Redondo Optics Inc.

Revolutionizing Smart Fiber Optic Sensors for Applications Where Weight, Size, and Power are Critical for Operation

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EPIC-HBK Workshop

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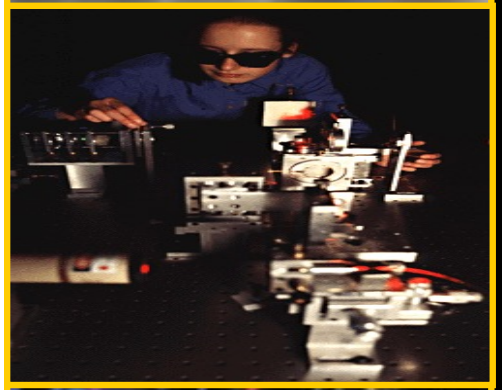
Company Overview

- Developing highly **disruptive photonics and fiber optic sensors** technology:
  - Industry's first photonic integrated circuit (PIC) microchip fiber Bragg-Grating sensor interrogator systems with battery power, wireless communications, and high-speed data acquisition electronics.
  - Applications across multiple high growth market verticals

- Privately owned company with over 20-years operation based in government and commercial grants investment resulting in comprehensive fiber optic sensors product lines and patent portfolio

- Transitioning from Technology Development and Pilot-Scale Production to High Volume Manufacturing and Commercial Sales

Innovation through photonic integrated circuits (PIC) microchip technology addressing multiple high growth markets

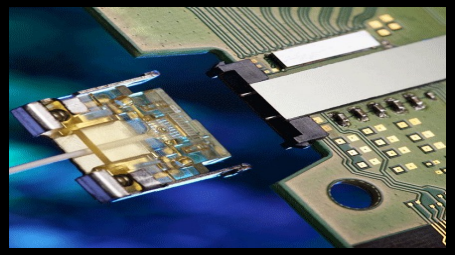


ROI Technical Skills Set

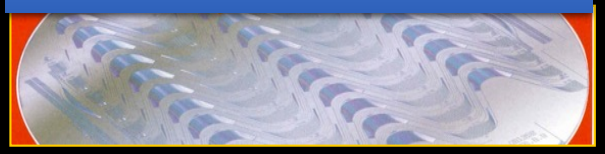
- **Optical Materials Design and Development**
  - Advanced Nanomaterials - optical glasses, ceramics, and polymers
  - Functional Doped Nanomaterials
- **Fiber Optic Sensors**
  - Sensor Chemistries
  - Specialty Fiber Sensor Design
  - Chemical, Biological, and Physical
  - Single point, multipoint, and distributed sensors
- **Photonics Integrated Circuit Design and Fabrication**
  - Advanced PICs design: passive, active, and hybrid devices
  - Advanced optical design: plasmonic structures, diffractive & binary optics
  - Nanofabrication production, testing, and assembly
- **Optoelectronics Systems Engineering**
  - High speed optoelectronics design and assembly
  - Electronic circuit design
  - Mechanical design and production
  - Device packaging
  - Firmware and Software Applications Development

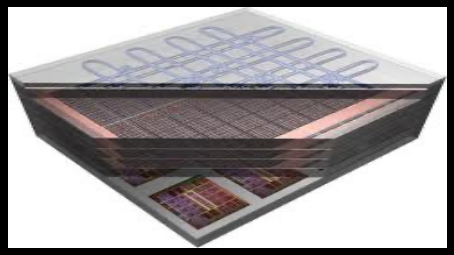
ROI's innovative technical team consists of a group of highly skill specialists from all around the world focus on developing tomorrow's optical technologies.

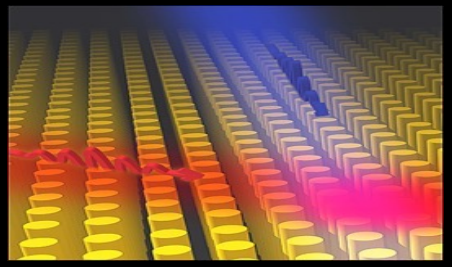
Keystone Nano-Material Platform for Multiple Markets



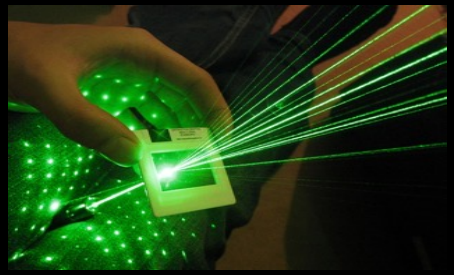
Photonic Integrated Circuit Microchip Devices

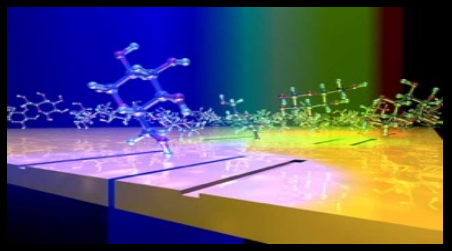


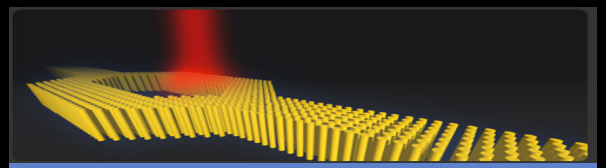




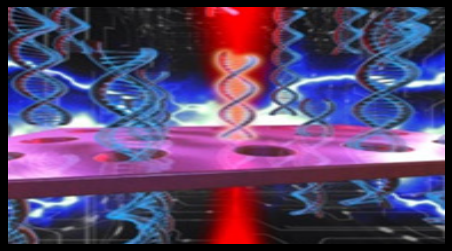
Diffractive – Refractive And Meta-Materials







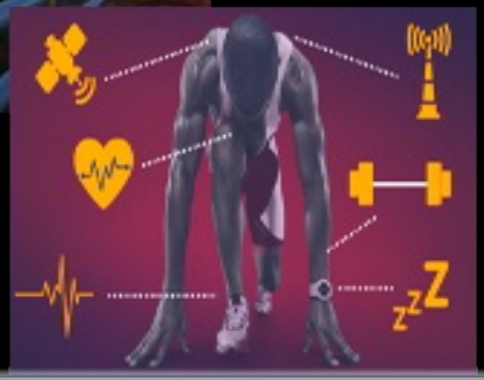
Photonic and Plasmonic Sensor Platforms



Redondo Optics proprietary Nano-structure materials technology has applications in diverse sectors including sensors, biotechnology, lighting and displays, telecommunications, high speed electronics, aerospace

Smart Fiber Optic Sensor Applications

Oil and Pipelines



Buildings
and Civil Infrastructures

Wearable Heath-Med

Renewable Energy

Defense and Homeland Security

ROI's Strategy

- Next Generation Fiber Optic Sensor Systems Must be:
  - Cost Affordable
  - Low Weight
  - Small Size
  - Self-Power
  - Simple User Interface
  - Wireless Network Connectivity

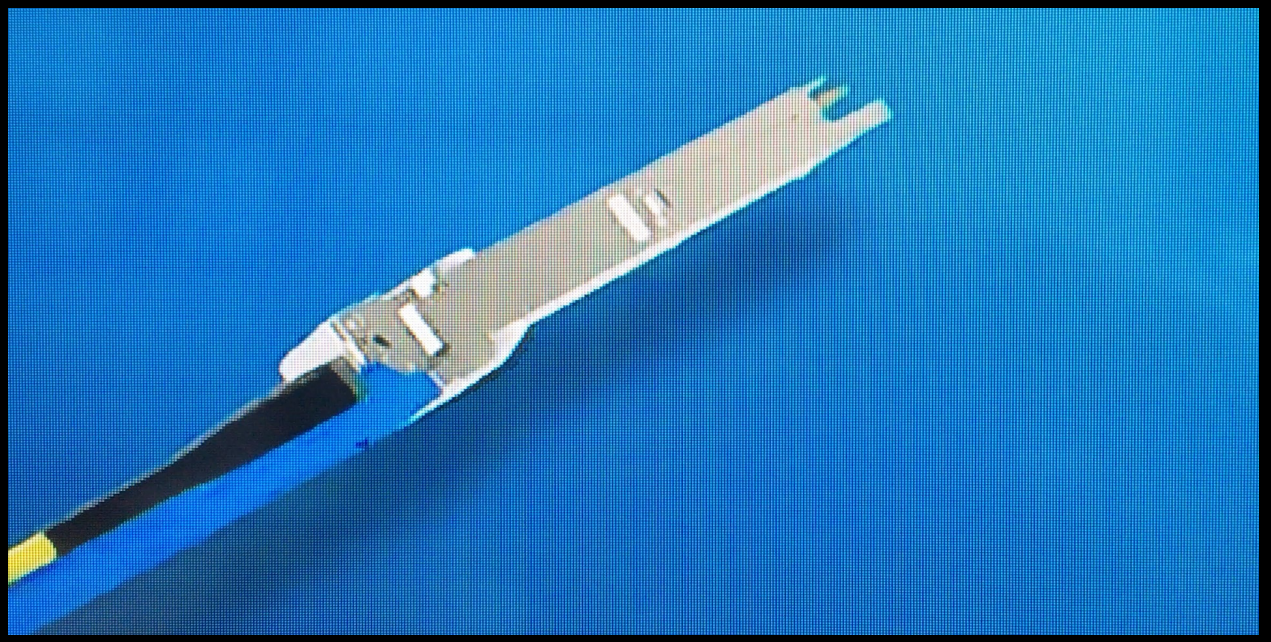
For Applications Where Weight, Size, Power, and Cost are Critical for Operation.

Photonic Integrated Circuits (PIC) Microchip Technology

- **ROI uses its patented PIC microchip technology to provide fiber optic sensor solutions for sensing applications where Weight, Size, Power, and Cost are critical for operation.**

- Developed on contract for applications with
  - **NASA**
  - **Department of Defense**
  - **Department of Energy**

ROI’ Sensor Solutions using Photonic Integrated Circuit Transceivers

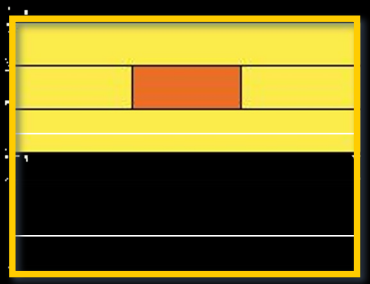


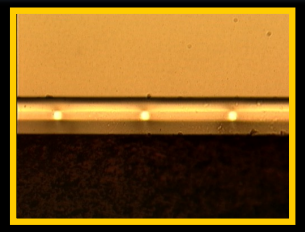
Wafer scale manufacturing for high-volume and low-cost transceivers production

ROI's Advantage

Proprietary photo-reactive spin-on-glass chemistry and etch-less manufacturing process

