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#WebinarsAEMAC

25 de Octubre, 16 h (Madrid, GMT+2)

WebinarsAEMAC Nº52

Monitorización en tiempo real de los materiales compuestos desde su proceso de fabricación a su uso en aplicación mediante sensores de fibra óptica

SALVADOR SALES

Investigador
del Photonic Research Labs

Universidad Politécnica de Valencia (UPV)

WEBINAR

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Monitorización en tiempo real de los composites desde su fabricación

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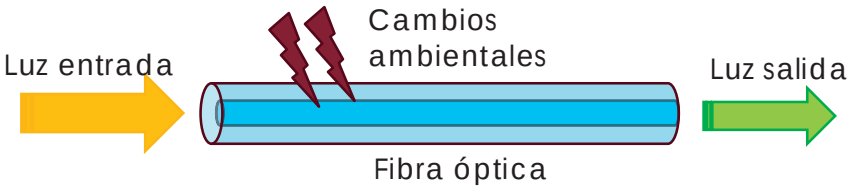
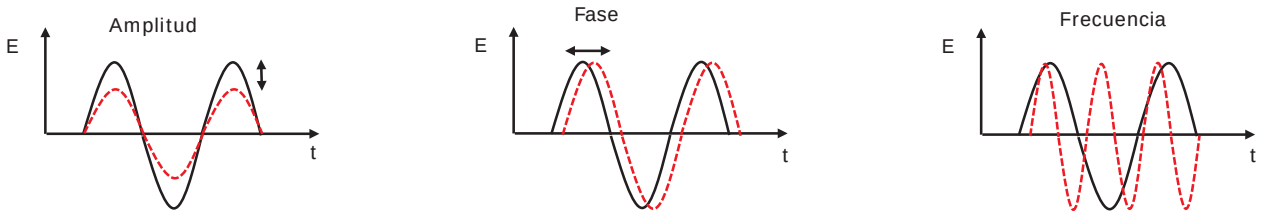
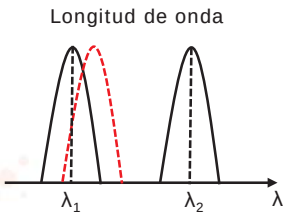
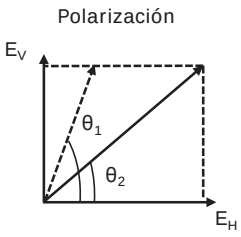
Sensor de Fibra Óptica

¿Cómo funciona?

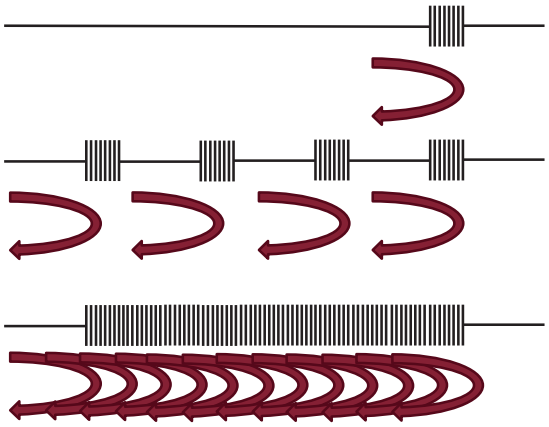








- Single-point sensor
- Multi-point sensor
- Distributed sensing



- Transmisión vs Reflexión (acceso solo por un lado vs acceso por dos lados; simple vs redundancia/señal-ruido)

Basados en los beneficios inherentes de la fibra óptica

- Small size (usually around 125-200 microns diameter, custom from 30 microns (even less to millimeters)
  - "Easy" to embed in structures/composites / ¿low structural impact?
- Lightweight (aerospace, high-speed cars/ships, etc)
- Low attenuation. Sensor can be places up to 100 km far from the central unit
- Passive
  - Immunity to electromagnetic interference
  - No risk of ignition / ATEX Compatible / Suited to hazardous ambients
- Fast answer (many sensors can be monitorised up to MHz frequency sampling, even more GHz range)
- Possible to multiplex hundreds/thousands of sensors in a single optical fiber, every millimeter or less.
  - Enables distributed sensor netwoks / Continuous remote real-time monitoring
- Custom packaging and installation (depending on the application and environment)
- Compatibility with traditional sensors.
- Silica is a very stable material : resolution, accuracy, long-term behavior
  - Novel composites materials are being studied / tested / employed

Sensores de fibra óptica

¿Por qué no?

- Wired sensors
  - Fiber + source + detector should be installed
  - ✓ Solutions? Integrated photonics / give us some time/investments ;-)

- Datalogger (central unit. Source+detector+electronics) cost
  - ✓ Market increasing / price decreasing … Integrated photonics / give us some time/investments ;-)

- Unkown sensors
  - ✓ Here we are
  - »» Of course Fiber Sensors are not the solution for everything … maybe Photonic Sensors ;-)

Basados en los beneficios inherentes de la fibra óptica

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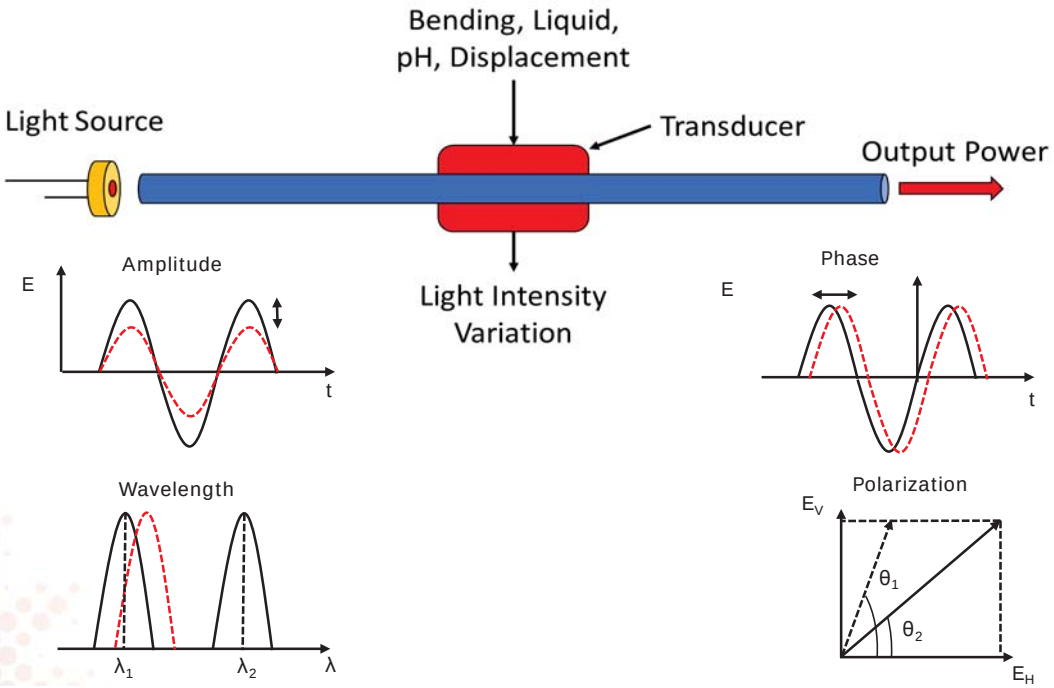
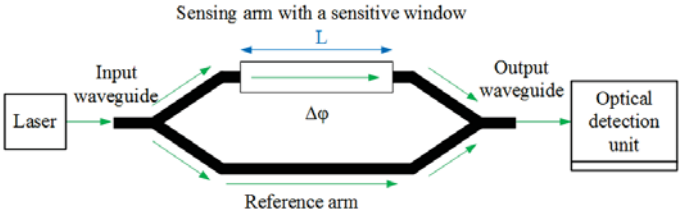
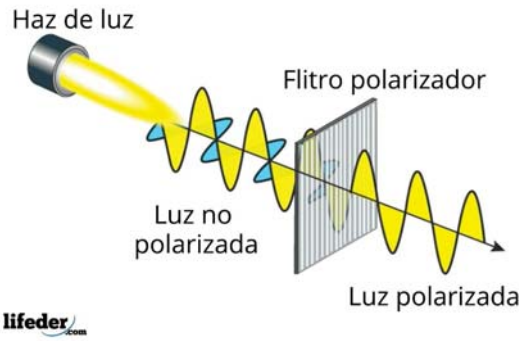
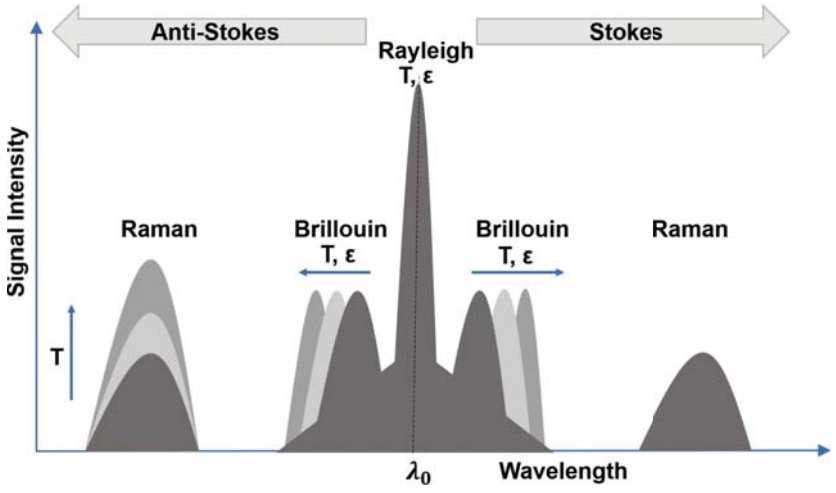
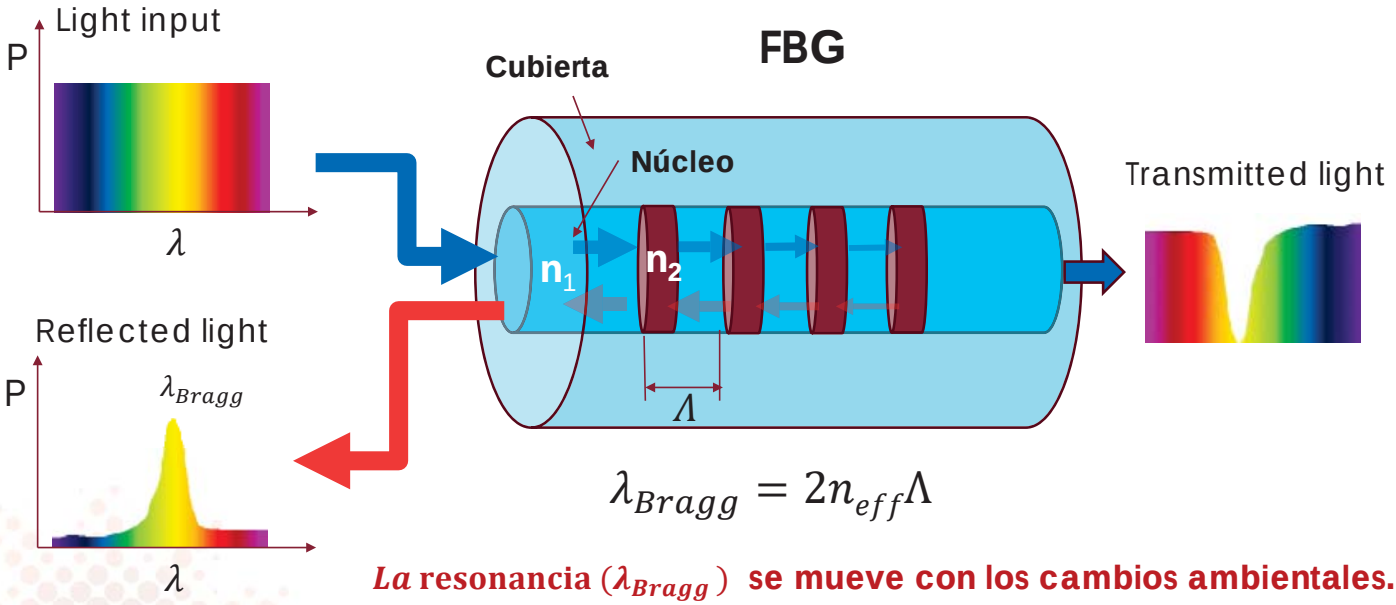

