ADVANCED OPTICAL TECHNOLOGIES S.L.

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Outline

- Introduction
- Bladed-rotor monitoring
- Spectroscopy solutions for food and pharmacy industries

Introduction

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- Company mission: To apply photonic solutions to all kind of industries
- Origin: Spin-off from the research group Applied Photonics Group (University of the Basque Country)
- Initial projects:
  - Bladed-rotor monitoring system → Turbines, compressors, fans,…
  - Integration of spectroscopy based sensors in food/pharma processes

Bladed-rotor monitoring system

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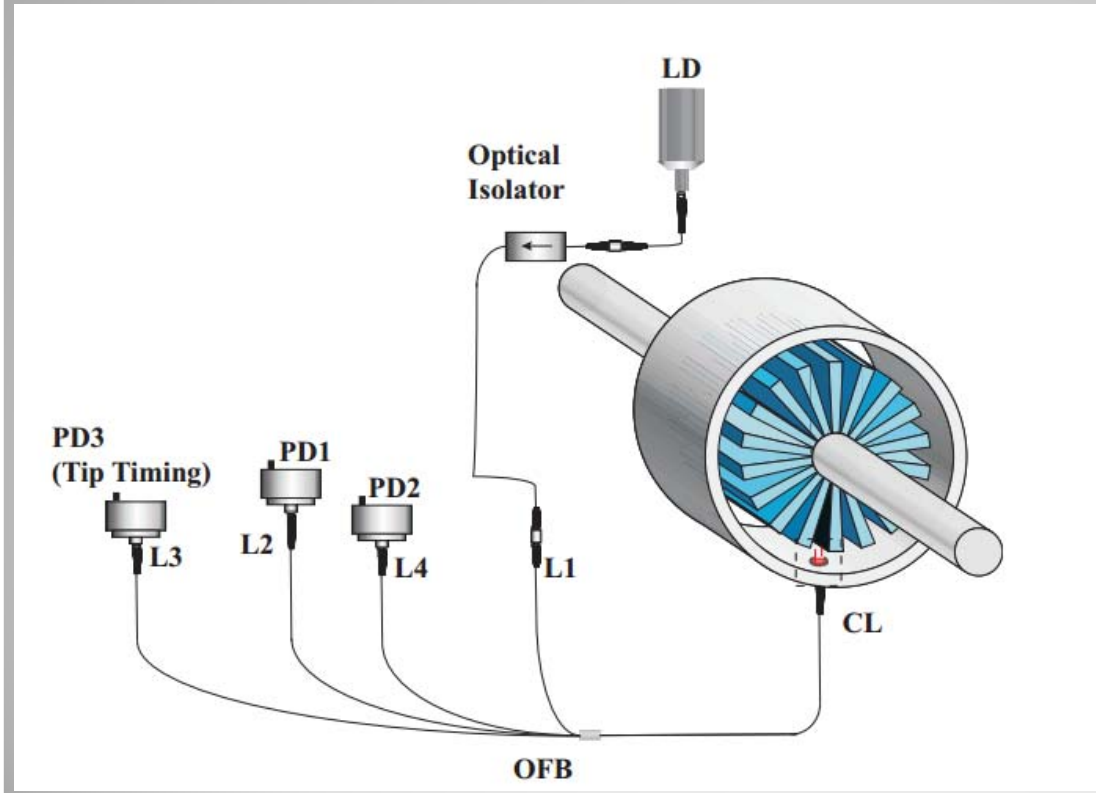
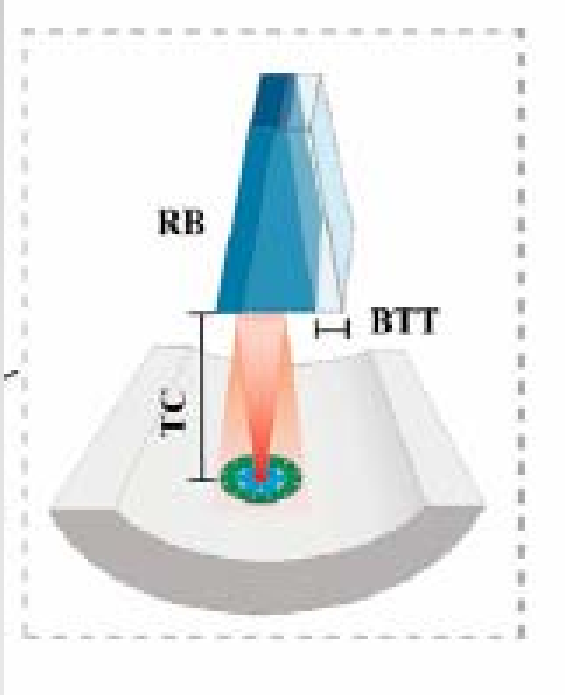
Sensor based on a tetrafurcated bundle (TC + TT)