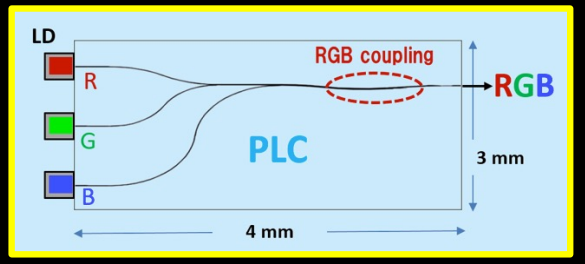
Silica Waveguide Component

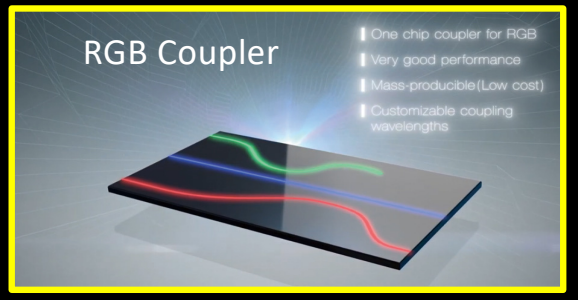




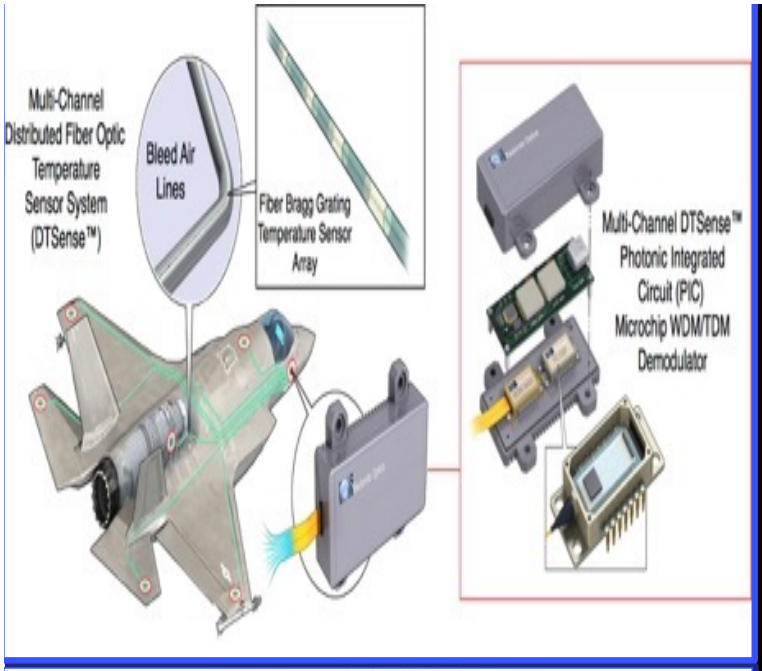
Waveguide Product Wafers

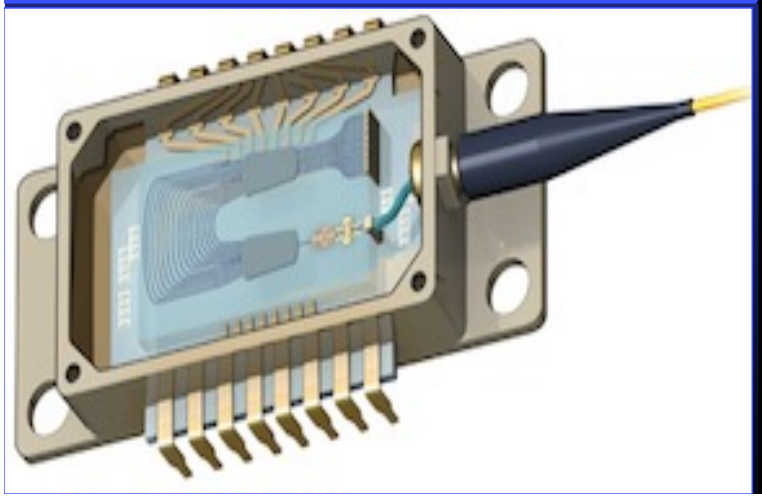
PLC Chip Products





Manufacturing focus with fast throughput and significant cost/yield advantages

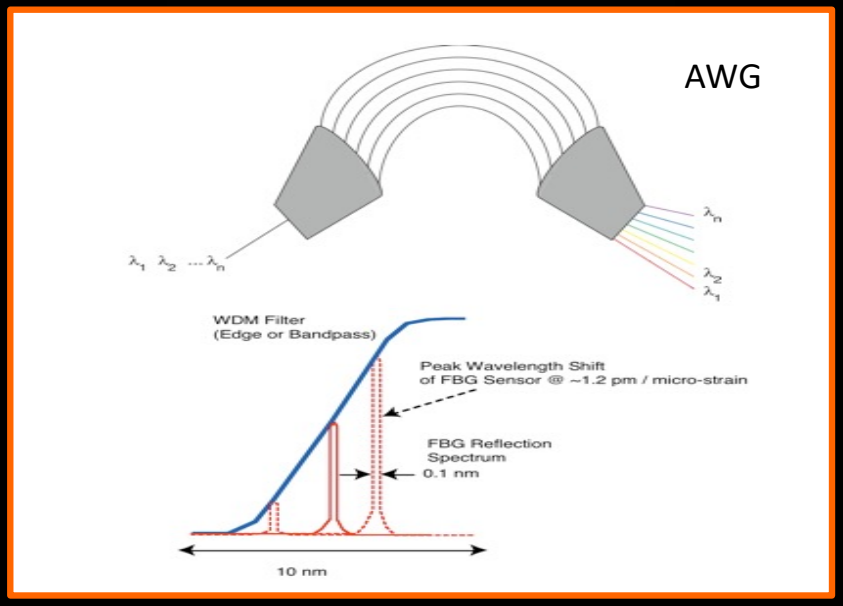




Miniaturization of a Fiber Bragg Grating Interrogator (WDM/TDM)

- Develop a miniature optical fiber Bragg grating interrogator sufficiently small and with low power consumption to be incorporated into a jet fighter for bleed air temperature monitoring.
- Requirements:
  - Single fiber with sixteen (16) FBG Sensors
  - Weigh less than 0.25-lbs
  - Size less than 5-cubic inches
  - No moving parts
  - Operation wavelength 1510-1580-nm
  - Wavelength resolution ≤ 5-pm
  - Data rate ≥ 20-kHz per channel

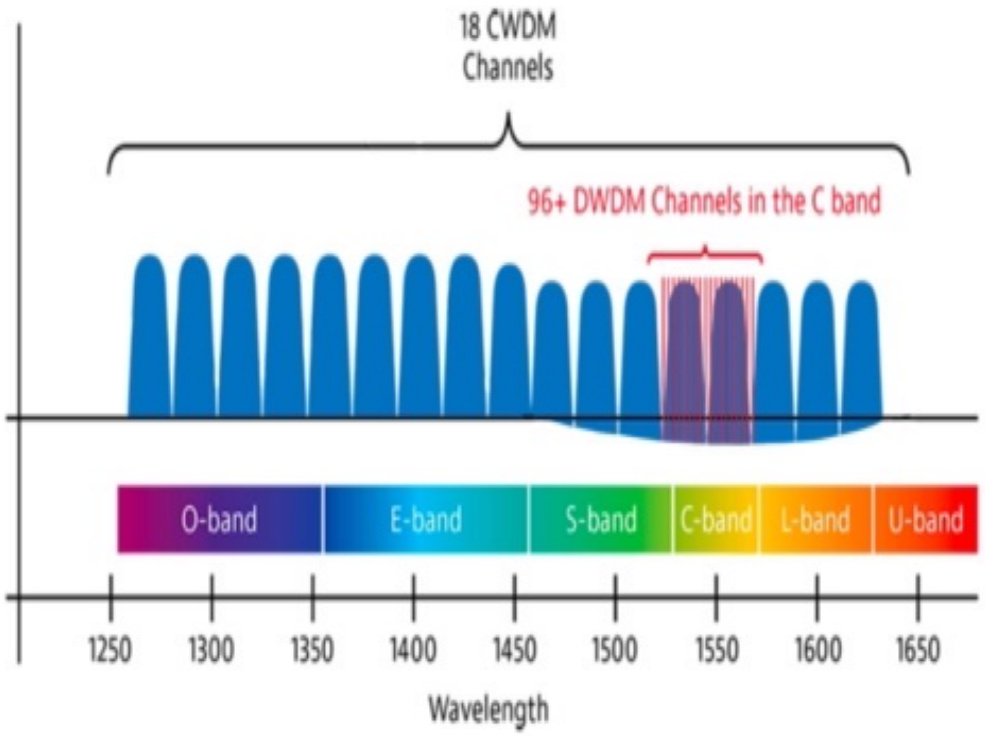
CWDM and WDM PIC Chips for Wavelength Demodulation of FBG Optical Signal

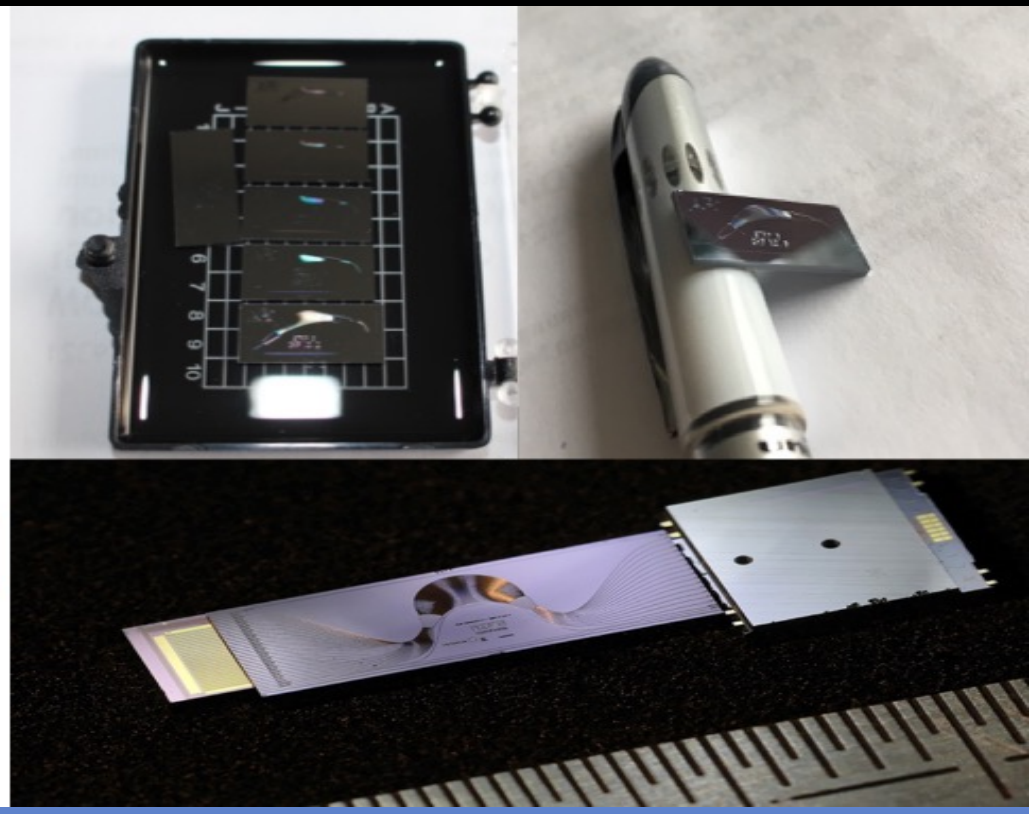


The WDM filter passively transforms the FBG peak wavelength shift to a linear intensity variation, directly related to the physical state (peak wavelength position) of the sensor grating at the photodetector element.

WDM filters of carefully selected spectral properties form the basis of the FBG sensor demodulator in the optical microchip.

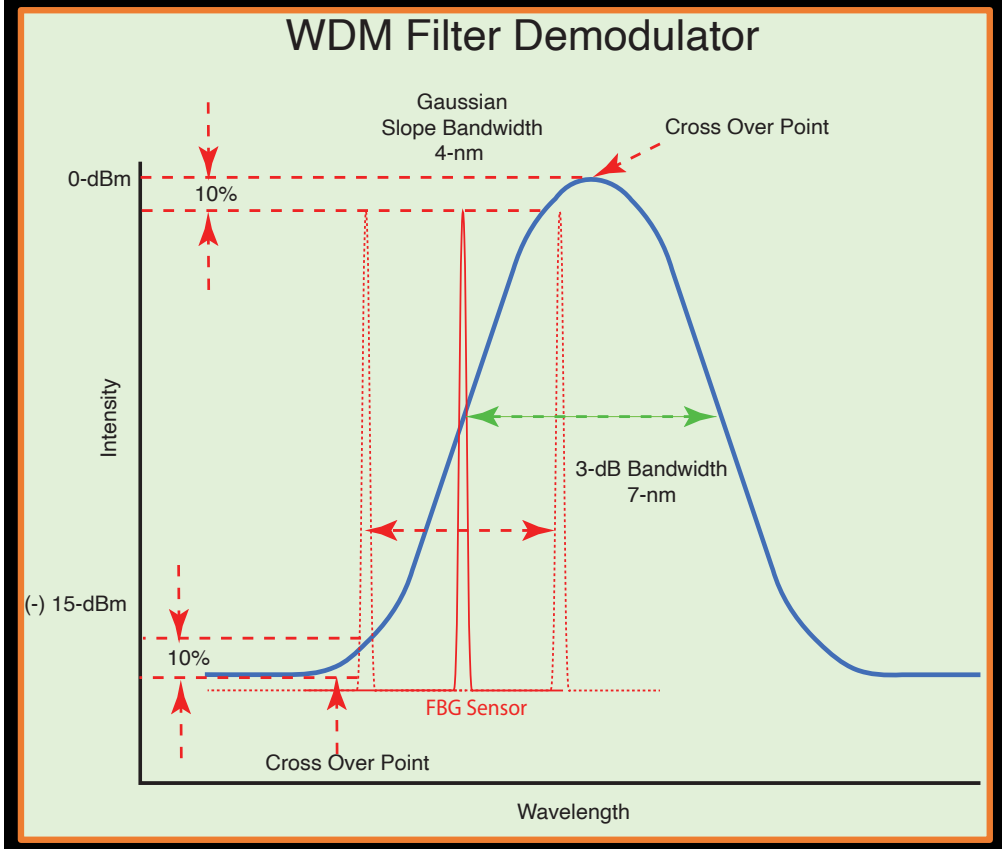
CWDM and WDM PIC Chips for Wavelength Demodulation of FBG Optical Signal





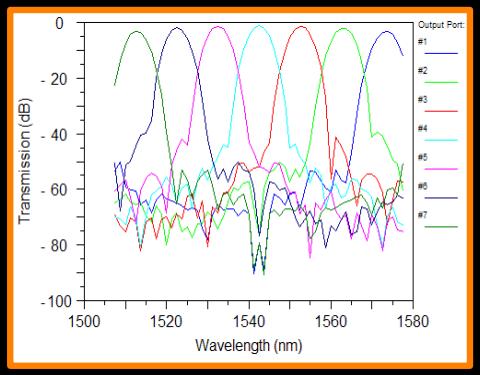
WDM filters of carefully selected spectral properties form the basis of the FBG sensor demodulator in the optical microchip.