Bending, Liquid,
pH, Displacement
Light Source
Transducer
Output Power
Light Intensity
Variation
Amplitude
E
t
Phase
E
t
Wavelength
λ1
λ2
λ
Polarization
EV
θ1
θ2
EH


Sensing arm with a sensitive window
L
Input waveguide
Laser
Δφ
Output waveguide
Optical detection unit
Reference arm

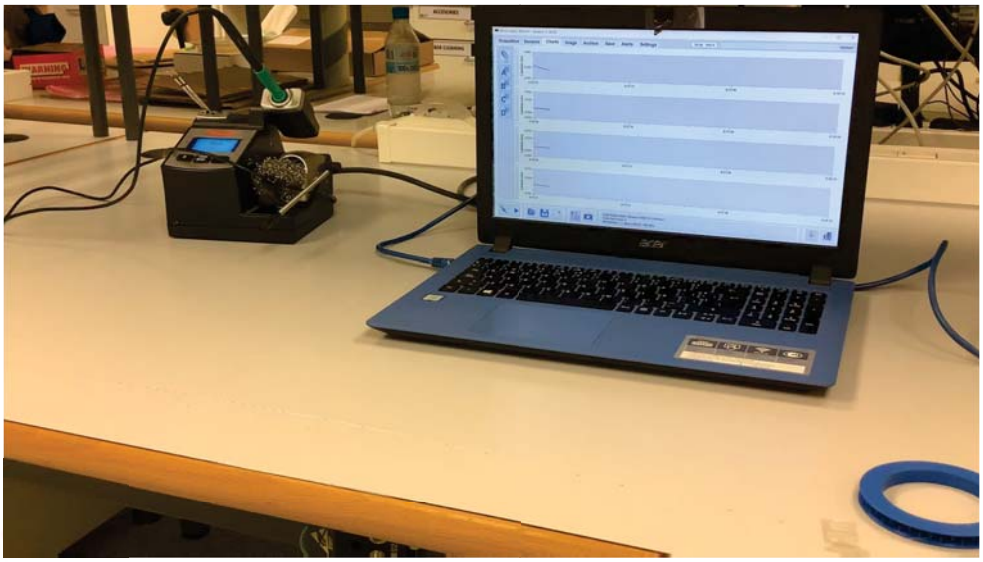

Haz de luz
Flitro polarizador
Luz no polarizada
Luz polarizada
lifeder


Anti-Stokes
Stokes
Rayleigh
T, ε
Signal Intensity
Raman
Brillouin
T, ε
Brillouin
T, ε
Raman
T
λ_0
Wavelength

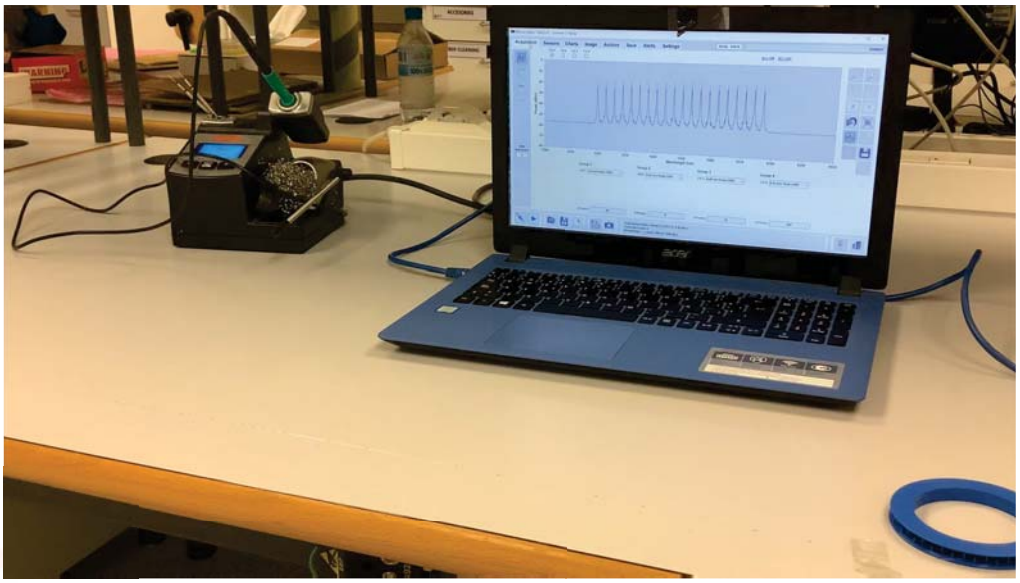


$$\lambda_{Bragg} = 2n_{eff}\Lambda$$

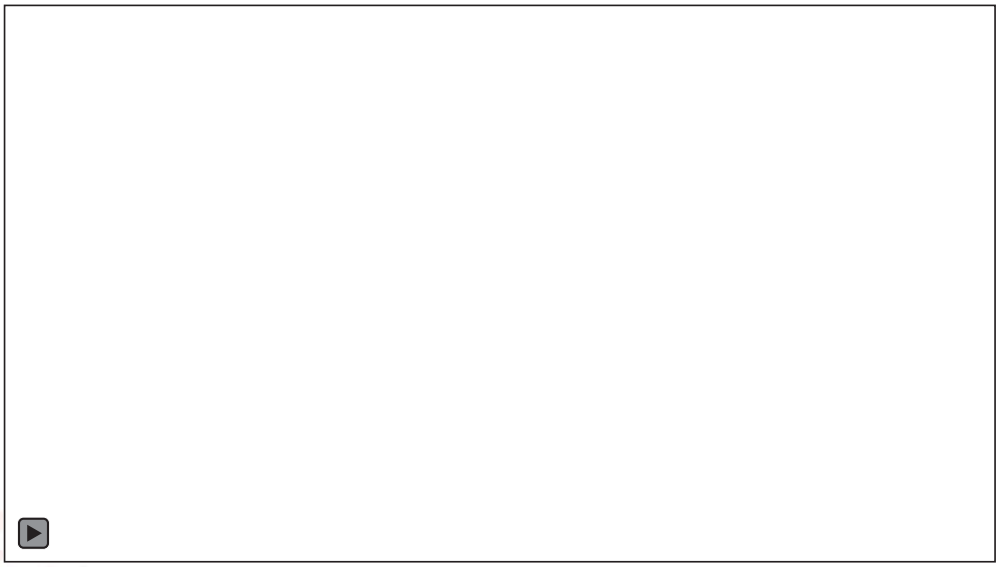
***La* resonancia (λ_{Bragg}) se mueve con los cambios ambientales.**



