60, 5/60, 100, 1/100, or 5/100.
3. The acquisition speed is described as normal or high speed. N and H are used respectively. The high-speed version is typically at least a factor of two faster than the normal-speed version during the acquisition of data.



### 3U model with laptop computer

The 3U version of the DSTS comes with removable carrying handles. The user can easily replace the handles with tabs (sold separately) that will allow the unit to be installed in a standard 19-inch rack.

### Optional Accessories



Fiber fusion splicer - FSP-100-S/M



Precision fiber cleaver - FSP-100-CLV

## Optional Accessories

| Bar Code | Part Number                  | Description                                                                                                                                                                                                                                                                                                                    |
|----------|------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 74023    | DSTS-TRAVEL-CASE-3U          | Plastic travel case for 2U or 3U DSTS unit, with extendable pull handle and wheels. Designed for checking on airplane. Approximate dimensions: 23.75 (H) x 22.5 (W) x 15 (D). {60.3 cm x 57.2 cm x 38.1 cm}.                                                                                                                   |
| 65518    | FIBERMICROSCOPEHANDHELD      | Handheld Video Microscope kit for Fiber Optic Connector Inspection. The kit includes an LCD display with video probe. An AC power adapter with battery charger and a rechargeable battery pack is included. Several common adaptor types come with the unit, including an SC/FC PC female adaptor and an LC/PC female adaptor. |
| 48980    | CI-1100-A2-PT2-FS/APC/F      | Tip for SC and FC APC type female (in receptacle) connector for CI-1100-A2 handheld microscope.                                                                                                                                                                                                                                |
| 36939    | HUXCLEANER-2.5               | Receptacle fiber cleaner for FC, SC and ST types.                                                                                                                                                                                                                                                                              |
| 5336     | Fiber-Connector-Cleaner-SA   | Disposable Cletop reel type A optical fiber connector cleaner.                                                                                                                                                                                                                                                                 |
| 8122     | SMJ-3A3A-1300/1550-9/125-3-1 | 1 meter long, 3 mm OD jacketed, 1300/1550 nm 9/125 $\mu$ m Corning SMF 28e fiber patchcord, terminated with angled FC/APC connectors on both ends.                                                                                                                                                                             |
| 11       | PMPC-03                      | Flanged sleeve thru connector for polarization maintaining FC/PC connectors. Keyway width is 2.03/2.07 mm wide for 2.00 mm wide (Type R) key connectors.                                                                                                                                                                       |
| 19711    | AA-200-11-9/125-3A3A         | Universal connector with a male angle FC/APC connector at the input and a female angle FC/APC receptacle at the output end for SM 9/125 applications.                                                                                                                                                                          |
| 58975    | DSTS-3U-19IN-RACK-MOUNT-KIT  | Brackets with handles & hardware to convert 3U DSTS to 19" rack mountable version.                                                                                                                                                                                                                                             |
| 77982    | FSP-100-S/M                  | Fiber fusion splicer for singlemode and multimode fiber, featuring fiber core alignment and automatic fiber identification (singlemode vs multimode) for optimum splice loss. Suitable for bare fibers, patch cords, drop cables etc. A fiber cleaver and fiber stripper is included with the unit as a kit.                   |
| 77984    | FSP-100-CLV                  | Precision fiber cleaver for fusion splicing, with automatic blade rotation for maximum lifetime.                                                                                                                                                                                                                               |

## Related Products

### Fiber Optic Sensor Probes, Components, Termination Kits, and Training

OZ Optics offers a full spectrum of fiber optic sensor probes, components, termination kits and training. OZ Optics' standard fiber optic products have been used worldwide in high performance sensor and telecommunications applications since 1985. OZ Optics also offers specialty fiber optic sensor probes and custom cabling for high temperature applications and other hostile and corrosive environments. System integrators with experience in structural and pipeline monitoring will find that OZ Optics offers a complete suite of enabling products and services for installing and maintaining fiber optic systems. If you are planning a pipeline or structural monitoring project, please contact OZ Optics to learn more about our fiber optic solutions.

## Questionnaire

- What is your application? Please describe briefly.
- Are you looking for a BOTDA module (requires both ends of fiber to be connected to DSTS) or a BOTDR module (requires only one end of fiber to be connected to DSTS) or a COMBO unit with both BOTDA and BOTDR functions?
- What are your resolution and precision requirements for temperature measurements?  
Resolution: \_\_\_\_\_  
Precision: \_\_\_\_\_
- What are the highest and lowest temperatures you expect?
- What are your resolution and precision requirements for strain measurements?  
Resolution: \_\_\_\_\_  
Precision: \_\_\_\_\_
- What is the maximum strain to be measured?
- What is the desired sensing range or fiber length in this application?
- What spatial resolution do you desire?
- Do you want to measure temperature, strain or both?
- What is the desired data acquisition time?
- Do you need fiber calibration / system design / project engineering service?
- Where will the unit be housed?
- Do you need a portable model with a laptop computer or a 19" rack-mounted model with a laptop computer?
- Any additional information?

For more information about our strain and temperature sensor systems and related products, please visit [www.ozoptics.com](http://www.ozoptics.com).