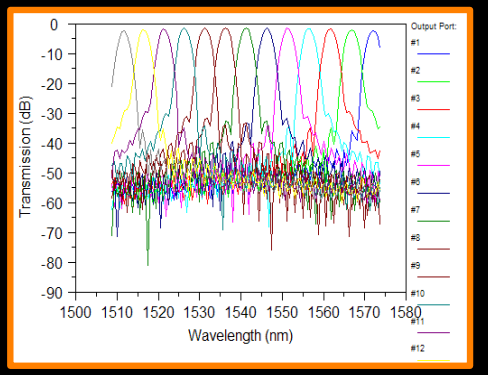
FBG-Transceiver
PIC Microchip WDM Edge-Filter Demodulation



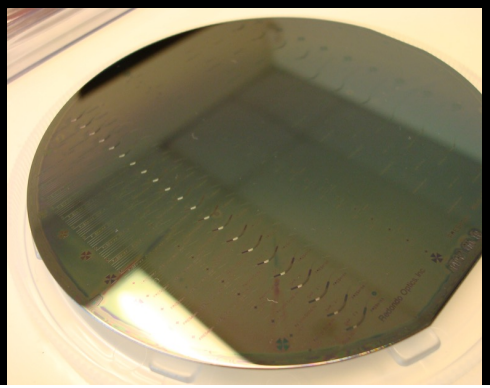
Wavelength Bandwidth of Gaussian WDM Filter Designs

- Standard-Band 4.0-nm
- Narrow-Band 2.5-nm
- Broad Band 10-nm
- Ultra-Broad Band 60-nm

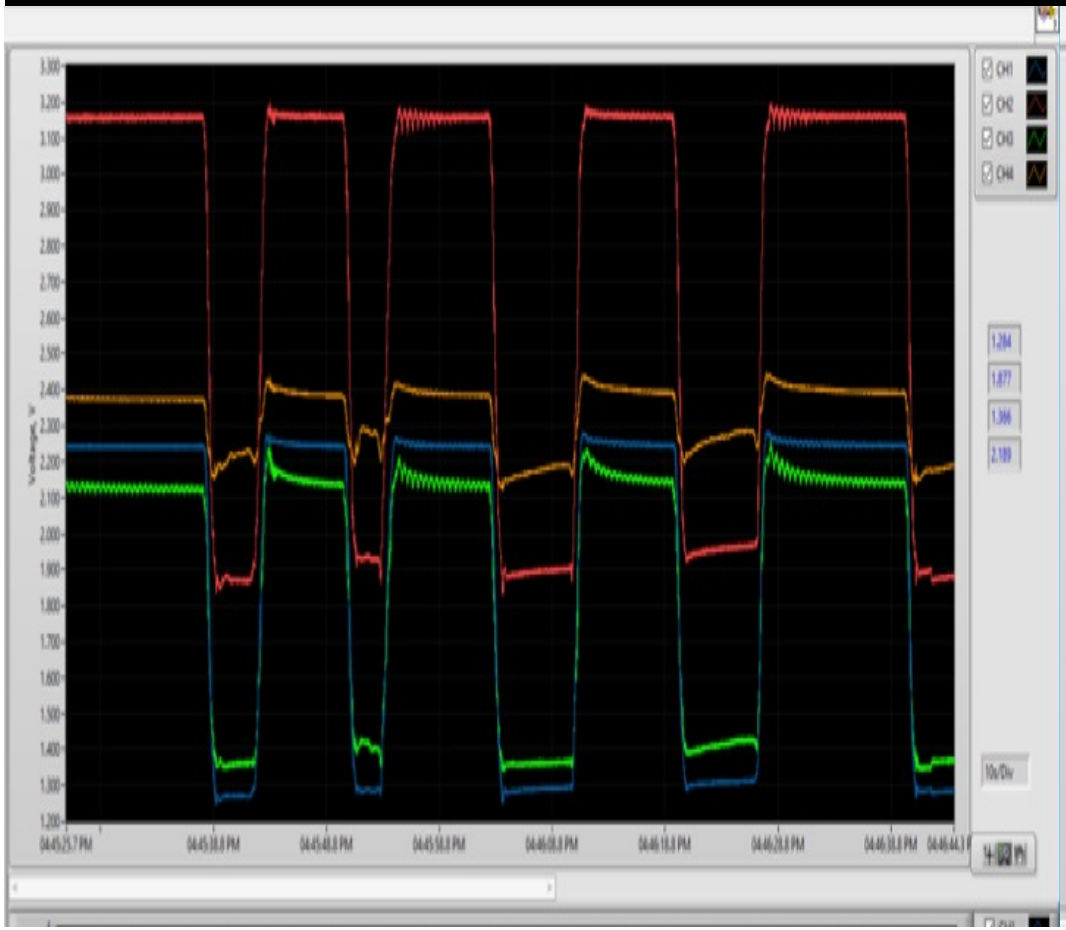


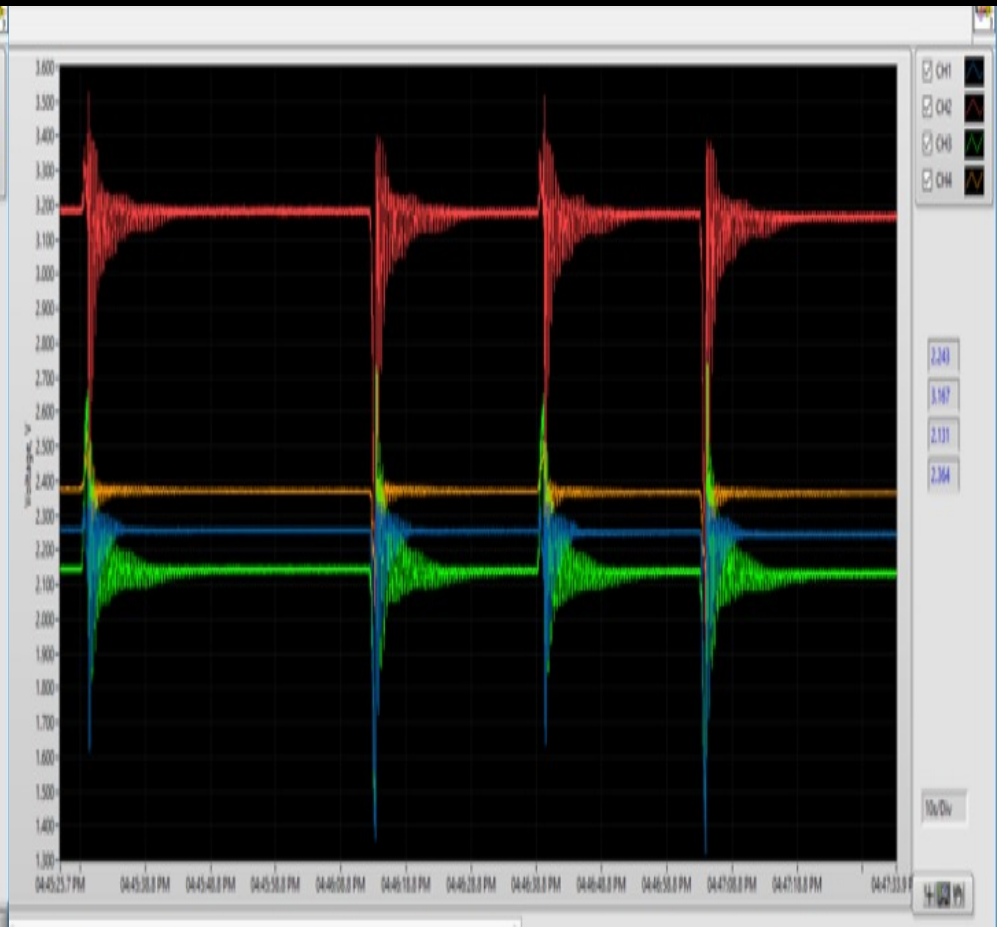


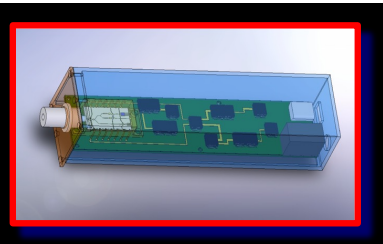
Single Fiber Multi-Channel FBG-Transceiver Interrogation System



FBGT System Response to Passive and Dynamic Strain

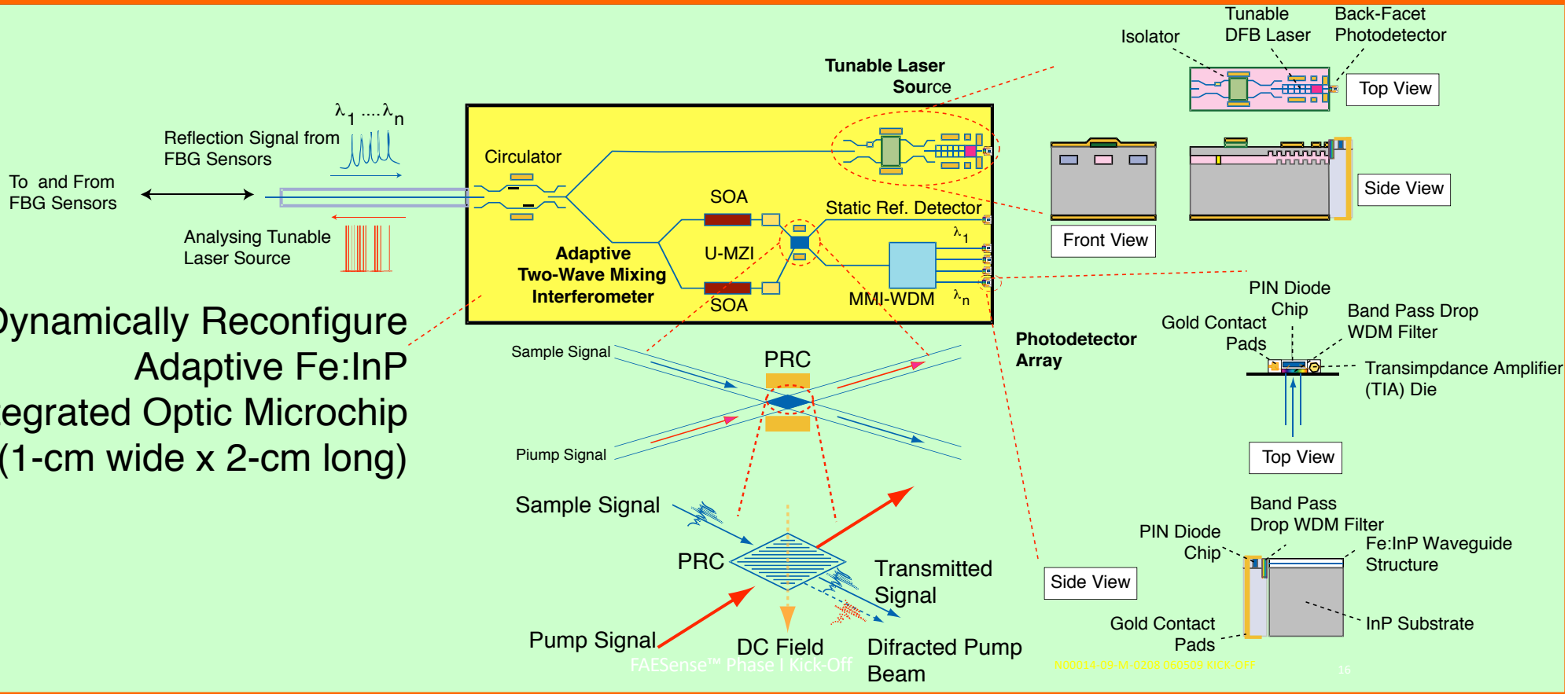




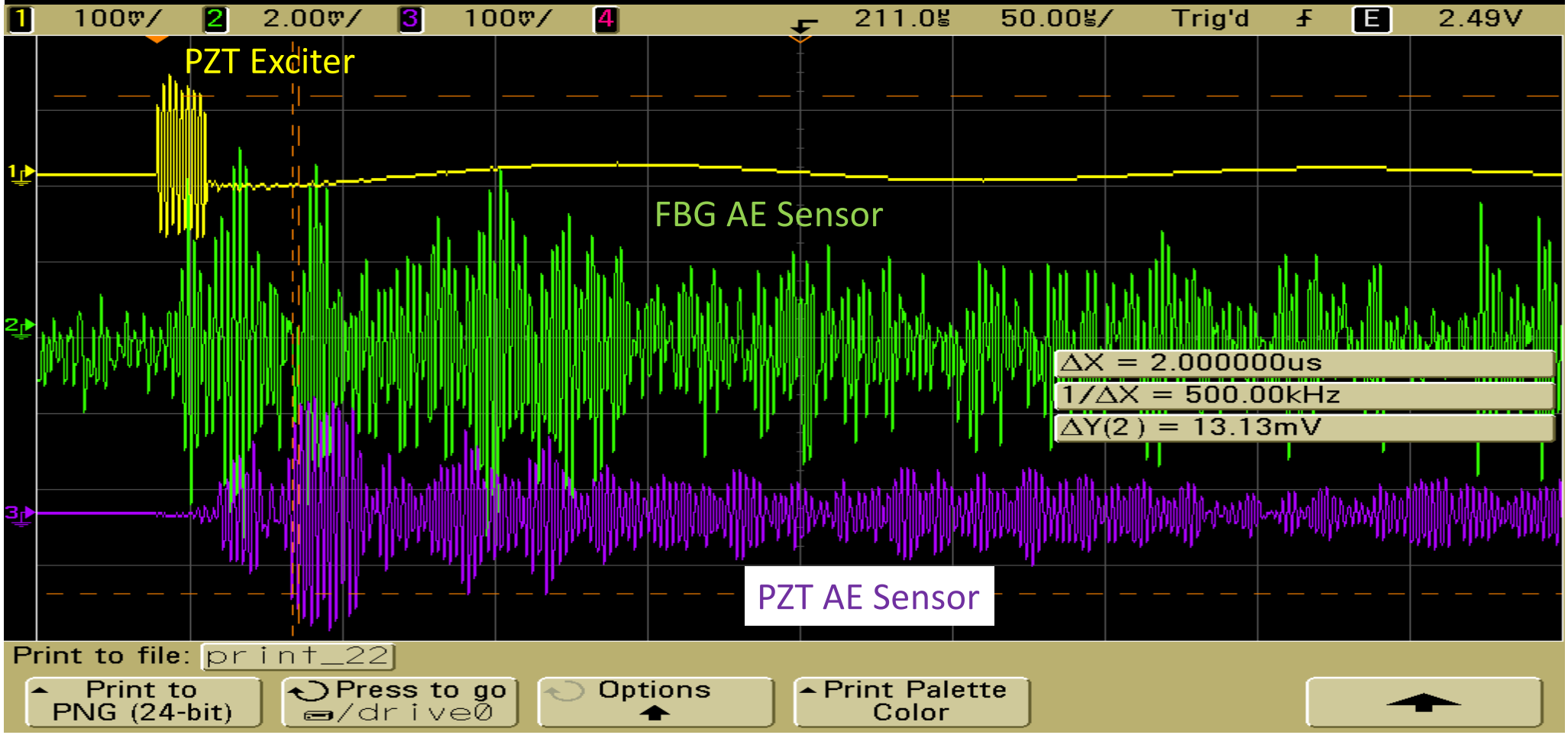


Adaptive Two-Wave Mixing Interferometric System for High Frequency Acoustic Emission Monitoring

Dynamically Reconfigure Adaptive Fe:InP Integrated Optic Microchip (1-cm wide x 2-cm long)