4 **FBGs en una sóla fibra**

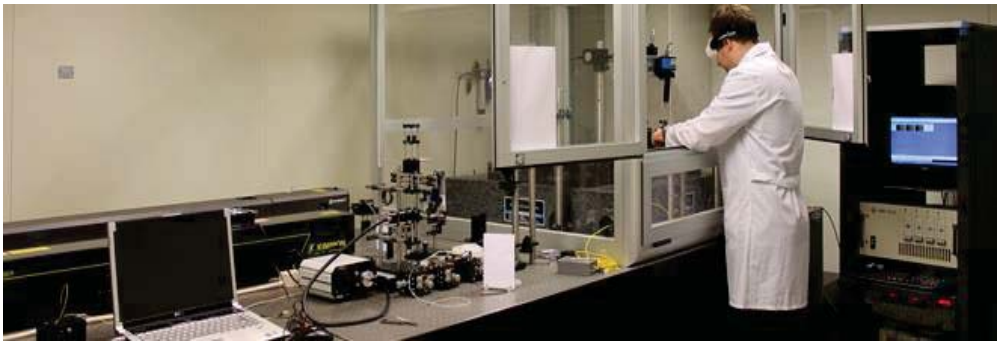


20 FBGs en una fibra

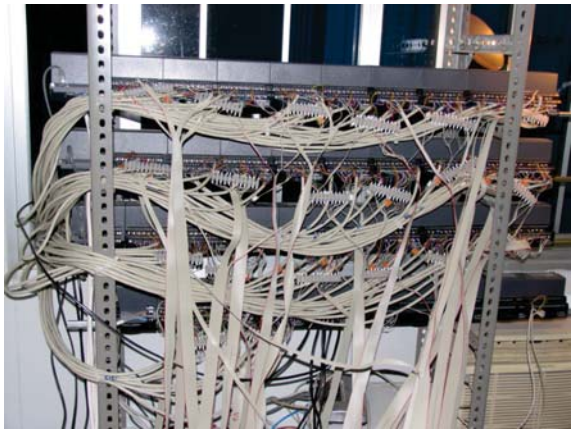


Fiber Bragg Gratings (FBGs)

Fabricación/ Nuestra experiencia



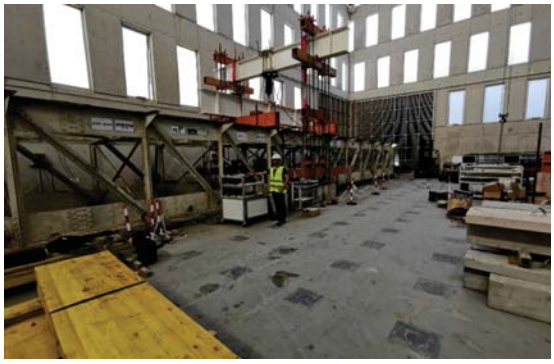
- **We have our own facilities to manufacture optical fibre sensors.** Unique fabrication systems. Collaborators world-wide.
- **Start: 2001 UE Project:** "Optical Fibre Sensors for Small Office Home Office", OFFSOHO (IST-2001-37052).
- InnoSpace H2020-ERC-COG-2016 724663, FINESSE MSCA-ITN-2016-ETN-H2020, BlueSpace H2020-ICT-2016-2, PROMETEO Research Excellence, National Research projects (PID2020-118310RB-I00, TEC2017-88029-R-AR, PDC2021-121601-I00, etc)

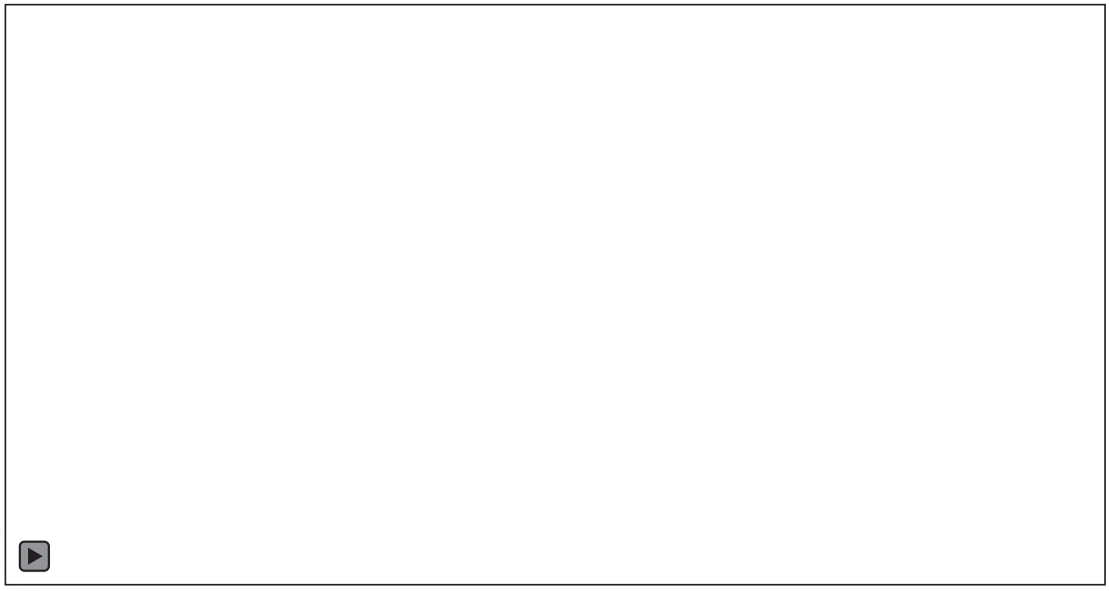


- **Sólo una fibra puede sustituir a todos estos cables (50 Sensores/FBGs en una sóla fibra)**
- **Estabilidad/mejora ruido/precisión**

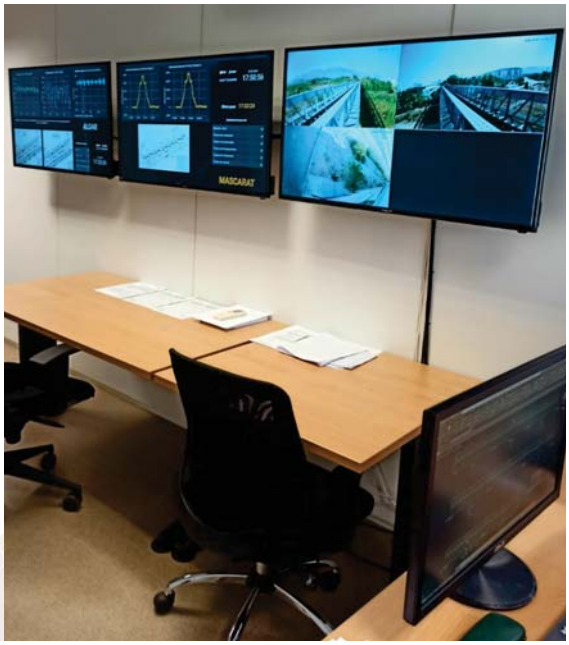
Fiber Bragg Gratings (FBGs)

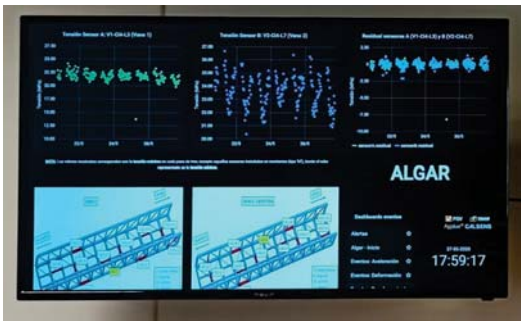
Structural Health Monitoring / Monitorización estructural





Sistema en tiempo real de monitorización de más de 500 sensores en tres puentes

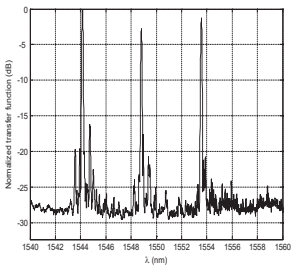


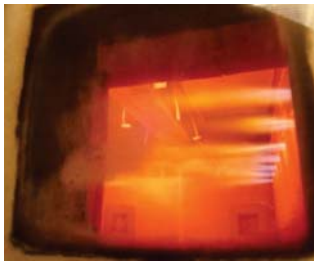


Fiber Bragg Gratings (FBGs)