Bladed-rotor monitoring system

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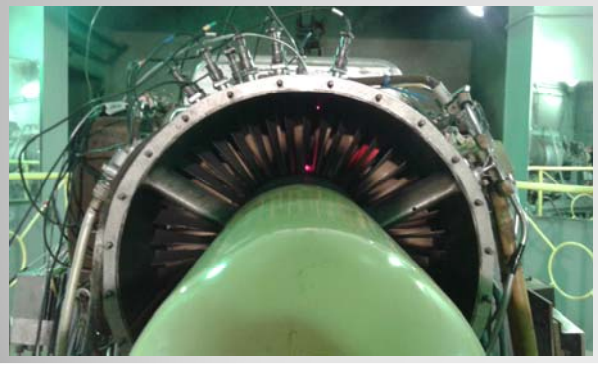
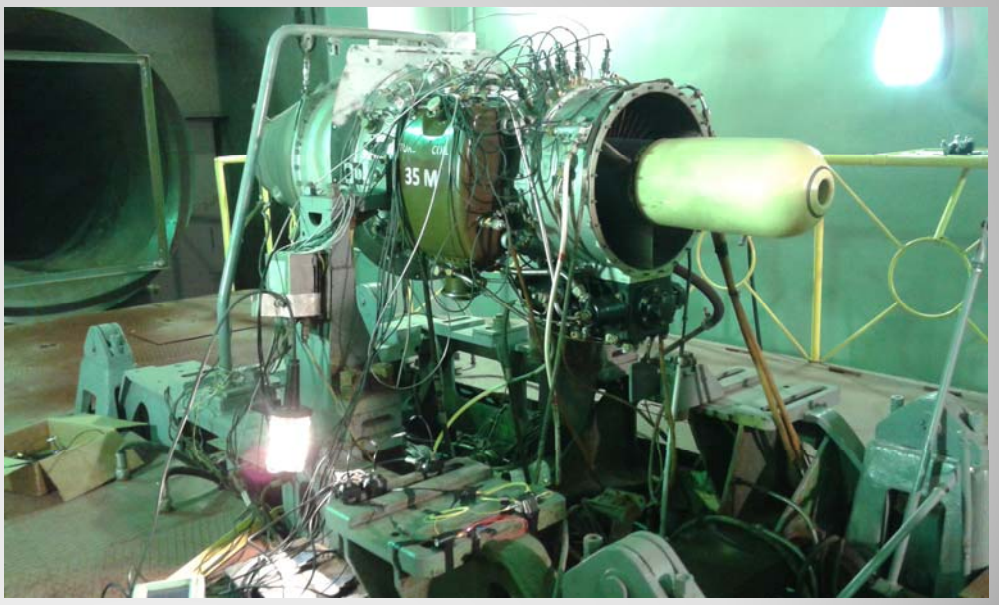
TC and TT measurements for the 1st compressor stage

- In collaboration with Air Force Institute of Technology in Warsaw (Poland)
- Engine → SO-3 (PZL TS-11 Iskra)





Bladed-rotor monitoring system

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Compressor characteristics

- Rotational speed: 6,900 rpm (idling) to 15,600 rpm (takeoff)
- Sharp blade profile
- Rough blade surface and with corrosion
- 28 blades
  - Length =100 mm
  - Chord = 37 mm
  - Width = 1.5 mm