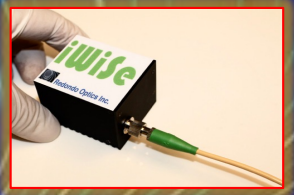
Standard Acoustic-Ultrasound Test



Redondo Optics Innovations Timeline
FBG Sensors & Interrogators

1st Product Launch
FBGT-200

Wireless Interrogator
Transceivers
5-Models

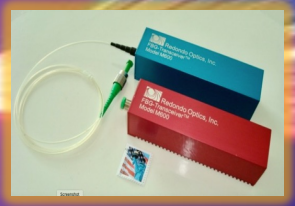


Over 200-Units Sold
$1-Million Sales

10,000 Units/Year Sales
$50-Million Business

2004 | 2007 | 2012 | 2018 | 2020 | 2022 | 2025 | 2030

Redondo Optics Inc.
Founded
1st DoD SBIR Contract



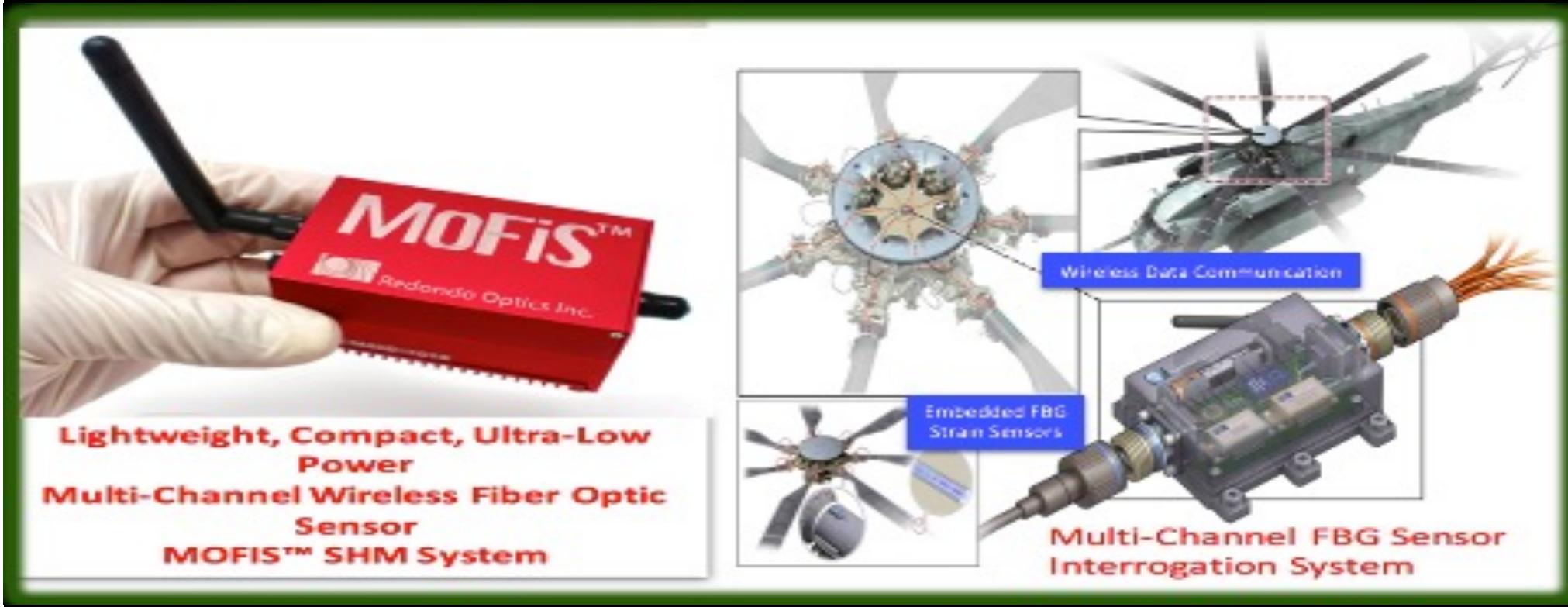
FBG-Transceivers
Passive Line Expansion
5-Models

FAESense-Transceivers
Dynamic Line Expansion
5-Models

Strategic Alliances
Active Marketing & Sales
Manufacturing Expansion

Infrastructure Market
- Railroads
- Roads, Bridges, and Tunnels
- Wind Turbines and blades
- Electric Grid
- Public Transit
- Electric Vehicles

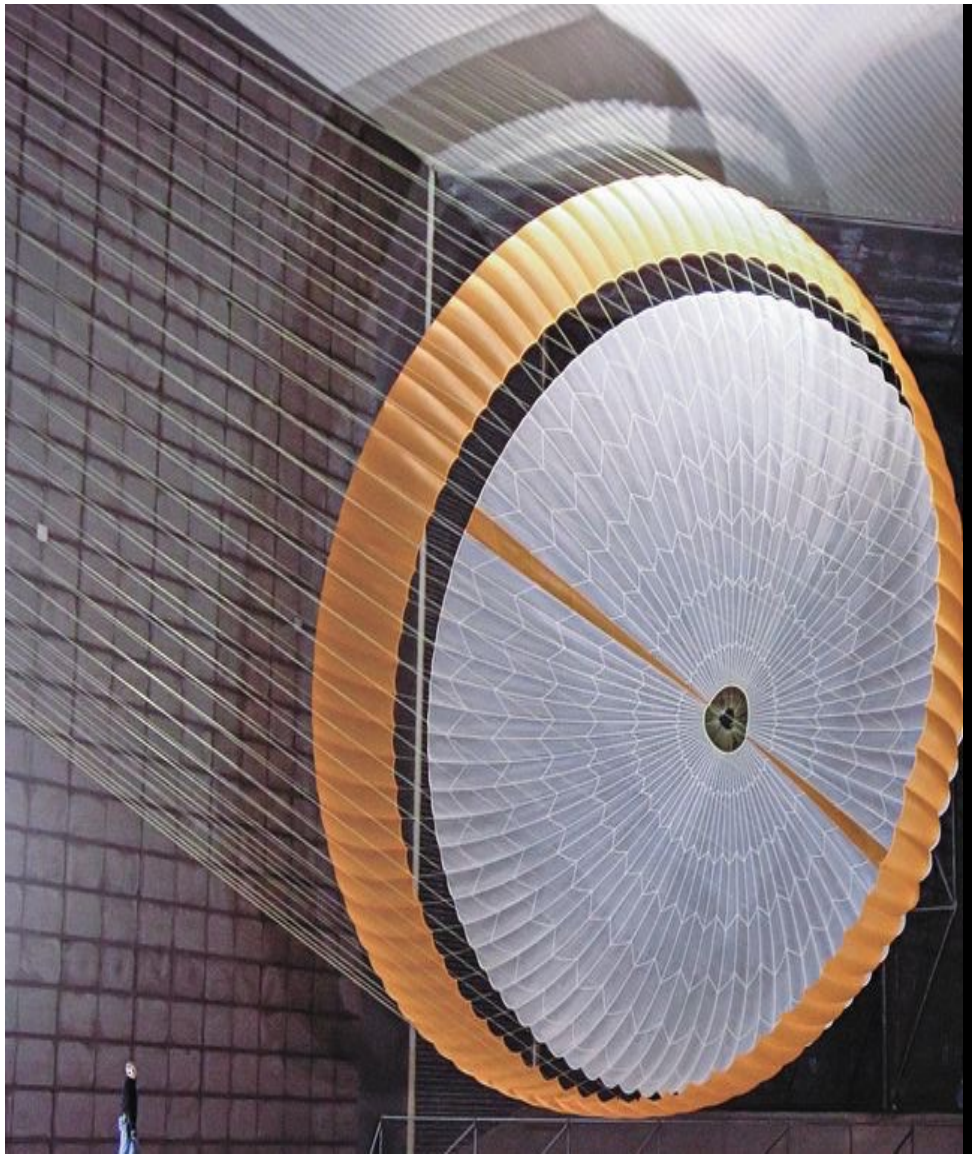
Real-time Condition Monitoring of Helicopter Blades



Light Weight, Self-Power, Wireless Fiber Optic Sensor (MOFIS™) System for the In-Flight Real Time Detection, Localization, and Classification of Fatigue Damage in Helicopter Rotors

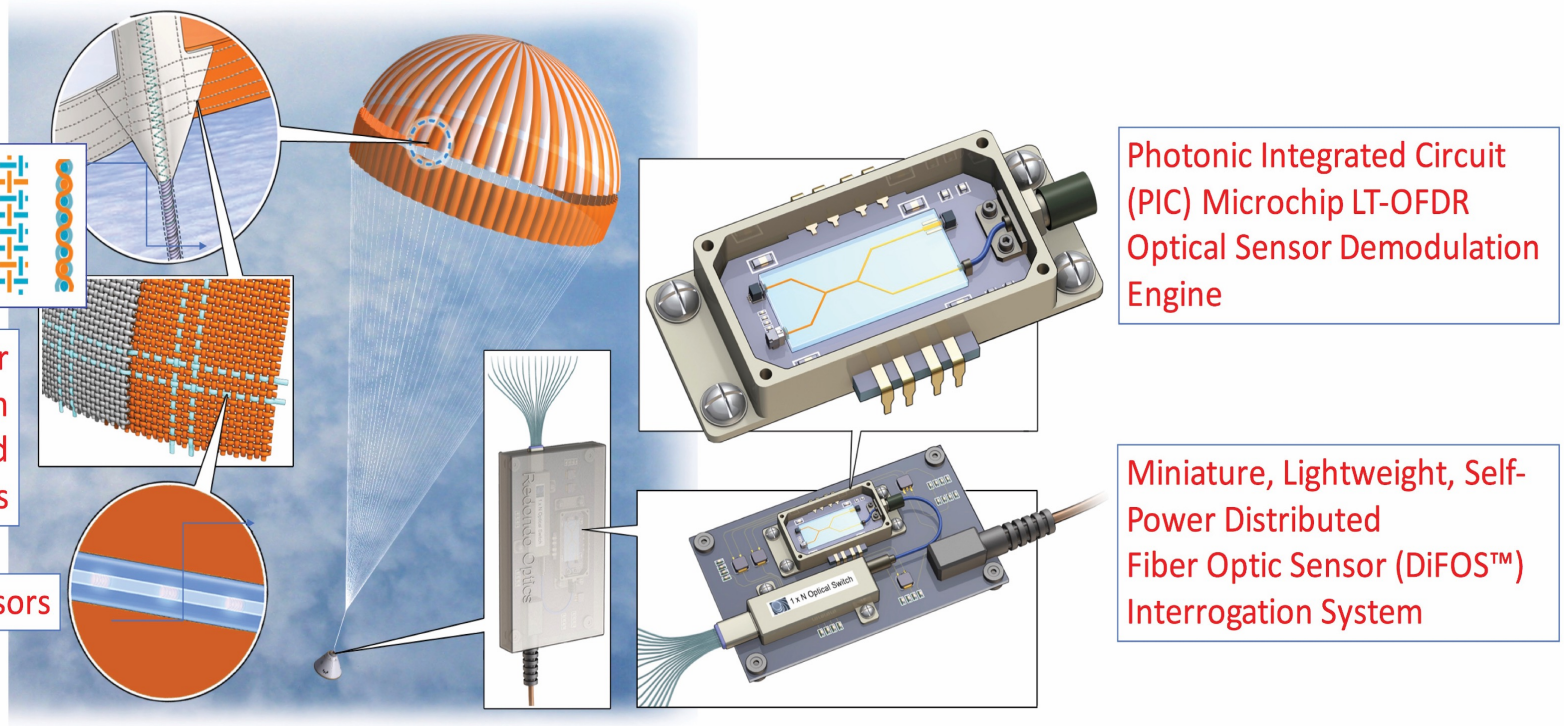
Fiber Multiplex WDM Based MOFIS System

Software GUI interface for performance testing of WDM MOFIS System under simulated test conditions on a down-scale helicopter rotor blade structure

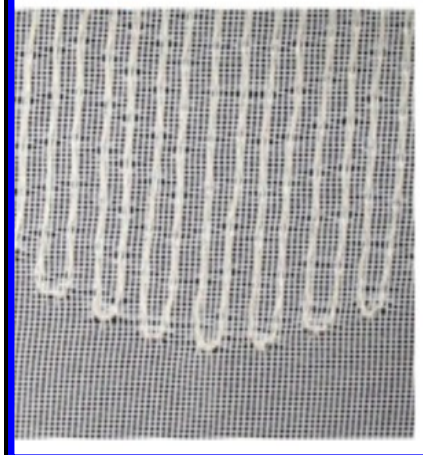


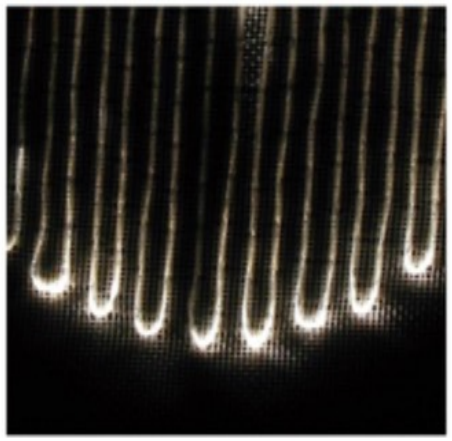
Smart Parachutes and Decelerators Fabrics Using Distributed Fiber Optic Sensors

Weaved Distributed Fiber Optic Sensor (DIFOS™) SHM System



Weaved Distributed Fiber Optic Sensor (DIFOS™) SHM System for Monitoring of Load/Stress/Strain and Potential Structural Damage in Supersonic Disk-Gap-Band (DGB) Parachutes