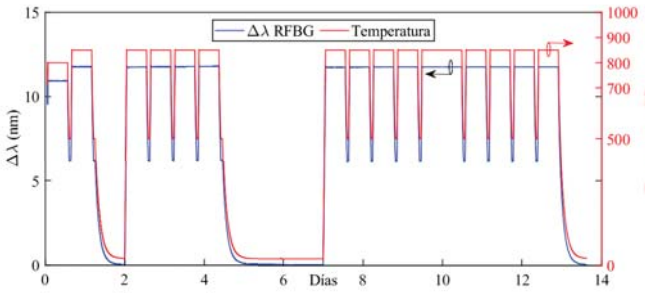
Muy alta temperatura

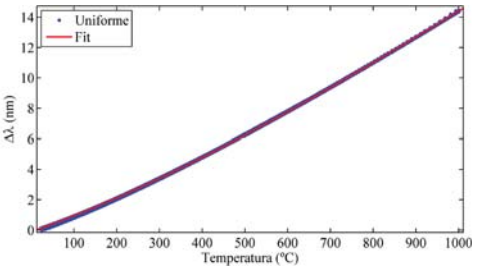
Array of 3 sensors at the end of the fiber



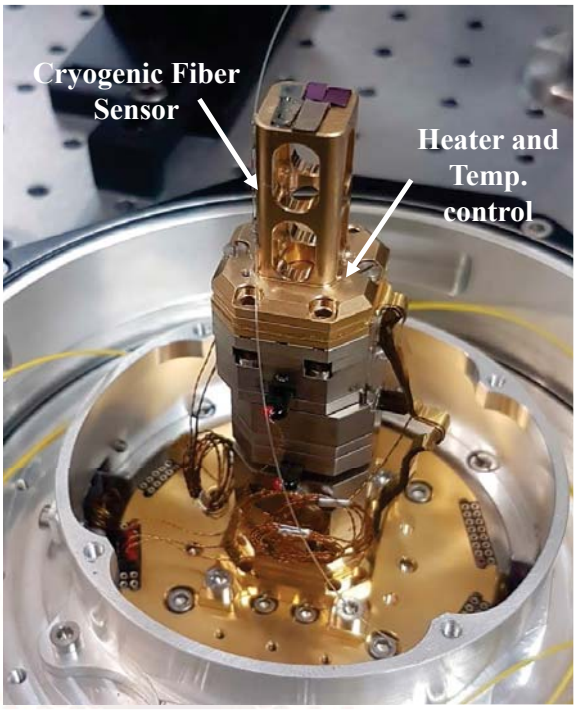


"ISO 843 fire test"



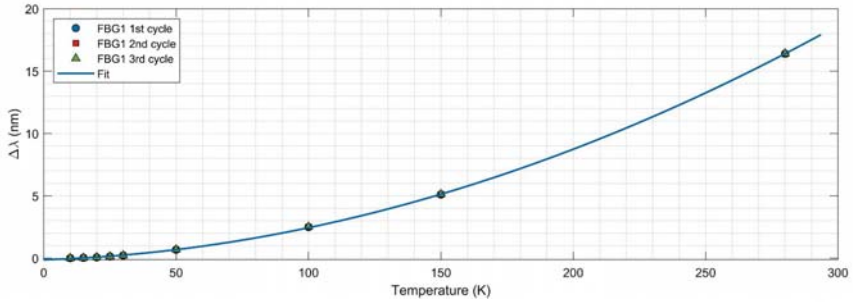


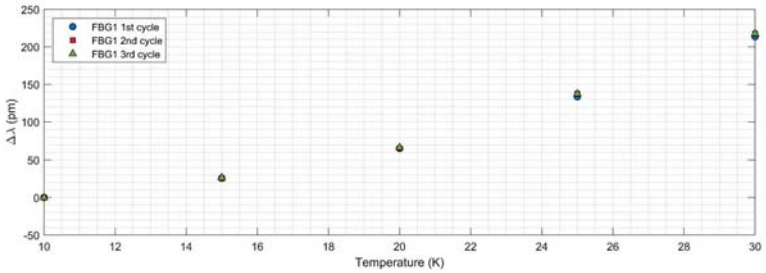
RFQ/3-14285/15/NL/PA, HiTOS system, "Optical-Fibre Temperature Sensor for Structural Health Monitoring: Engineering Model Space Assesment"

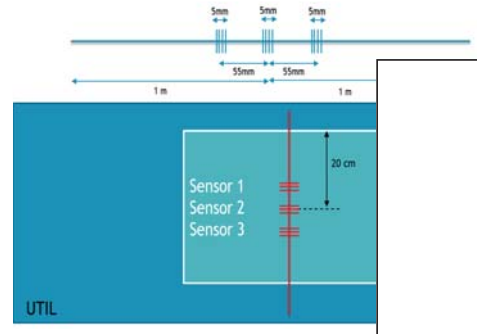


Tests realizados en condiciones de vacío (mean 4.7· 10^{-5} bar).

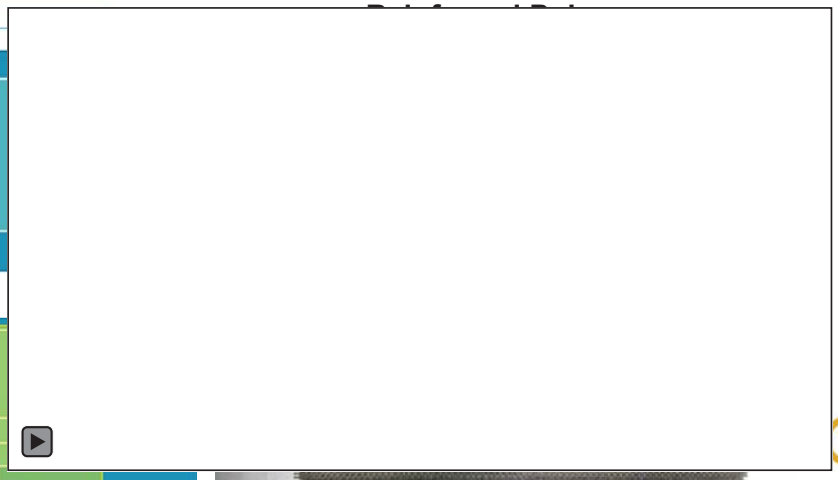
Ciclos de temperature de 14K a 30 K, vuelta a temperature ambiente (298 K) y nuevamente a temperaturas crioénicas para testar la estabilidad de las FBGs.