Bladed-rotor monitoring system

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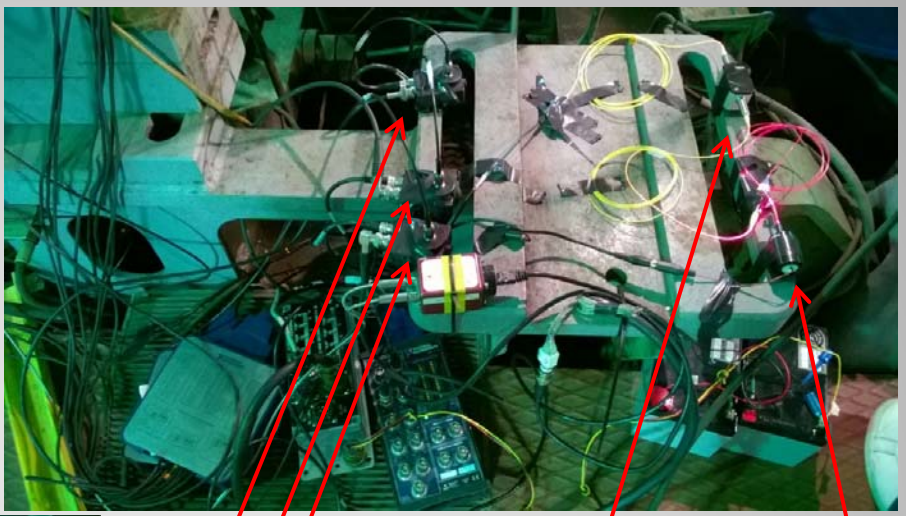
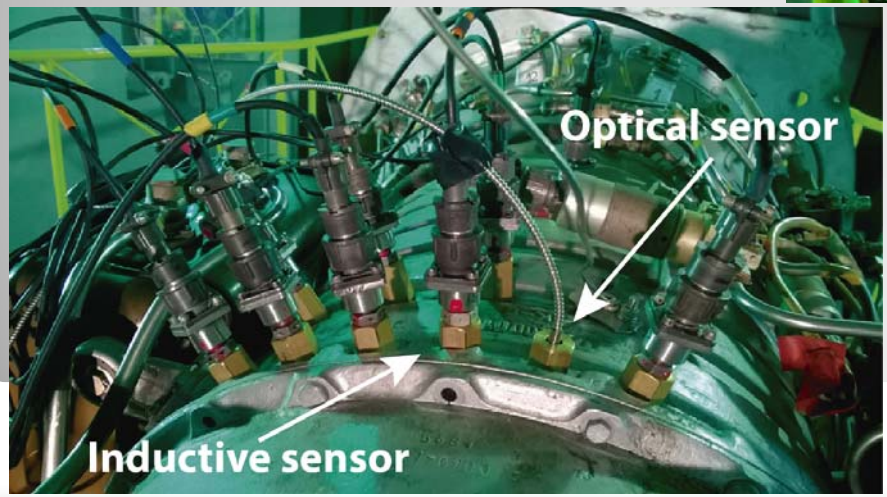
Optical sensor installation