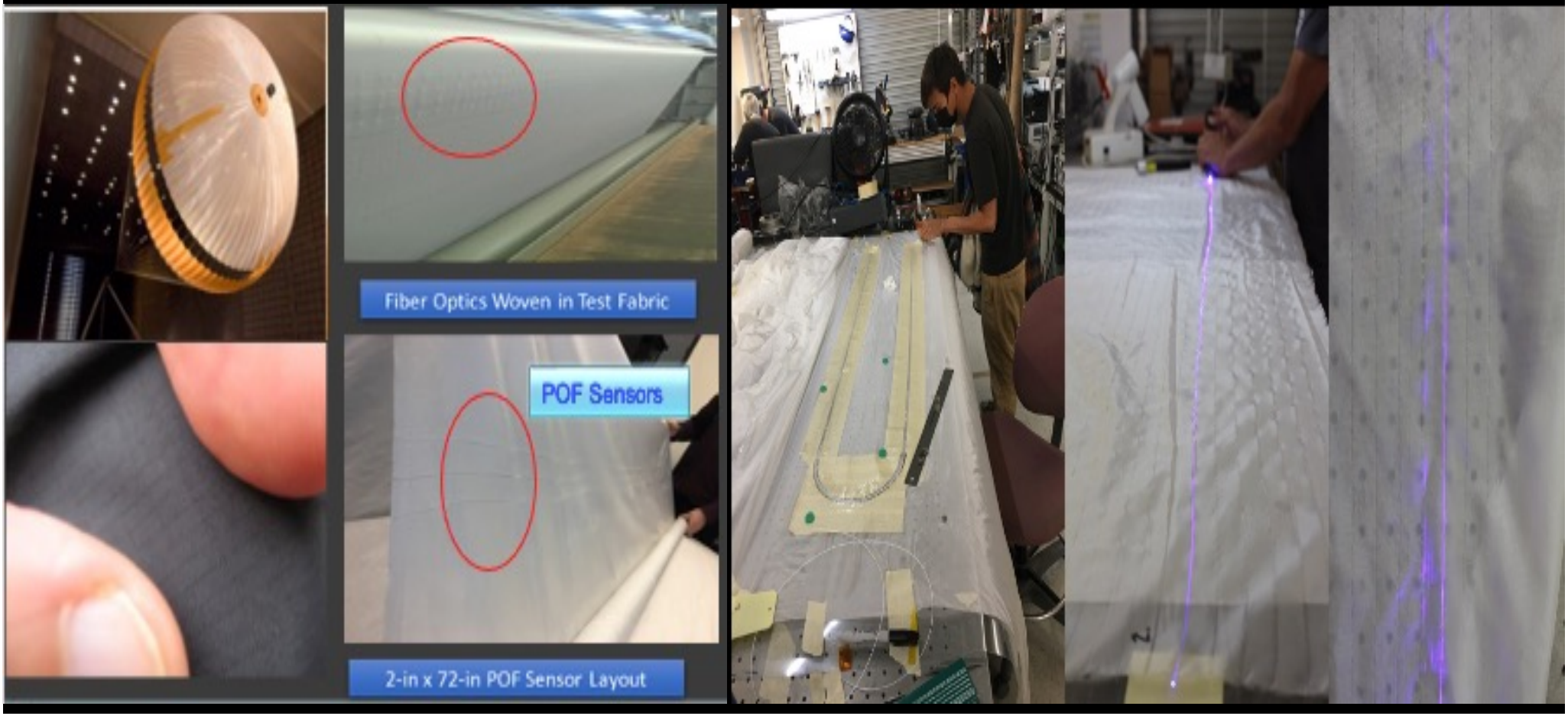


Weaved Distributed Fiber Optic Sensors

- Fiber optic strain gauge (FBG sensor) technology offers a very feasible alternative solution to electrical strain gauges since they are produced within a flexible and mechanically durable (glass or plastic) optical fiber typically of the order of 50-µm to 250-µm diameter that can be readily embedded – weaved – along with the natural or synthetic fiber materials used to produce the strands, yarn, ropes, and fabrics used in the construction of decelerator parachute or ballute structures.

POF sensors mechanical and thermal properties are ideal for use in the DIFOS™ SHM system with proven capabilities to withstanding elongation loads in excess of 40%, as well as temperatures above 100°C.

POF Sensors in Smart Fabrics

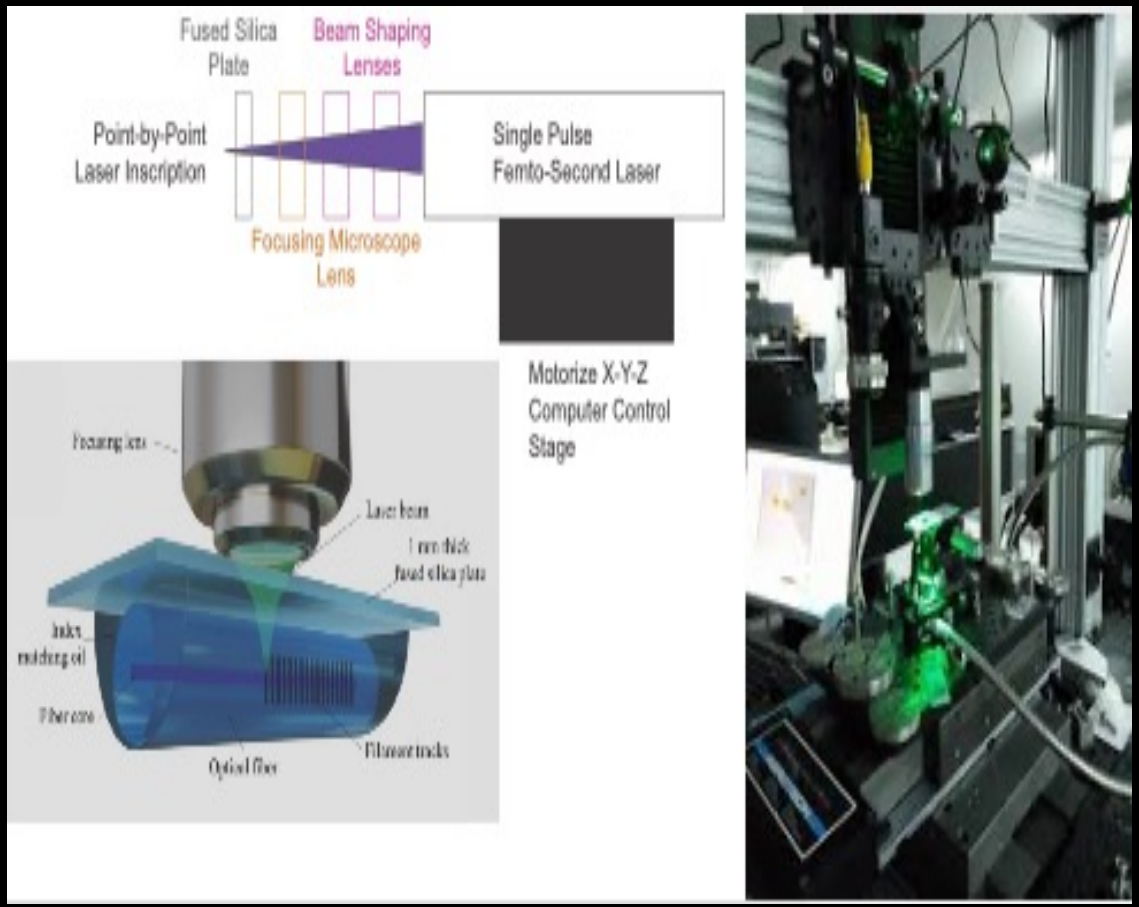


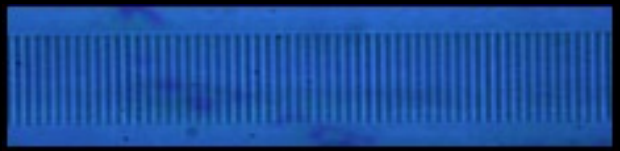
Polymer Optical Fiber Sensors

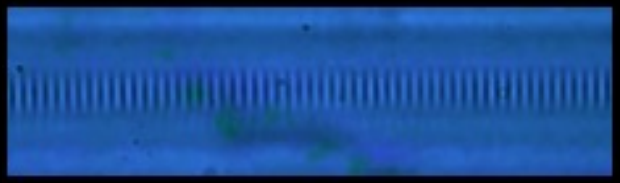
- **Polymer optical fiber (POF) Sensors** have the unique ability to measure high strain distributed along the **fiber** up to 40% using the **optical** frequency-domain reflectometry (OFDR) techniques.

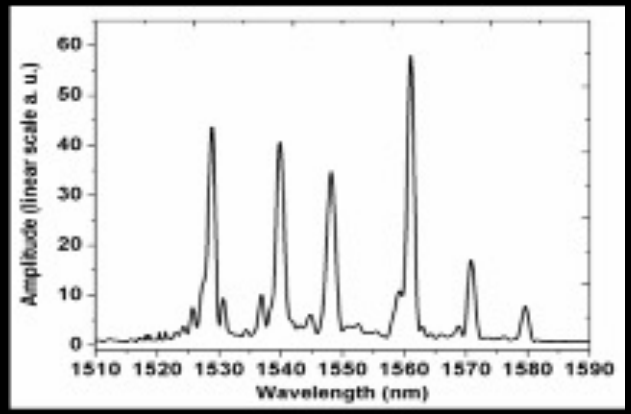
- Both, standard PMMA **fibers** and perfluorinated (PF) graded-index (GI) POF are introduced and evaluated in potential use and applicability.

Femto-Second Laser Inscribed POF-FBG Strain Sensors

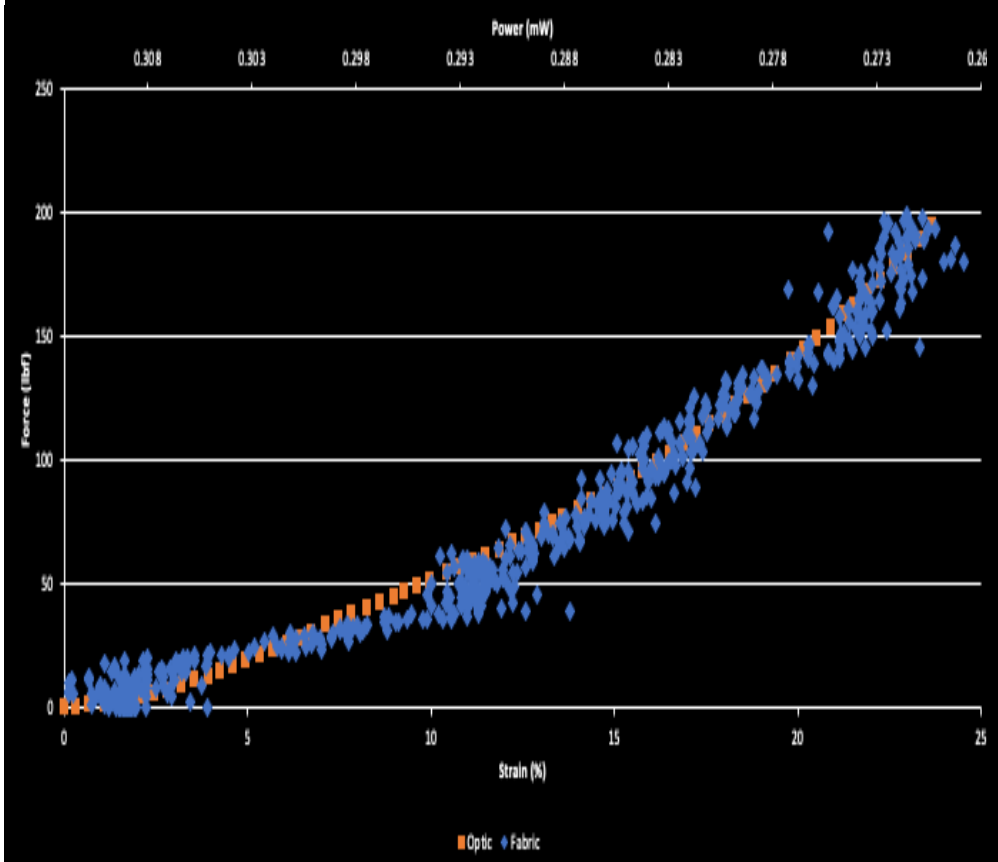


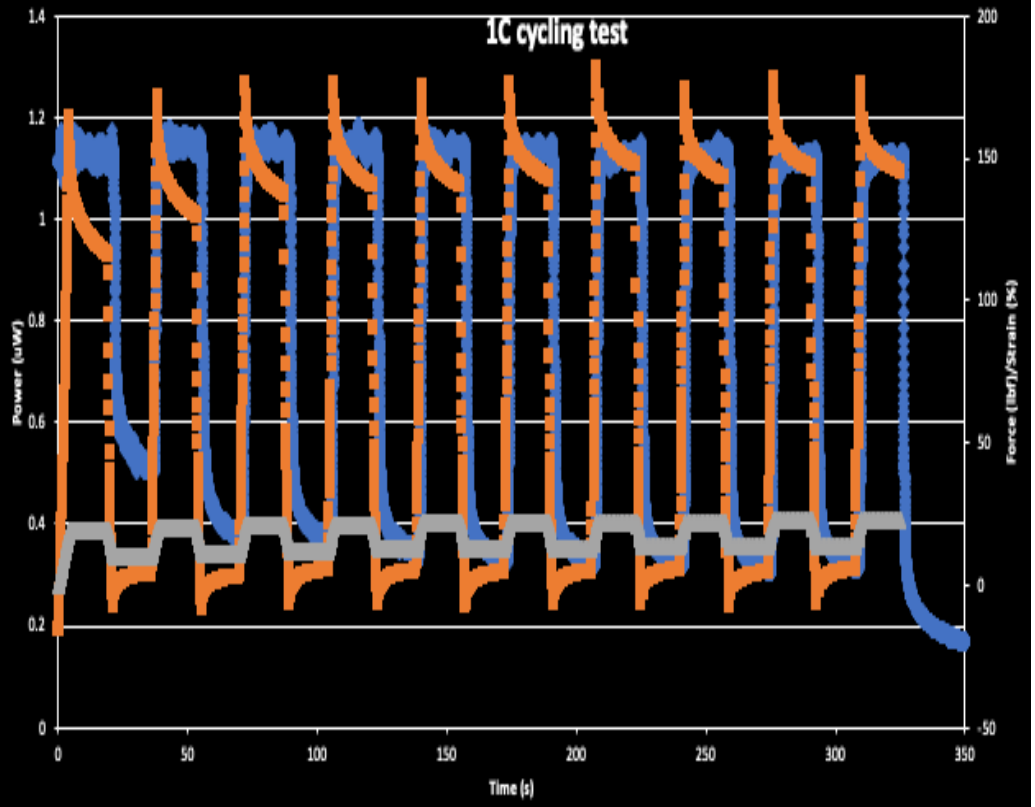






Force vs Strain and POF Signal
Load to 200-lbf






Screenshot


DiFOS™
Redondo Optics, Inc.