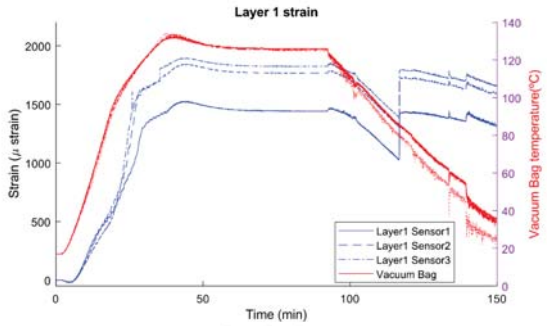


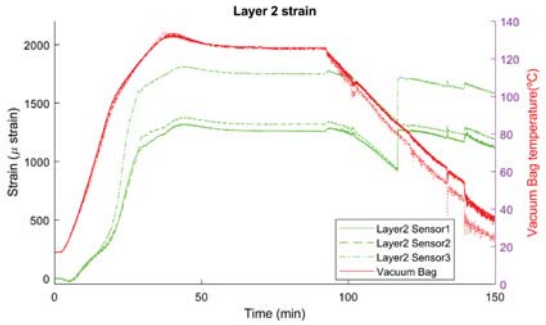
FBGs embedded in Carbon Fiber

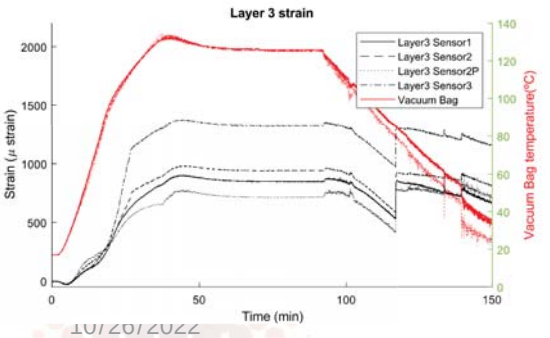


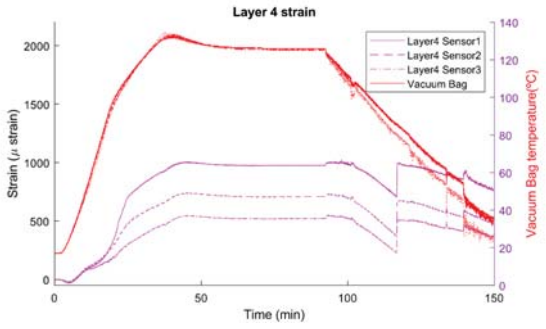
Fiber Optic Sensors

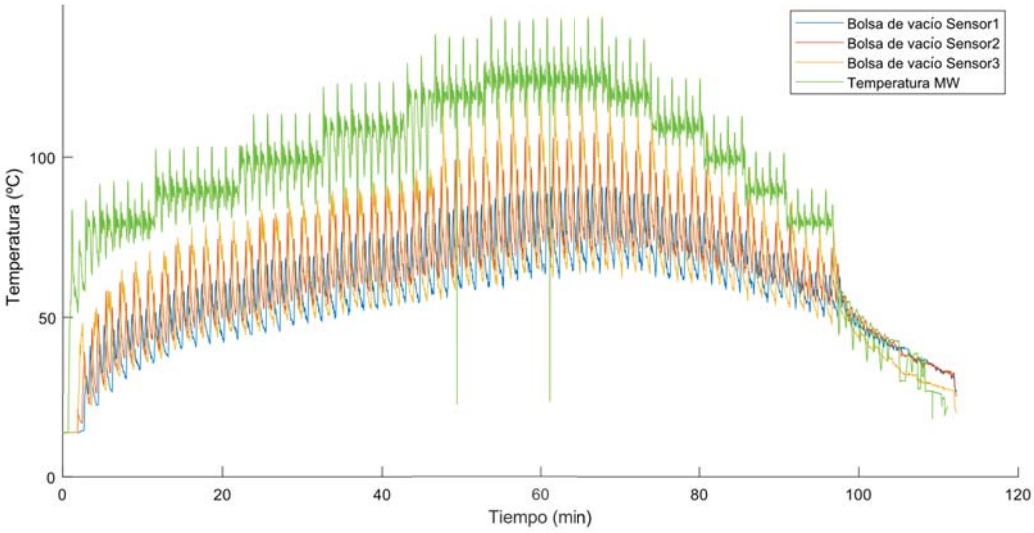
Monitorizando el proceso de curado en un horno







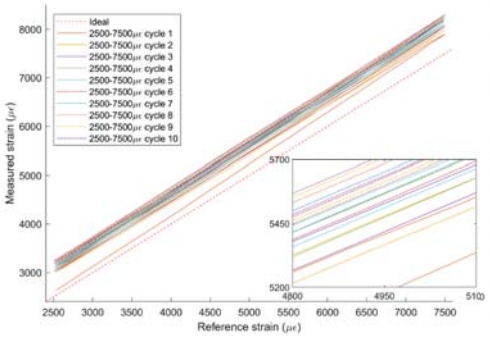


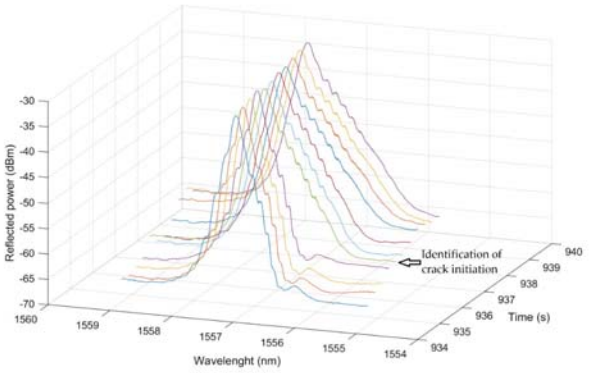

Bolsa de vacío Sensor1
Bolsa de vacío Sensor2
Bolsa de vacío Sensor3
Temperatura MW
Temperatura (ºC)
0
50
100
0
20
40
60
80
100
120
Tiempo (min)

FBGs embedded in Glass Fiber Reinforced Polymer

PULTRUDED BEAMS

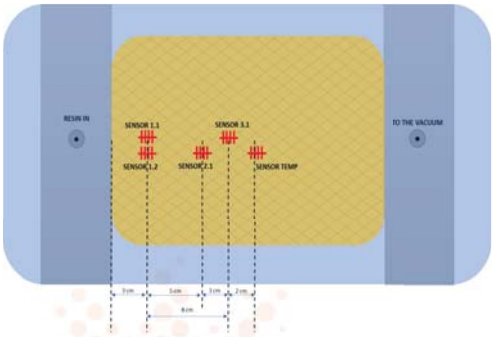
FBGs embedded in Glass Fiber Reinforced Polymer

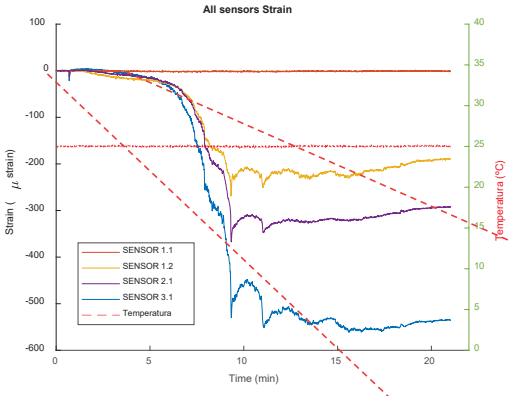


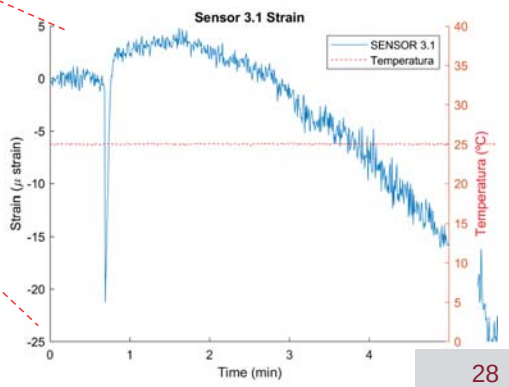


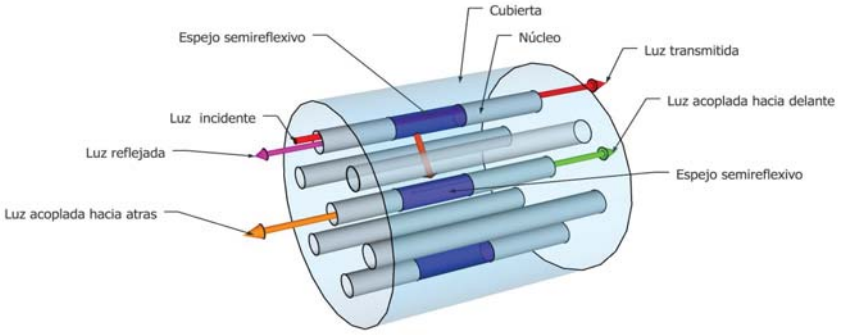
CFRP Tapes under study

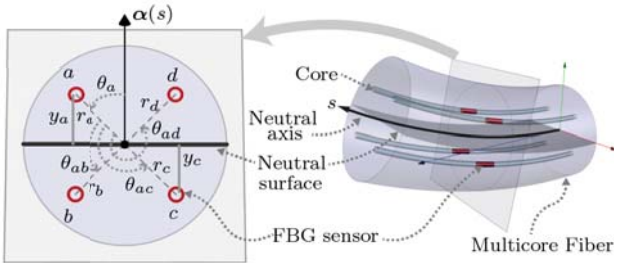
VARI (vacuum assisted resin infusion)

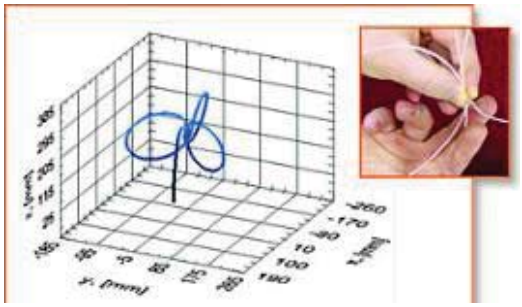




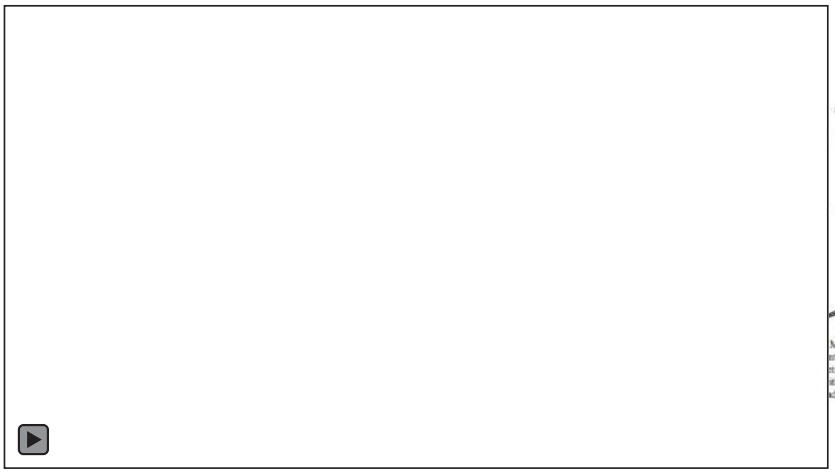


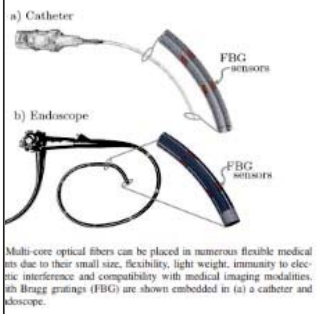

Cubierta
Espejo semireflexivo
Núcleo
Luz transmitida
Luz acoplada hacia delante
Luz incidente
Luz reflejada
Espejo semireflexivo
Luz acoplada hacia atras


$\alpha(s)$
a
d
b
c
Core
Neutral axis
Neutral surface
FBG sensor
Multicore Fiber



Sensores embebidos en instrumental médico

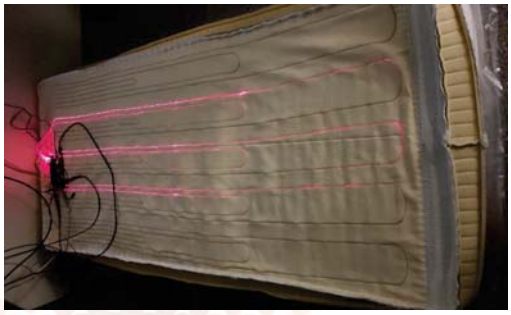




Multi-core optical fibers can be placed in numerous flexible medical
nts due to their small size, flexibility, light weight, immunity to elec-
tic interference and compatibility with medical imaging modalities.
ith Bragg gratings (FBG) are shown embedded in (a) a catheter and
ndoscope.