Photodetectors

Optical isolator

Laser module

Bladed-rotor monitoring system

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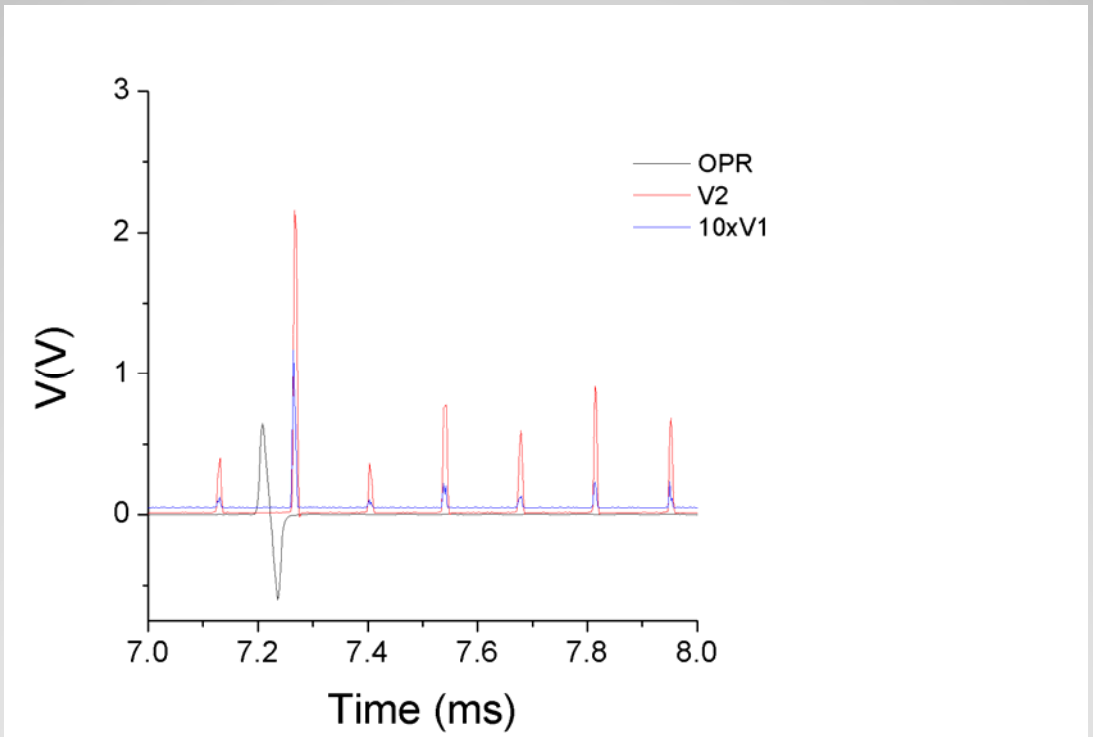
Acquired signals

Rotational speed = 15600 rpm



Bladed-rotor monitoring system

TC results for acceleration

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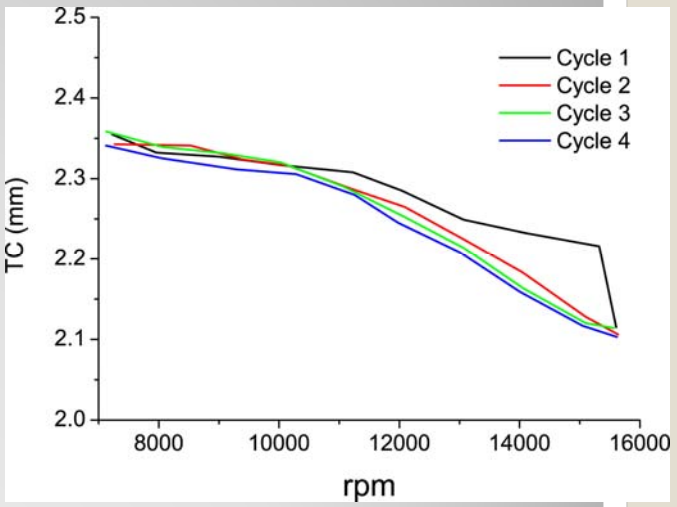
rpm	TC cycle 1 (mm)		rpm	TC cycle 3 (mm)
7226	2.355		7126	2.359
7960	2.332		8060	2.339
9003	2.327		9072	2.331
10025	2.317		10025	2.320
11229	2.308		11078	2.290
12041	2.285		12089	2.253
13064	2.249		13080	2.213
14112	2.232		14059	2.163
15321	2.216		15098	2.120
15603	2.115		15567	2.114

rpm	TC cycle 2 (mm)		rpm	TC cycle 4 (mm)
7265	2.343		7124	2.341
8533	2.341		8051	2.325
9406	2.323		9293	2.311
10147	2.316		10284	2.306
11174	2.288		11259	2.280
12092	2.265		11980	2.245
13068	2.225		12997	2.209
14055	2.183		14006	2.159
15096	2.128		15047	2.117
15635	2.106		15617	2.103



Bladed-rotor monitoring system

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TC measurement characterization

rpm	Mean TC (mm)	Mean TC (mm)*	Standard deviation (µm)	Standard deviation (µm)*
7000	2.353	2.351	7	8
8000	2.339	2.339	9	9
9000	2.326	2.325	9	10
10000	2.315	2.315	4	5
11000	2.286	2.281	11	7
12000	2.255	2.251	14	9
13000	2.212	2.207	18	11
14000	2.170	2.160	27	12
15000	2.134	2.119	34	5
15600	2.110	2.108	6	6