S/N:DIFOS-1000
Airborne Systems

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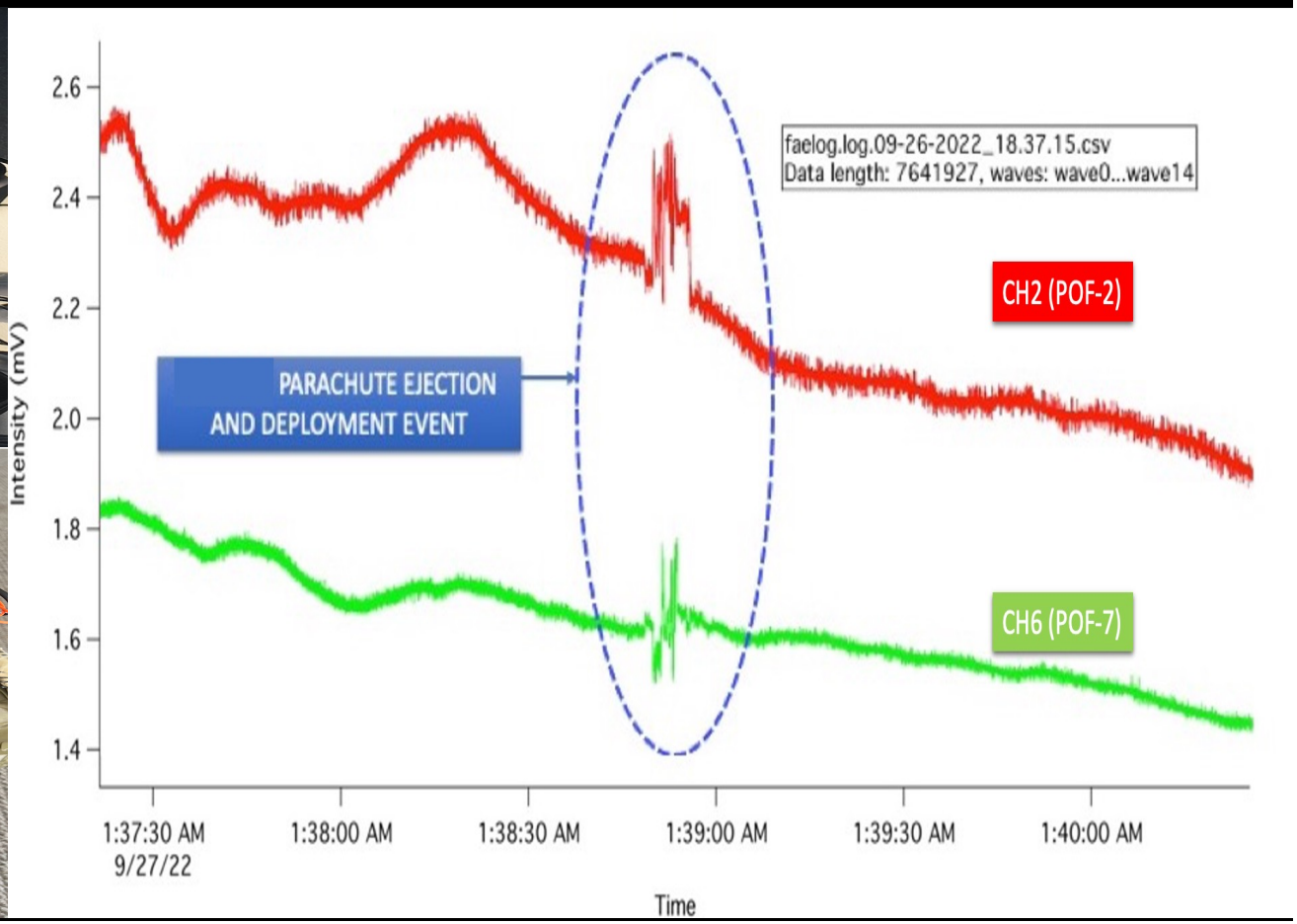
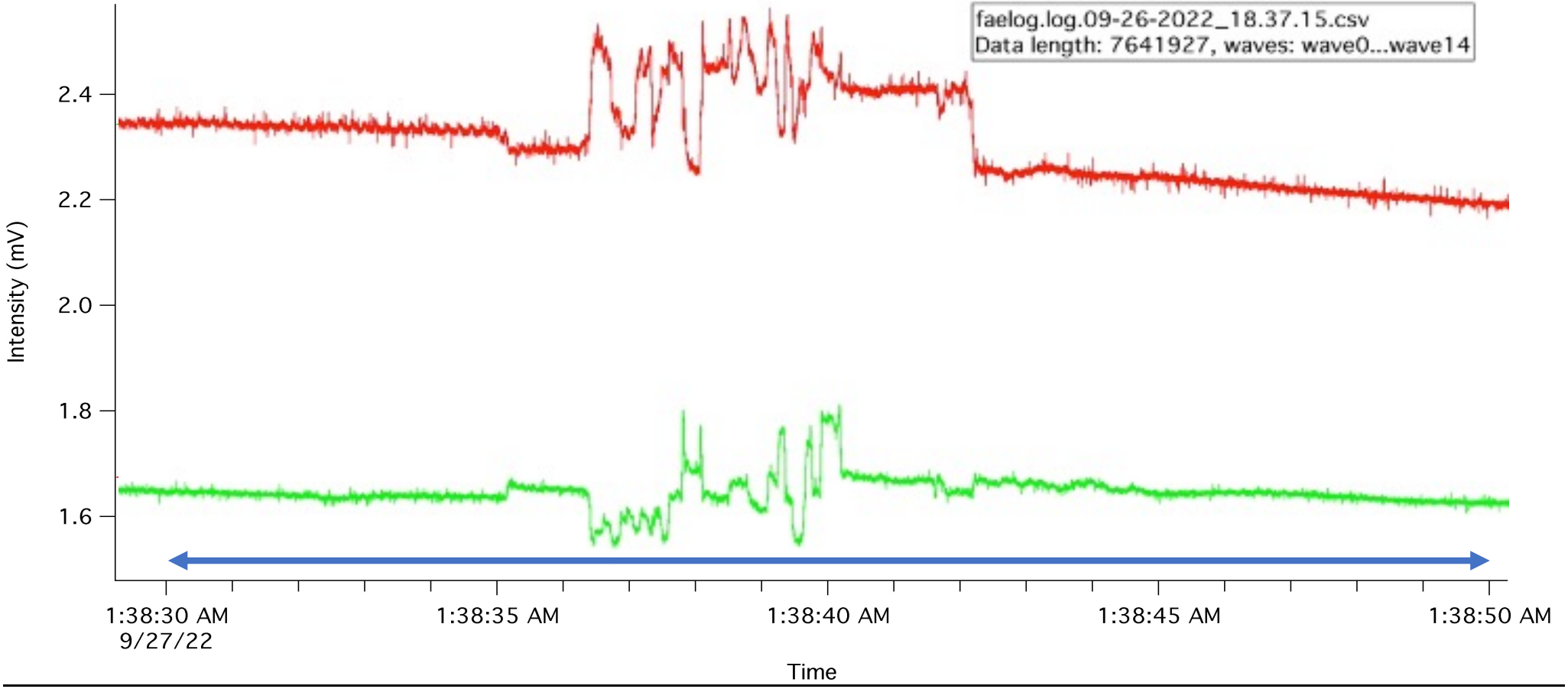
Parachute Gen I – POF-FBG Sensors –



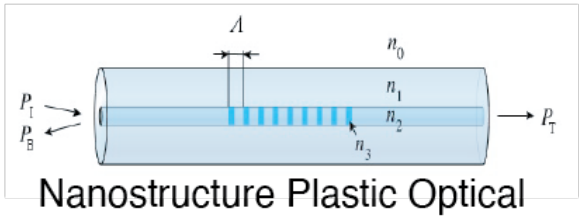
faelog.log.09-26-2022_18.37.15_CH2 (POF-2) and CH6 (POF-7)
Parachute Gen I – POF-FBG Sensors –



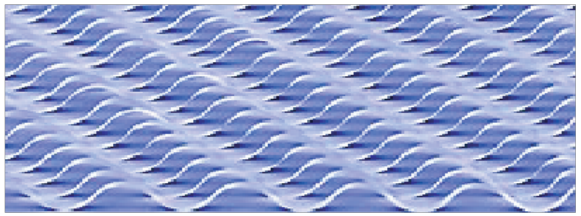
VISIOM™ Vital-Sign Physiology Monitor

- Smart fabric with arrays of weaved POF fiber sensors for monitor vital sign parameters such as Body movement, temperature, pressure, shock, respiration rate, hearth rhythm, blood oxygenation, CO_2 level, hydration level, sweat constituents (pH, salts, minerals, glucose, lactose, insulin), among others.

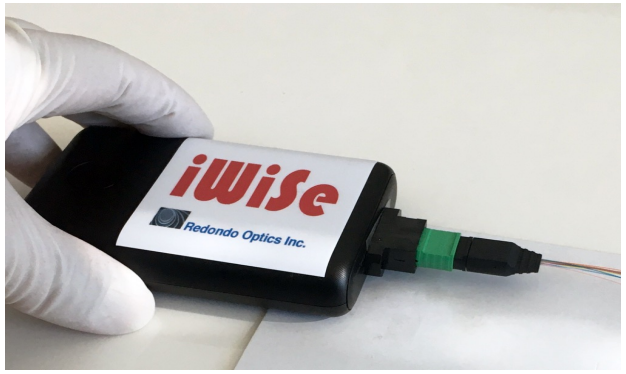
• Point-of-care diagnostics is a growing field, with novel tests being developed for a range of conditions and diseases including sepsis, influenza, Zika and preterm birth



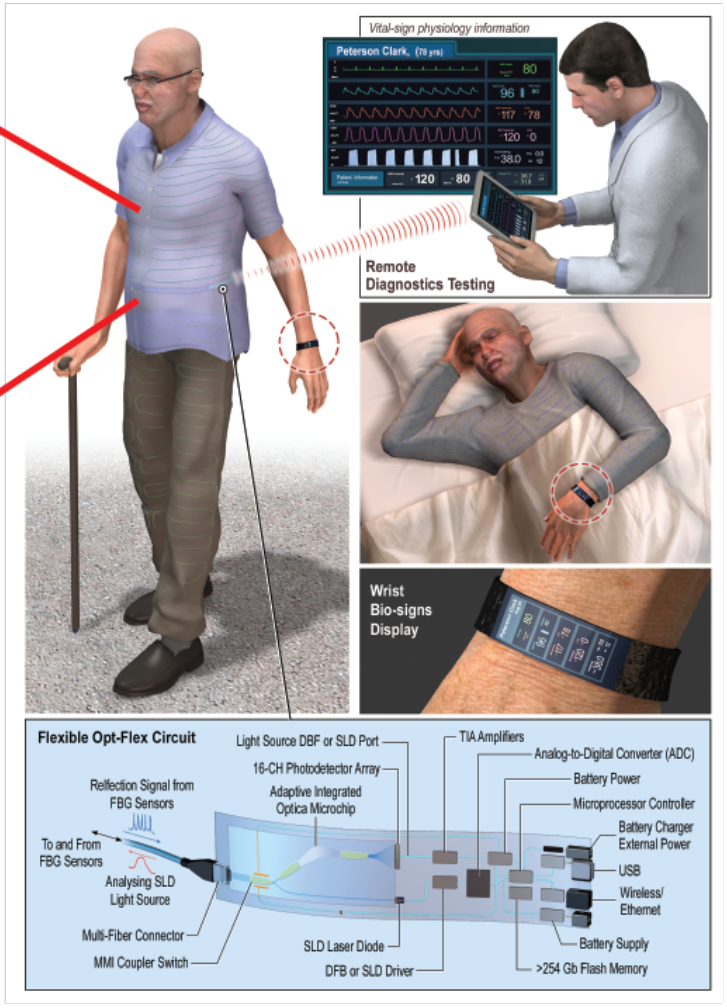
Nanostructure Plastic Optical Fiber Distributed Sensors

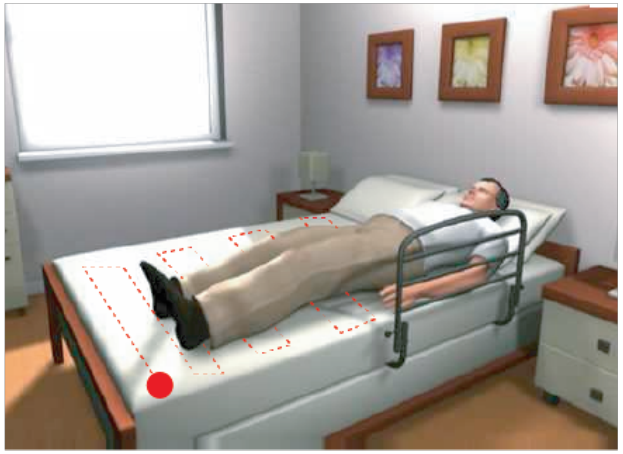


Smart Health Sensing Fabric



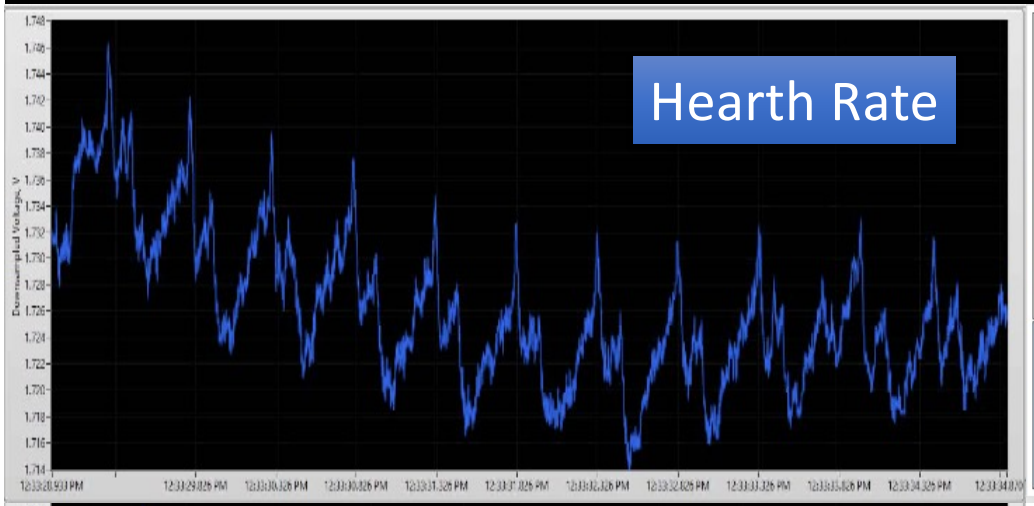
Battery Operated Wireless Optical Ttransceiver Interrogator