Robotics / Surgery

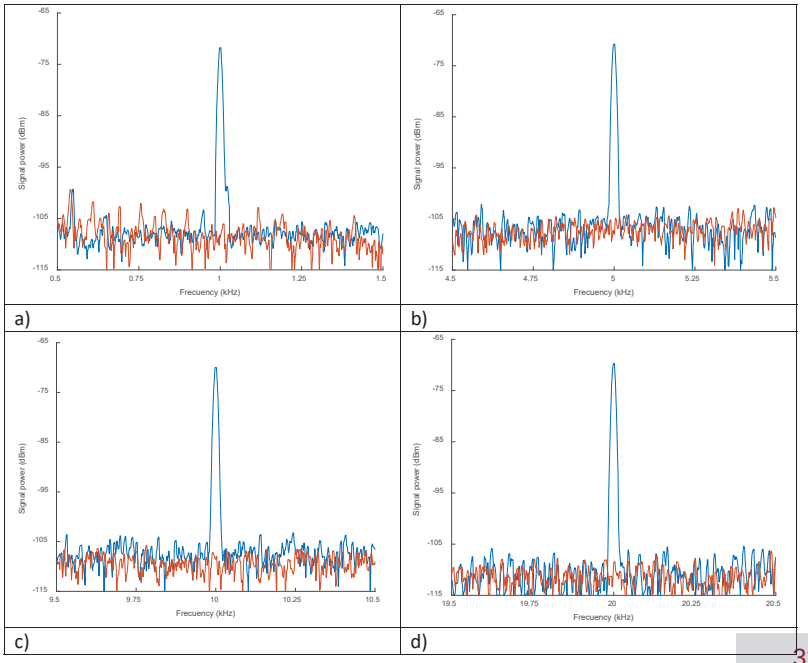
UNIVERSITEIT TWENTE.

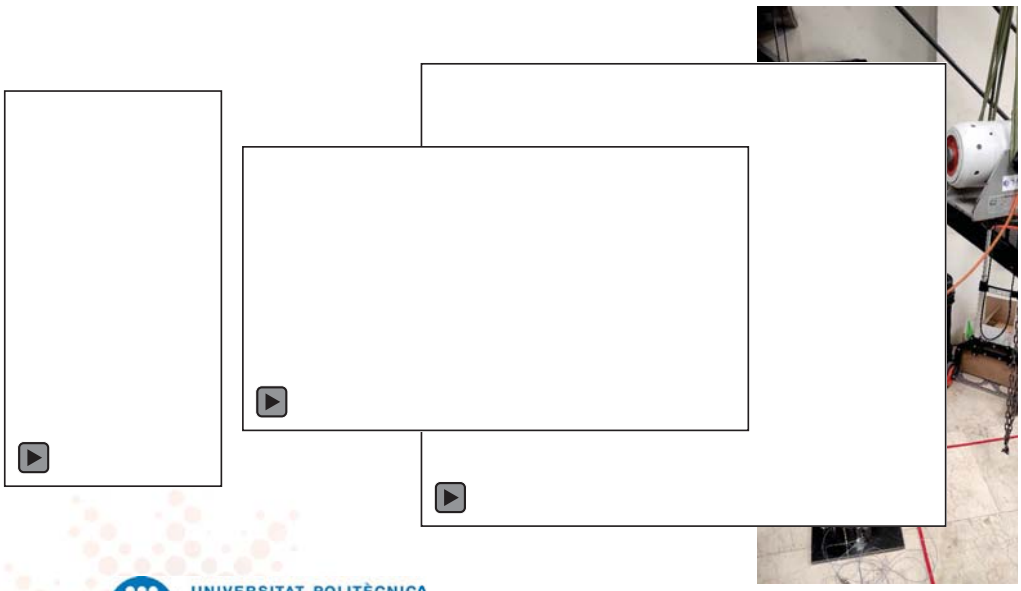


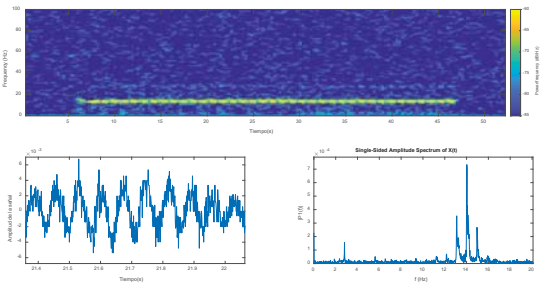
Senttix

aitex
textile research institute

Alta sensibilidad a la presión y detección de vibración (bajo coste)