* Discarding cycle 1

Bladed-rotor monitoring system

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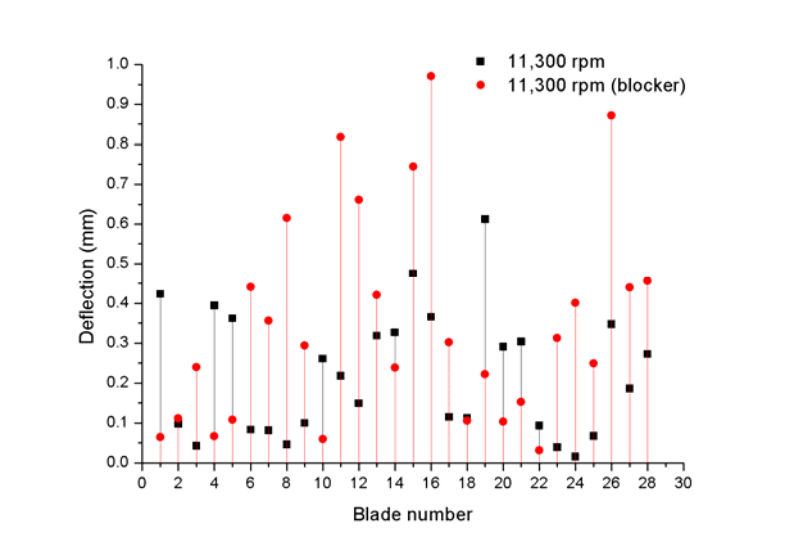
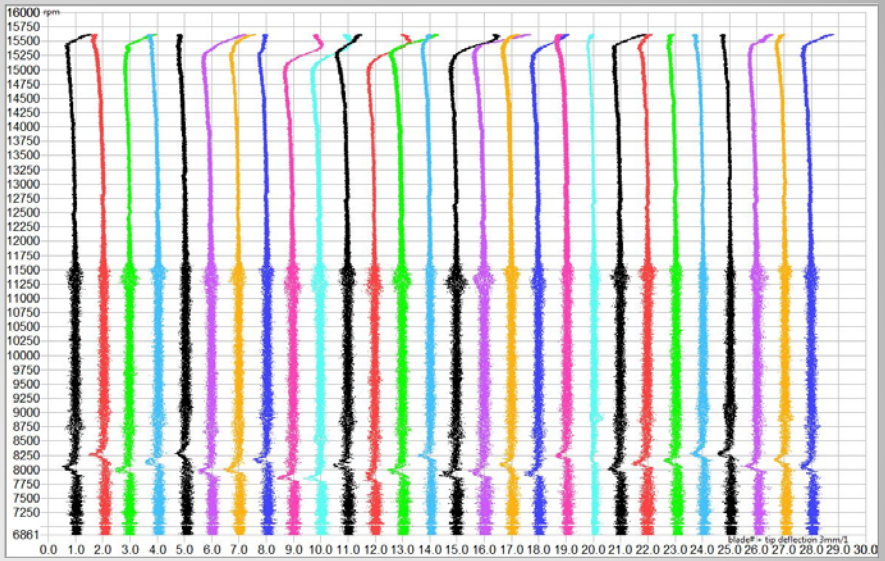
TT results → blade deflections and waterfall diagrams