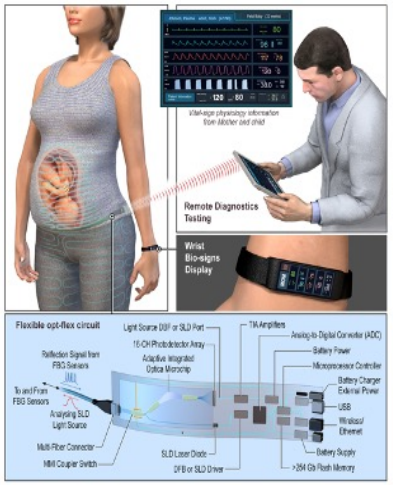


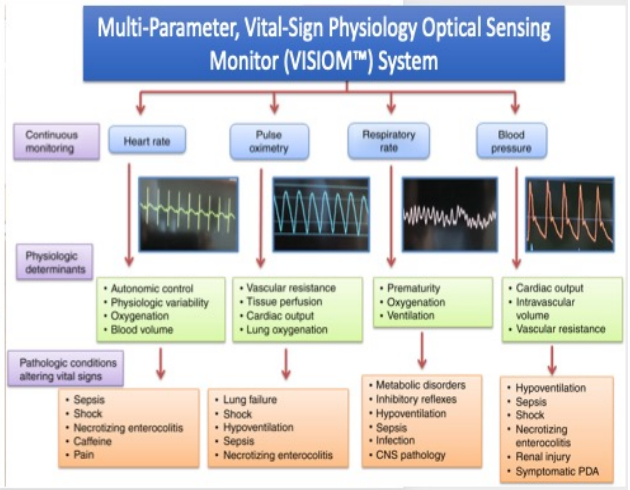


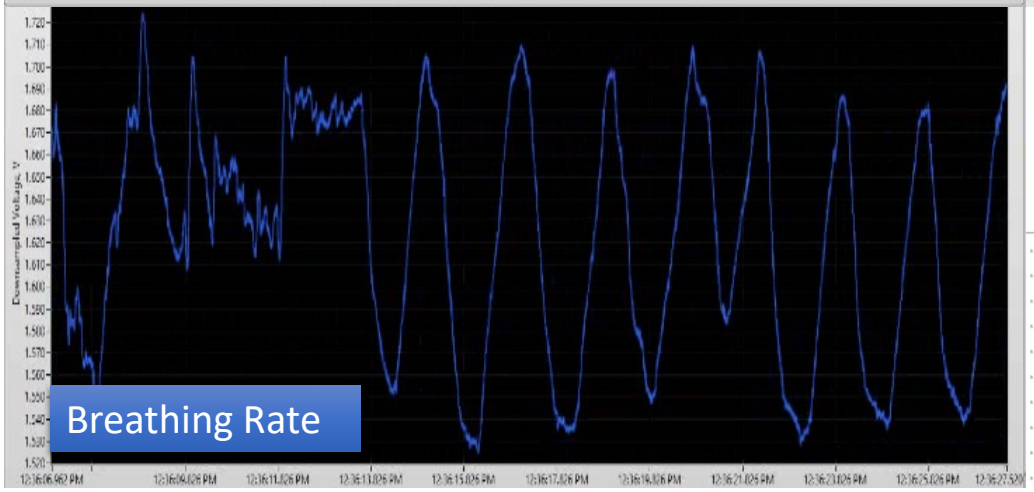
Smart Health Vital Sign Optical Sensing Monitor (VISIOM™) System

Multi-Parameter Physiology Monitor

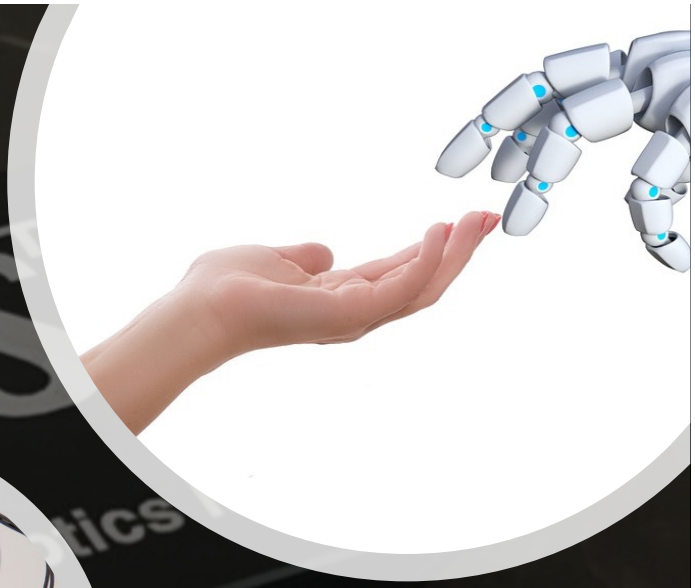


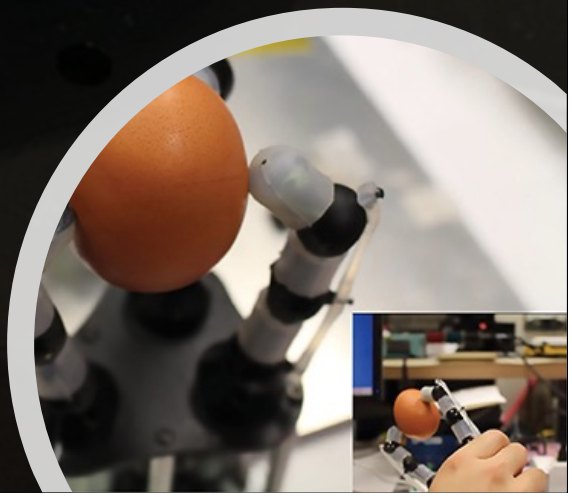






Fiber Optic “Nerves” in Robotics, Exoskeletons and Prosthetics

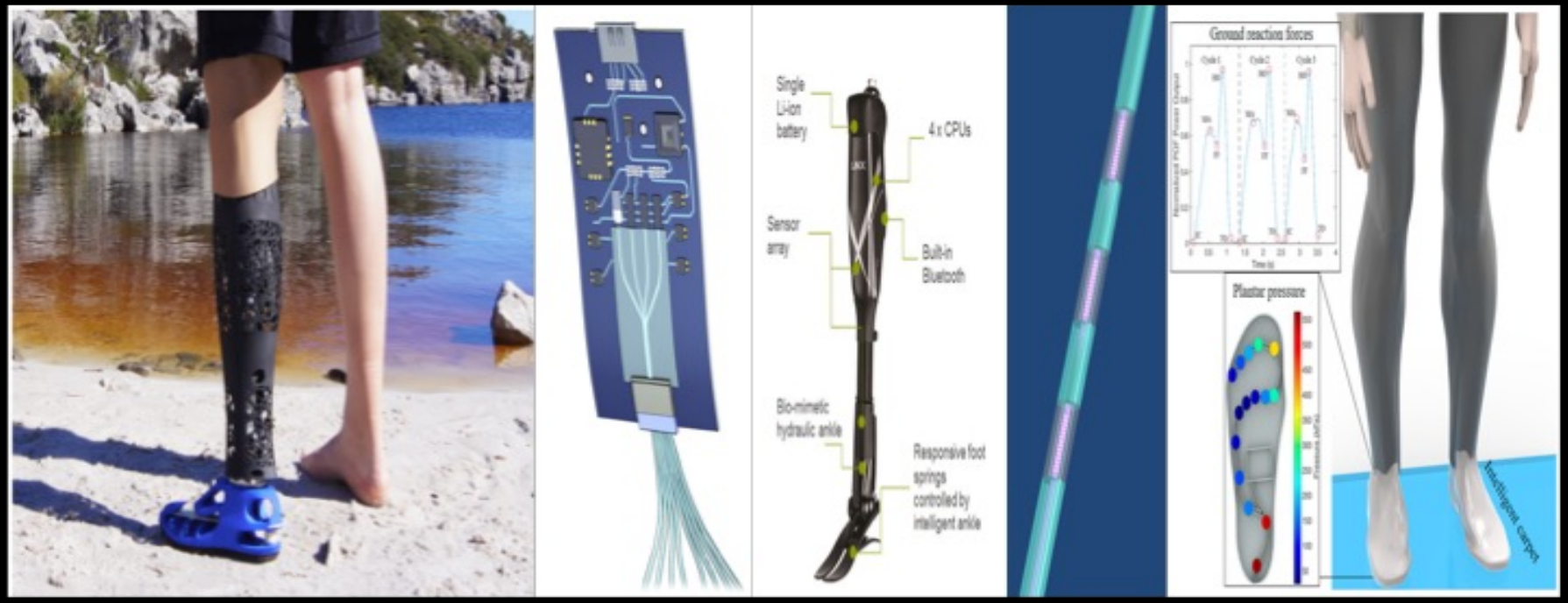




Stretchable plastic optical fiber strain, temperature, and pressure tactile sensor gives a human touch

Smart Prosthetics

Develop and demonstrate innovative fiber optic sensor solutions for Smart Prosthetics using advanced in-situ multiplexed fiber optic “nerve” sensing systems (iNSens™).



The smart prosthetic iNSens™ system integrates a distributed array of multi-point FBG sensors to measure all the passive and dynamic movements of the prosthetic interrogated in real time by a seamless smart “flex-optical-circuit” assembly

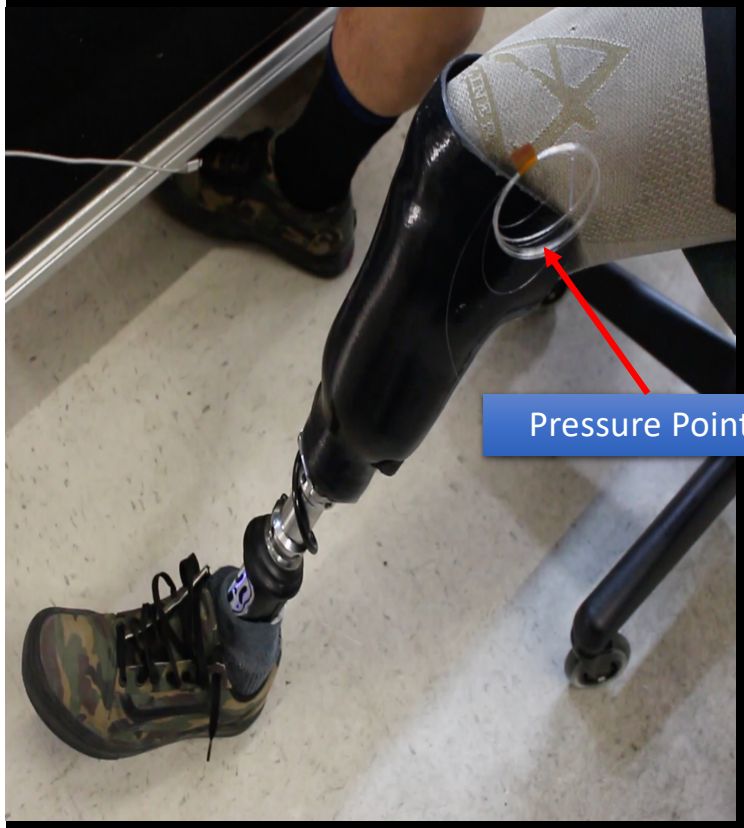
Soft Exoskeletons for Assisting Leaving of US Elder Population Using IcVISIOM™ Fabrics

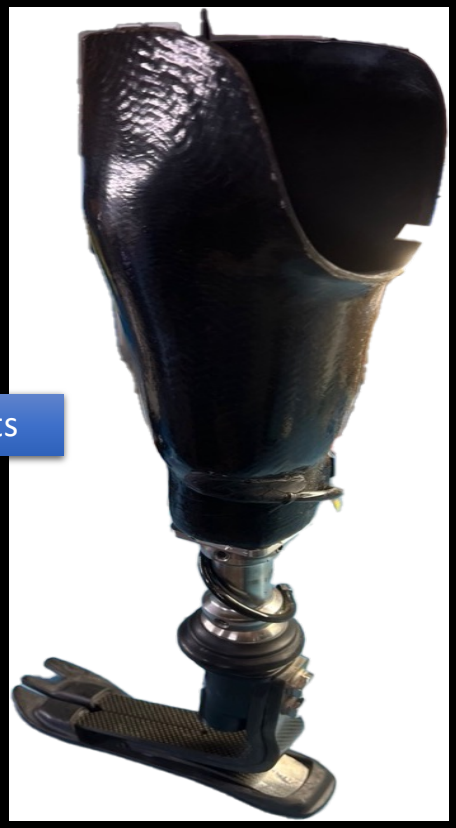
- Using form-fitting, fabric-based designs that are lightweight and non-restrictive, the Wyss Institute's soft exosuit uses compact, powerful actuators packaged in a belt to provide assistance to the wearer's legs in a physiologically relevant manner. These enhanced movements assist wearers in walking with greater stability and metabolic efficiency, which could prevent injury and reduce fatigue.