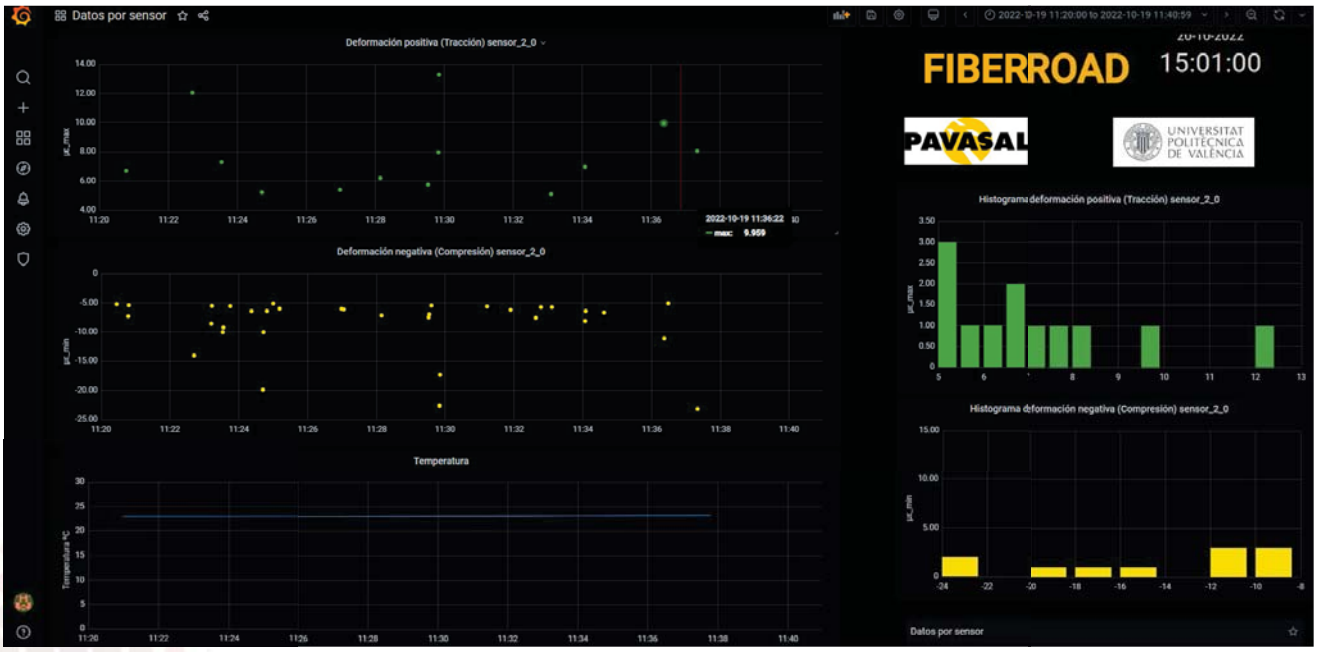


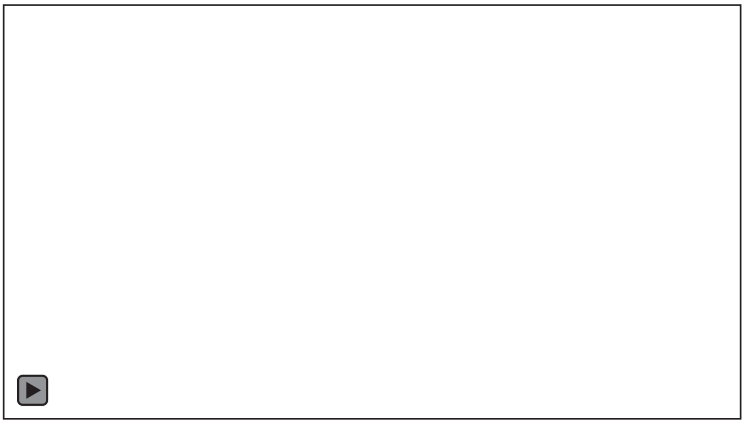


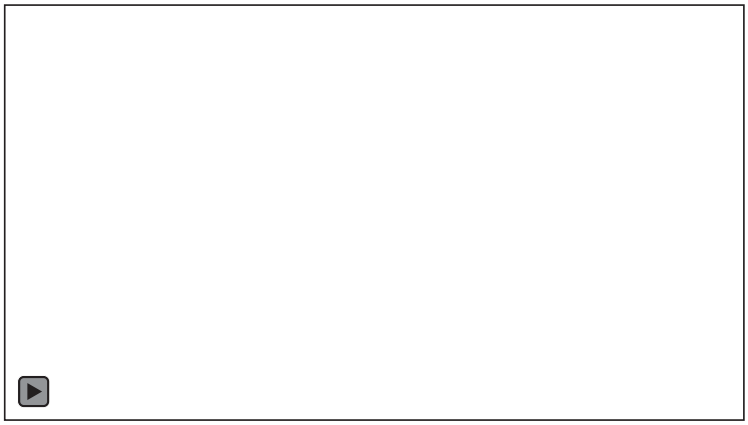


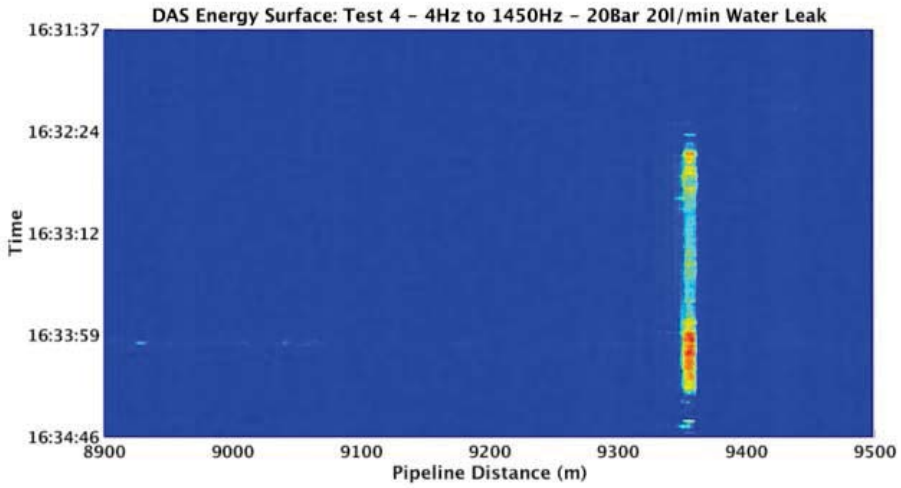
Single-Sided Amplitude Spectrum of X(t)


ARQUETA 5
ARQUETA 4
ARQUETA 3
ARQUETA 2
ARQUETA 1
LONGITUDINAL 4
LONGITUDINAL 3
LONGITUDINAL 2
LONGITUDINAL 1
TRANSVERSAL 3
TRANSVERSAL 2
TRANSVERSAL 1
Google

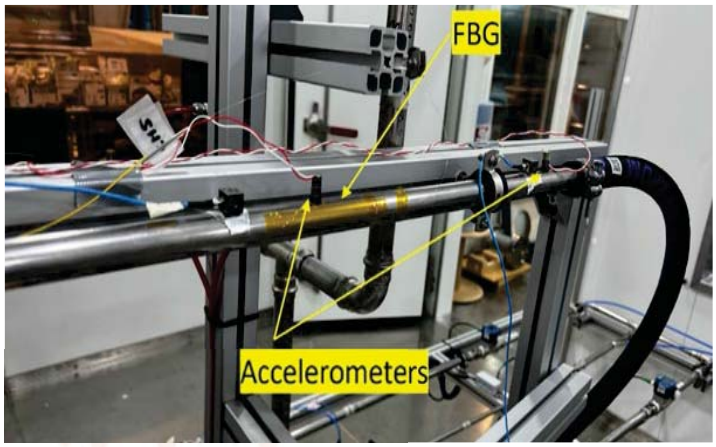

Datos por sensor
Deformación positiva (Tracción) sensor_2_0
Deformación negativa (Compresión) sensor_2_0
Temperatura
FIBERROAD
15:01:00
PAVASAL
UNIVERSITAT POLITÈCNICA DE VALÈNCIA
Histograma deformación positiva (Tracción) sensor_2_0
Histograma deformación negativa (Compresión) sensor_2_0
Datos por sensor

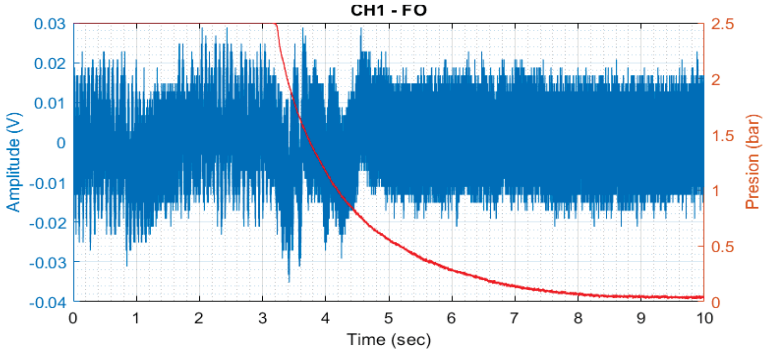


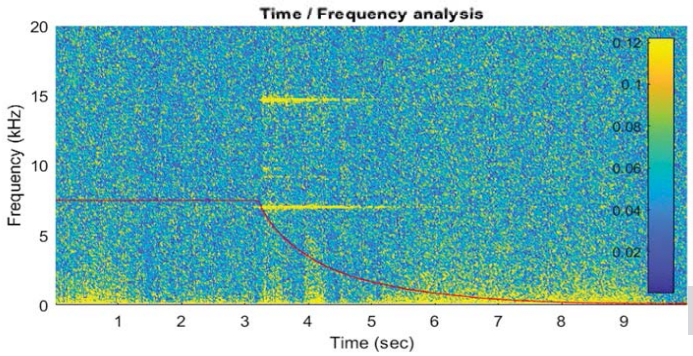




Broadband Energy Waterfall for DAS interrogator Presenting the Response to Leak Simulation Test Repetition Number Four.

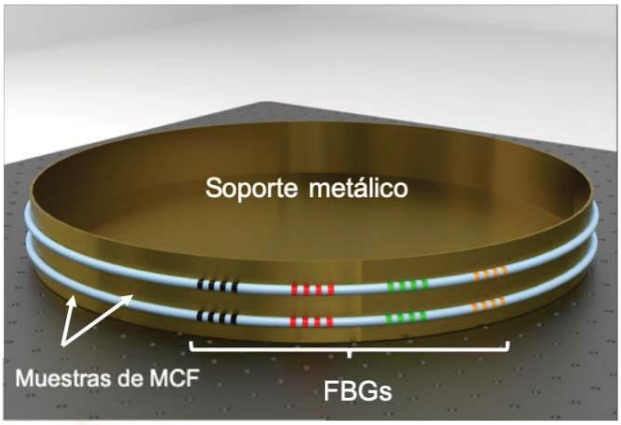

FBG
Accelerometers

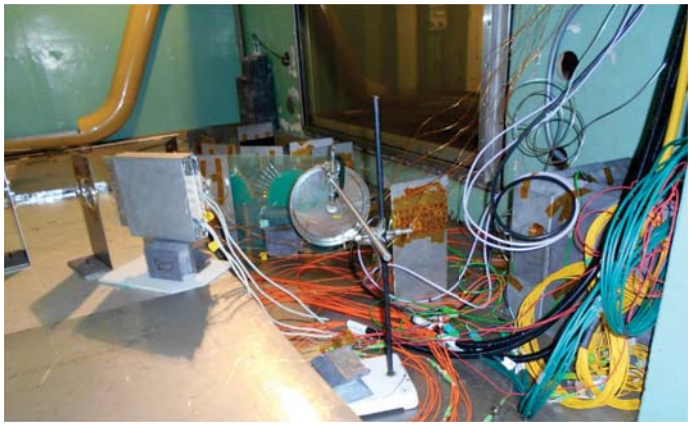

CH1 - FO
Amplitude (V)
Presion (bar)
Time (sec)

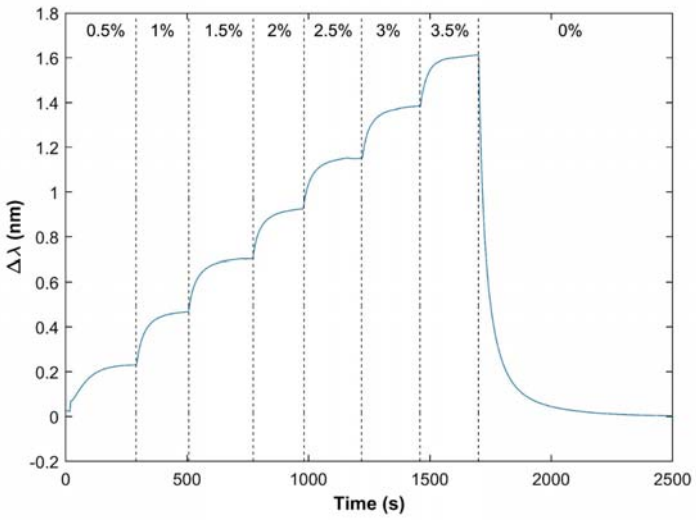

Time / Frequency analysis
Frequency (kHz)
Time (sec)