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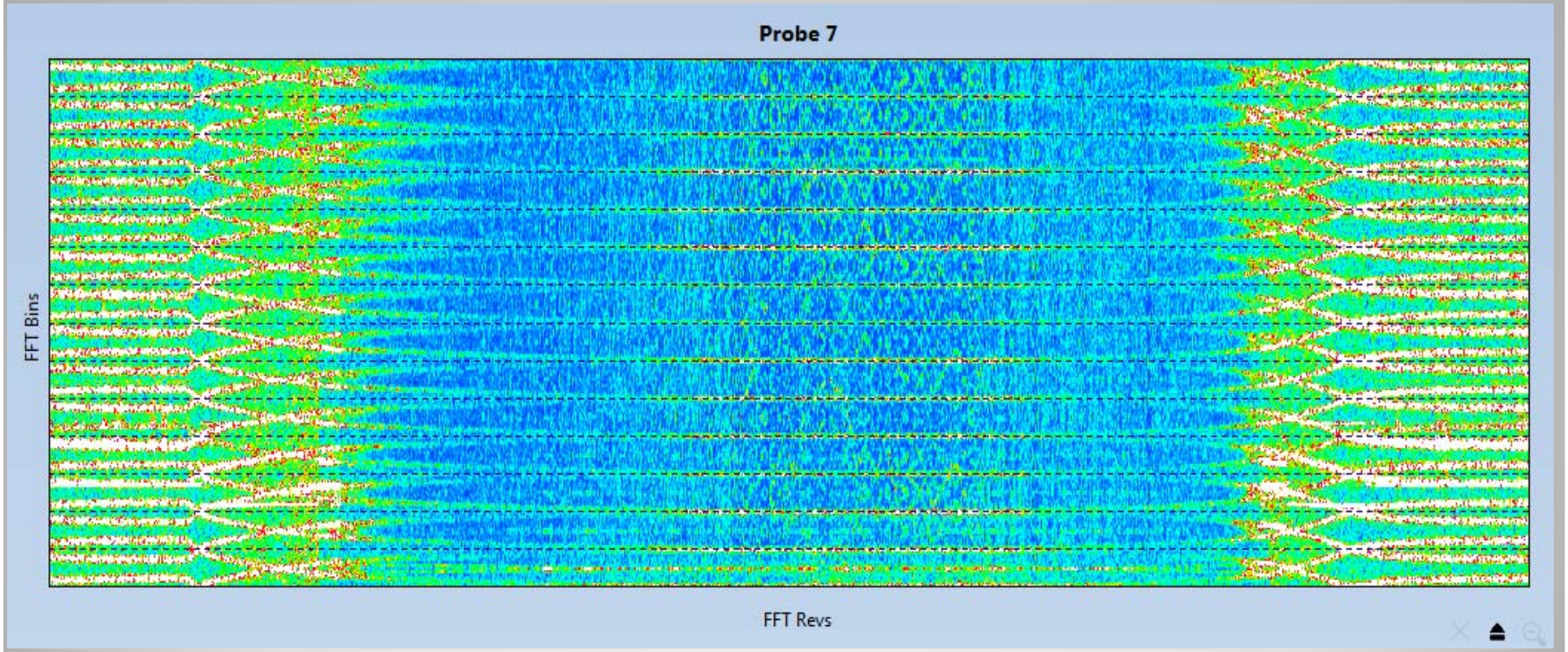
TT results → All-blade spectrum



Bladed-rotor monitoring system

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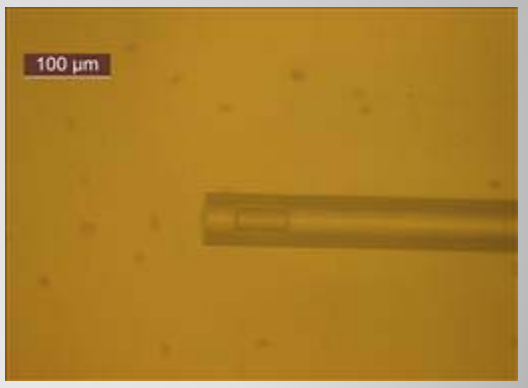
Future steps

- Software for real-time measurements
- Measurement of axial vibrations
- Measurements in the hot sections of the engine
- TC measurements in high-speed LPT
- Dynamic pressure sensors development
  - Extrinsic Fabry-Perot Interferometers
  - MCF Interferometers



Bladed-rotor monitoring system

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Conclusions

- Fine sensor performance at the first trial in field conditions:
  - TC → 12 μm precision
  - TT → similar results to those provided by a well-established inductive sensor
- Short time to set-up and calibrate
- Simultaneous and independent configuration for TT and TC measurements

Spectroscopy solutions for food and pharmacy industries

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- NIRS (Near Infrared Spectroscopy):
  - Response of molecular bonds within the sample to NIR radiation (λ =800-2500 nm)
  - NIR spectrum:
    - Light is either absorbed or scattered
    - Photon energy absorptions representing overtones and combinations mainly associated with –CH, –OH, –NH, and –SH functional groups
    - Information about the chemical composition and physical properties of the sample → Chemometrics
- Control the value chain at each critical point, from incoming goods to finished product release
- Integrated in food/pharmacy systems and equipment for real time measurements