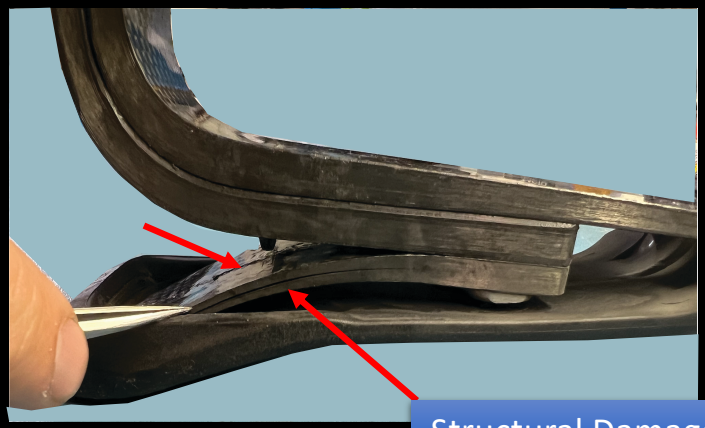
Currently in the United States, there are an estimated 3 million stroke patients and 400,000 MS patients who are suffering from limited mobility due to lower limb disabilities.

Inflatable composite material fabrics provide a high-strength "muscle-like" response to the user need back, legs, and limbs brain stimuli

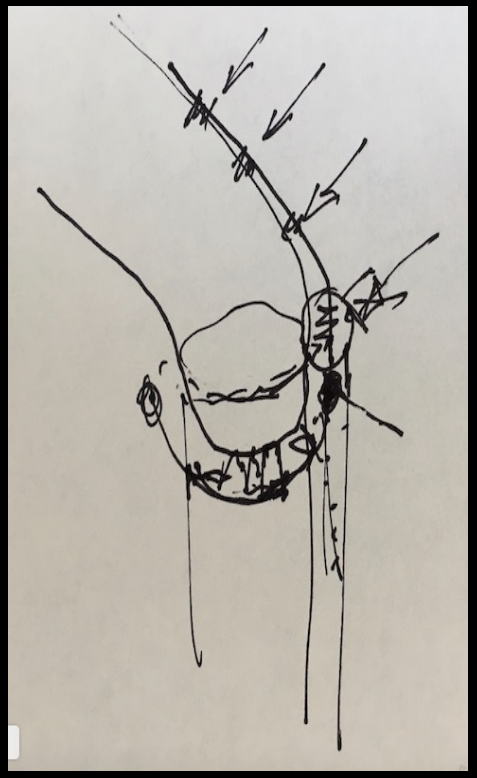
Smart Prosthetics Instrumented with iNSens™ System



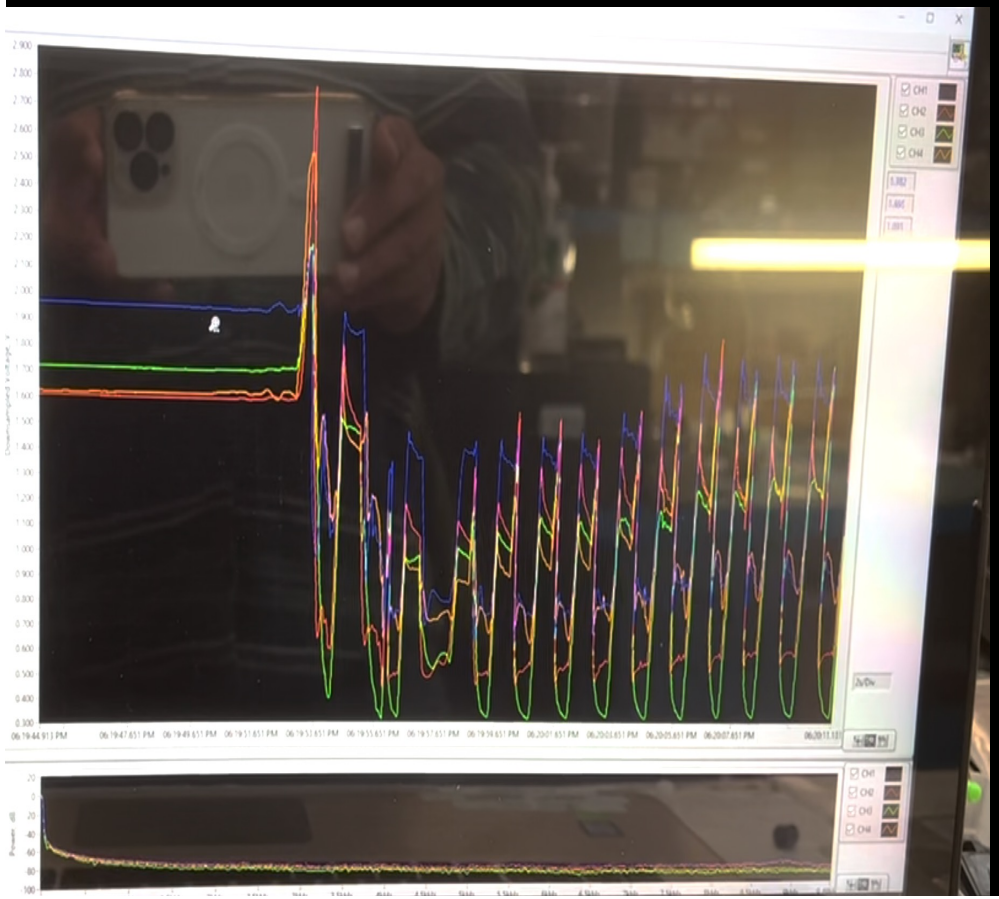


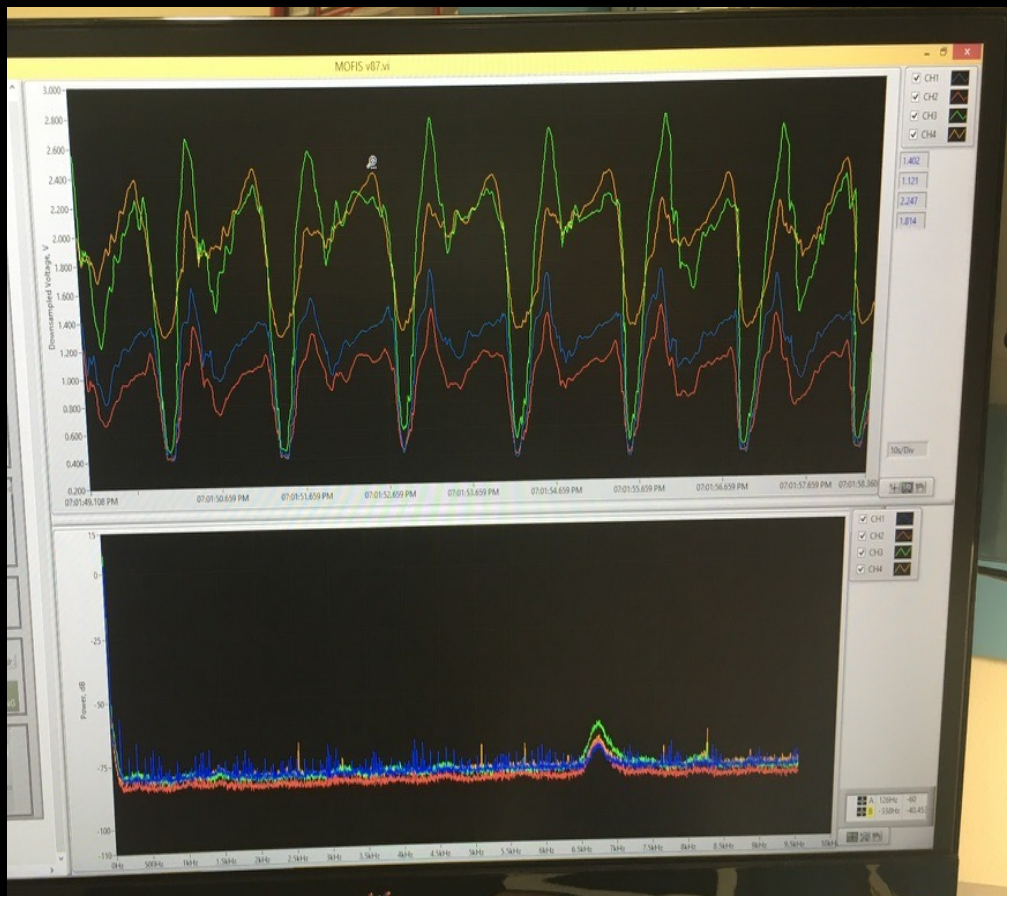


InSens™ Smart Prosthetics

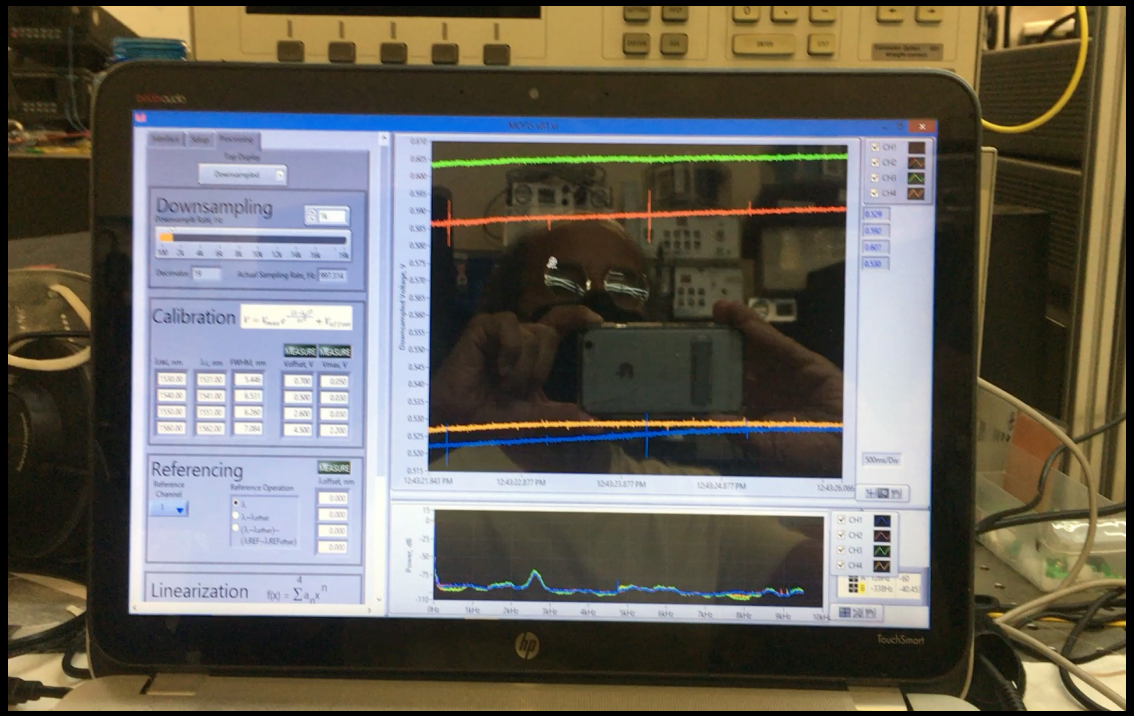


Bio-Mechanics of foot and knee bending during walking



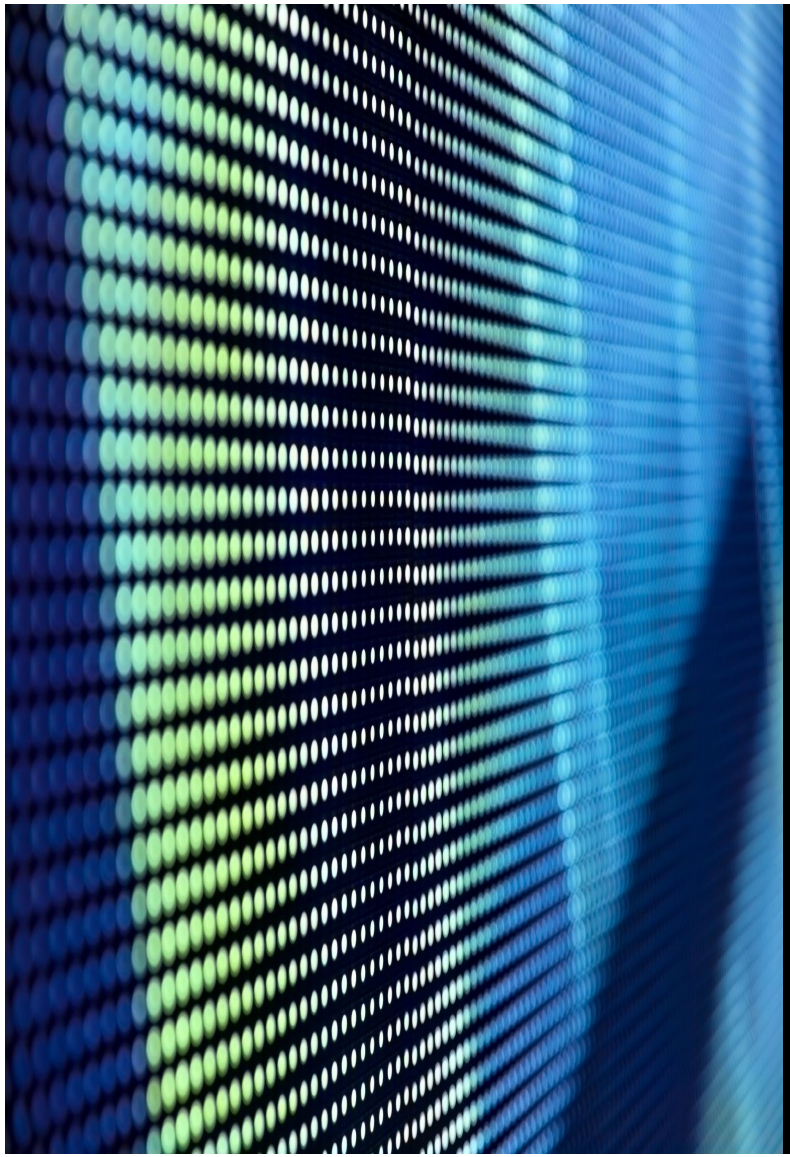


InSens™ sensors within knee and bottom foot of prosthetic



ROI Growth Plans and Investment Strategy

Looking to position for expansion within the Infrastructure market seeking partners to ramp up production and market penetration with the strategic support of policy makers and contractors.



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