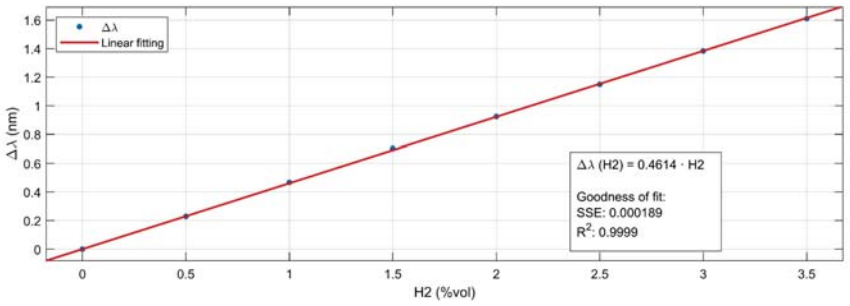
Fiber Bragg Gratings (FBGs)

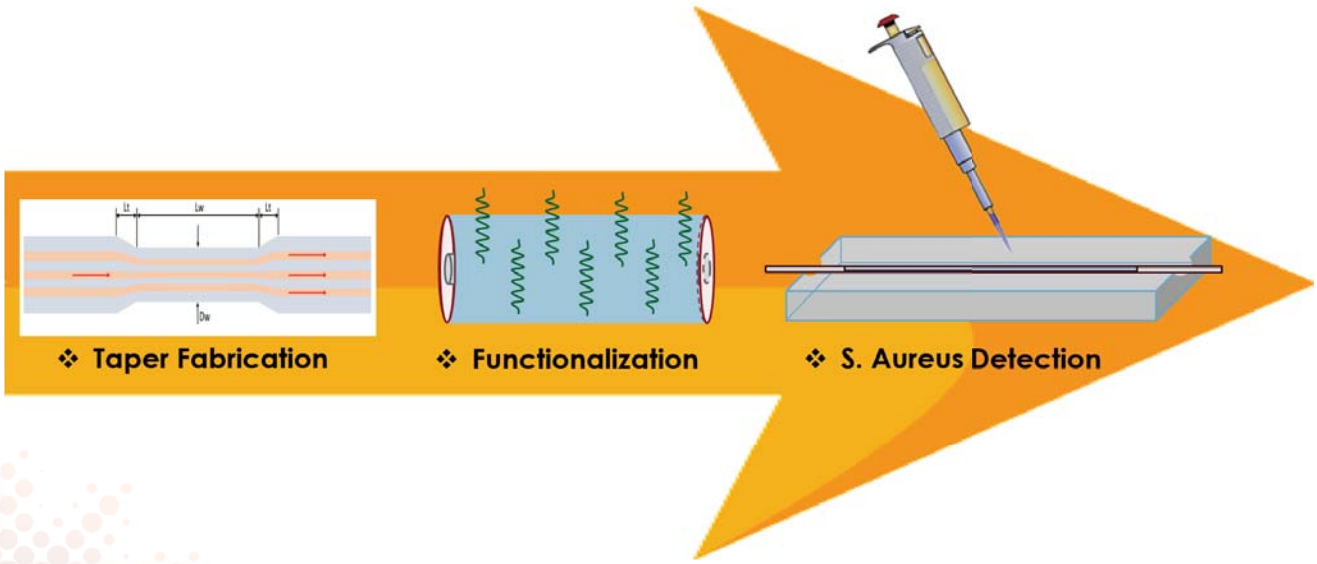
Mediciones de radiaciones nucleares

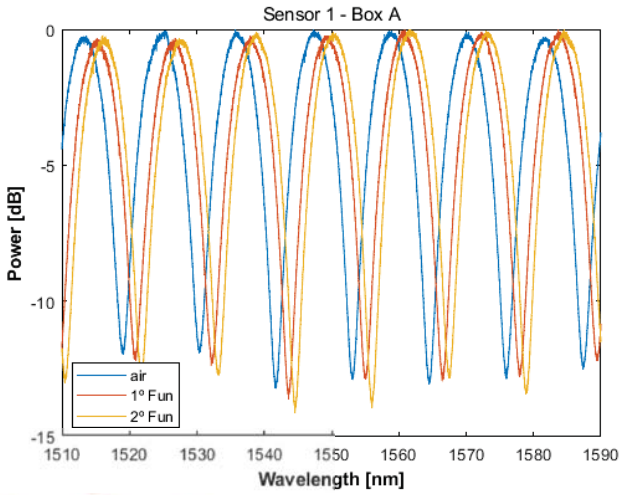




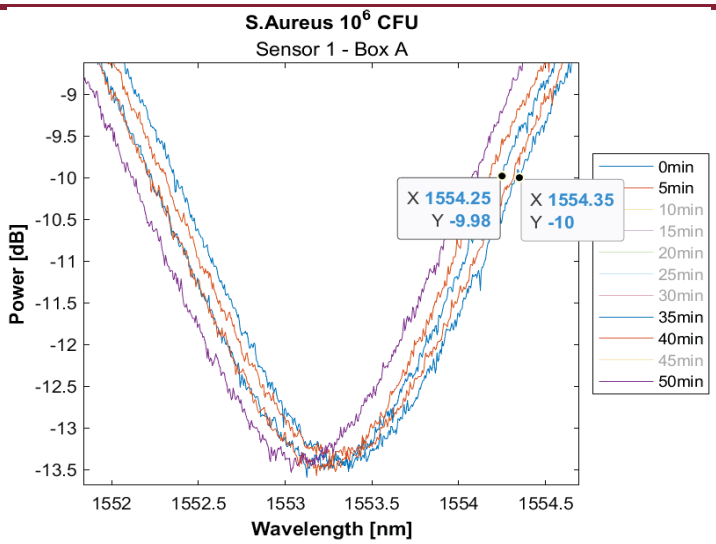

0.5%
1%
1.5%
2%
2.5%
3%
3.5%
0%
Δλ (nm)
Time (s)


Δλ
Linear fitting
Δλ (H2) = 0.4614 · H2
Goodness of fit:
SSE: 0.000189
R²: 0.9999
Δλ (nm)
H2 (%vol)


❖ Taper Fabrication
❖ Functionalization
❖ S. Aureus Detection



Δλ=2.9 nm



Δλ=100pm at 35 min

Δλmax=300pm at 50 min

Muchas cosas “divertidas” por venir

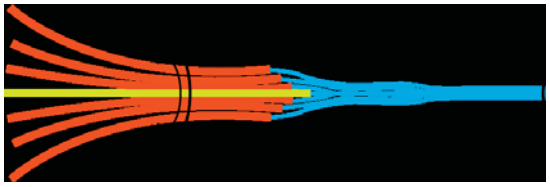
Tapered Axicon with LZM-100

80 µm fiber with 320 µm coreless ball-lens using LZM-100

Tapered capillary made with the LZM-100

Cross section of 19 into 1 combiner with LZM-100

Cross section of 6+1 PM combiner with LZM-100



Muchas cosas “divertidas” por venir

- ✓ **Gran rango de temperature: Desde 10K hasta 1400 K (comprobado), mejoras hast 2000K**
- ✓ **Monitorización structural – 3D Sensor de forma (No medir solo tensiones, vibraciones)**
- ✓ **Nuevos diseños: Sensores de: UV, H_2 y otros compuestos orgánicos e inorgánicos**

- ➢ **Se debe mejorar el proceso de integración con los composites**
- ➢ **Se debe reducer el coste en algunas aplicaciones / Photonics Integration**

Based on the inherent benefits of the optical fiber

- Small size (usually around 125-200 microns diameter, custom from 30 microns (even less to millimeters)
  - "Easy" to embed in structures/composites / ¿low structural impact?
- Lightweight (aerospace, high-speed cars/ships, etc)
- Low attenuation. Sensor can be places up to 100 km far from the central unit
- Passive
  - Immunity to electromagnetic interference
  - No risk of ignition / ATEX Compatible / Suited to hazardous ambients
- Fast answer (many sensors can be monitorised up to MHz frequency sampling, even more GHz range)
- Possible to multiplex hundreds/thousands of sensors in a single optical fiber, every millimeter or less.
  - Enables distributed sensor netwoks / Continuous remote real-time monitoring
- Custom packaging and installation (depending on the application and environment)
- Compatibility with traditional sensors.
- Silica is a very stable material : resolution, accuracy, long-term behavior
  - Novel composites materials are being studied / tested / employed

Gracias!!!

ssales@upv.es

Demetrio Sartiano, Ignazio Floris, Pedro Calderón, Amelia Ricchiuti, Chen Di, Javier Hervás, Benjamín Torres, Héctor García-Miquel, Daniele Tosi, Juliana Niño