Spectroscopy solutions for food and pharmacy industries

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- Advantages:
  - Real time measurements (seconds)
  - Minimal or no sample preparation
  - Optimal results for different kind of products: liquids, powder, grains, slurries,…
  - Multiple parameters determined at the same time
  - Non destructive measurements

Spectroscopy solutions for food and pharmacy industries

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- Continuous monitoring of the production quality:
  - Check the identity and quality of raw materials while optimizing their usage
  - Fast adjustment or stops if the specifications are not met
  - Increase product quality and consistency with tighter control
  - Verify final product specifications and streamline compliance with regulatory guidelines
- Fast payback → reduction of laboratory analysis, continuous process optimization
  - 10 laboratory samples/day x 20€/sample x 200 working days = 40,000€
  - Immediate process corrections minimize waste and re-work
  - Optimization of key parameters for maximum profit margins

Spectroscopy solutions for food and pharmacy industries

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- Disadvantages:
  - Requiring calibration using reference data from standard wet-chemistry methods
  - Limited diffusion in the industry
  - Lack of qualified staff to the correct implementation in industrial processes
  - Influence of external factors during spectra acquisition (temperature, moisture, homogenization, size of particles,…)

Spectroscopy solutions for food and pharmacy industries

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- System technology and components:
  - Light source: tungsten lamp
  - Optical probe
    - Transmission
    - Reflection
    - Transflection
  - Spectrometer
  - PC

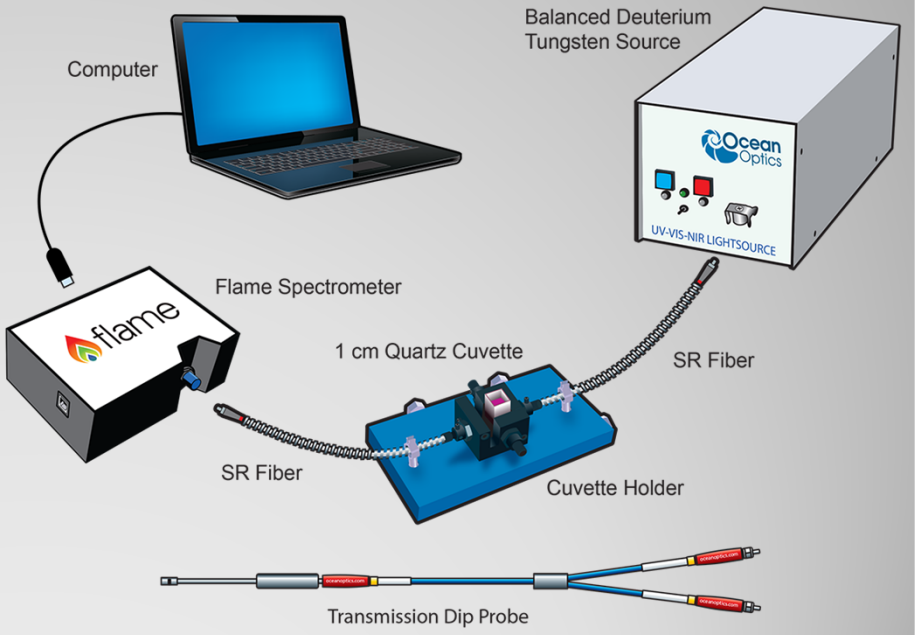

Image from Ocean Optics, Inc.

Spectroscopy solutions for food and pharmacy industries

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- Markets:
  - Dairy → % fat, protein, lactose, dry matter
  - Milk powder production → % fat, protein, moisture
  - Oil → free fatty acids, phospholipids, moisture
  - Grain and flour → % protein, ashes, moisture, fiber
  - Meat and fish → % fat, protein, moisture
  - Wine → % alcohol, sugars, acids
  - Cosmetics and Pharma → raw material inspection, tablet testing and control drying and blending processes
  - Contaminates and adulterants

Spectroscopy solutions for food and pharmacy industries

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- Equipment and systems:
  - Pasteurizers
  - Fermenting tanks
  - Reactors
  - CIP systems
  - Mixing systems
  - Homogenizers
  - Evaluation of raw materials and finished product
  - Complete process quality assurance systems by monitoring key parameters in real time.

Thank you for your attention!!

Any questions?

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