Integrated optical fiber pressure sensor for intravital monitoring

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Overview

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Objective

Design optical fiber pressure sensor for:

- Assessment of vascular lesions using instantaneous wave-free ratio (iFR) guided strategy
- Diagnosing angiogenesis in cancers

Motivation and Impact

Present technology

Electrical sensors (**piezoresistive**) or single-point optical fiber sensor (**OFS**) in tandem with pressure wire pullback

Clinical improvement

Distributed OFS with enhanced sensitivity to continuously monitor iFR (pressure index) **without a pullback**

- Less procedural time
- Economical
- Better health care

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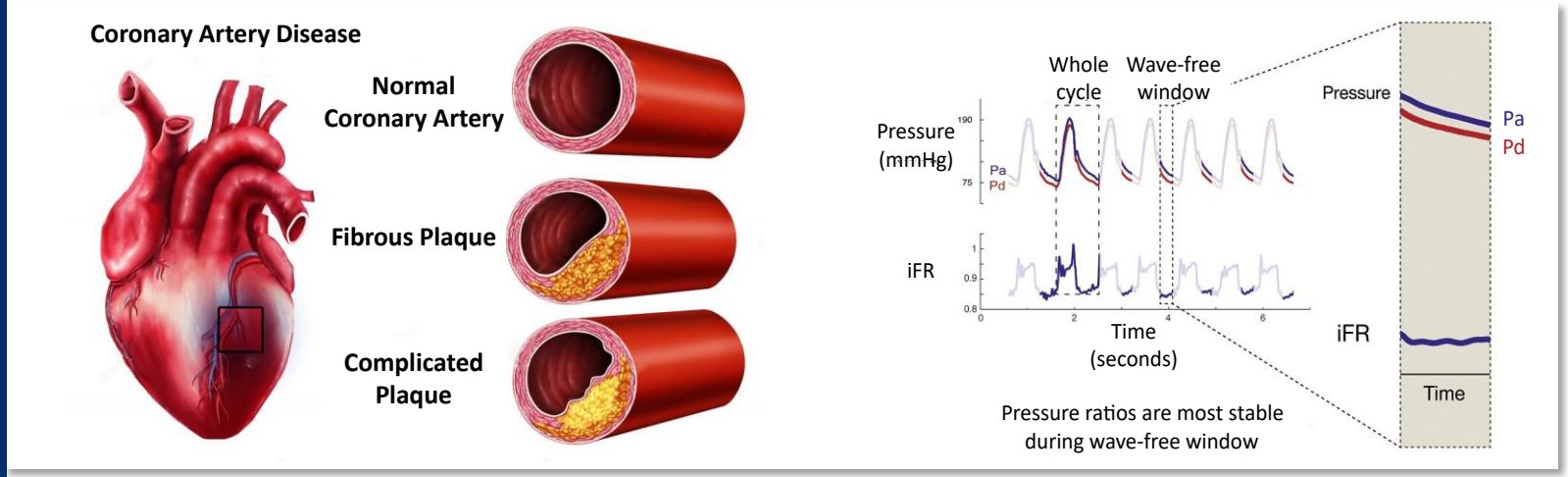
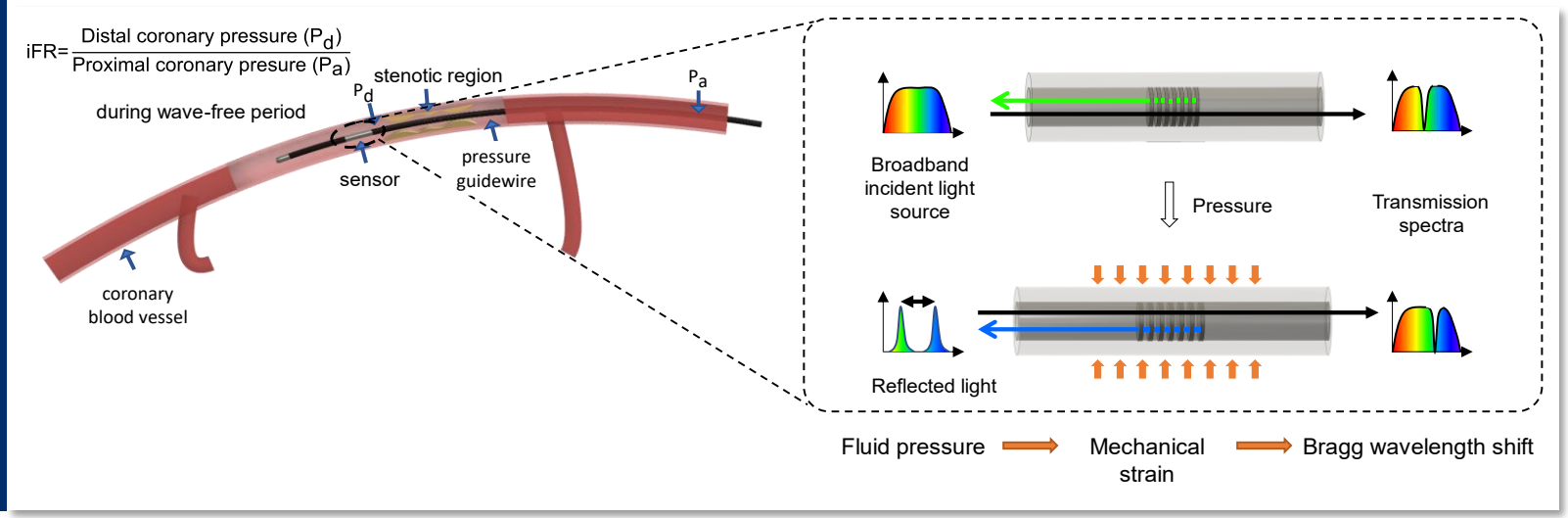
Our Approach

- Modified Fiber Bragg Gratings (**FBGs**) for distributed sensing
- Major challenges:
  a. Enhancing pressure sensitivity by 3 orders of magnitude
  b. Required spatial resolution 1-2mm
  c. Compensating cross-sensitivity
- Two-pronged strategy for enhanced pressure sensitivity
  a. Coating with elastomeric material
  b. Appropriate signal processing algorithms





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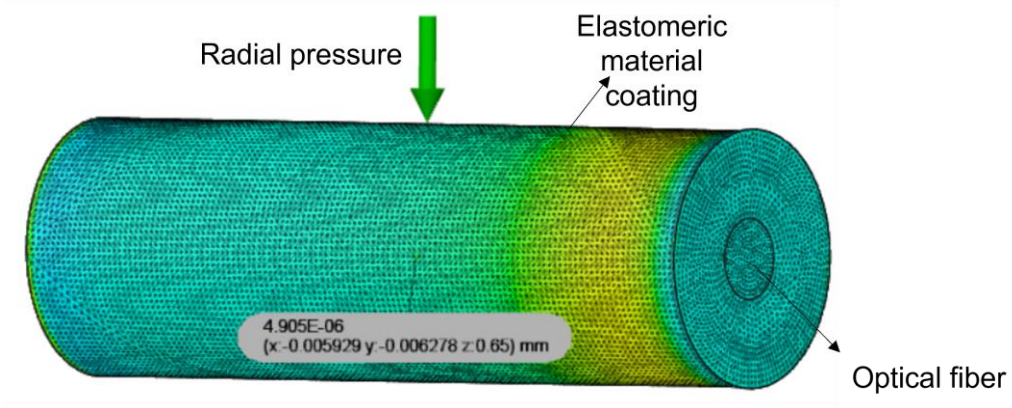
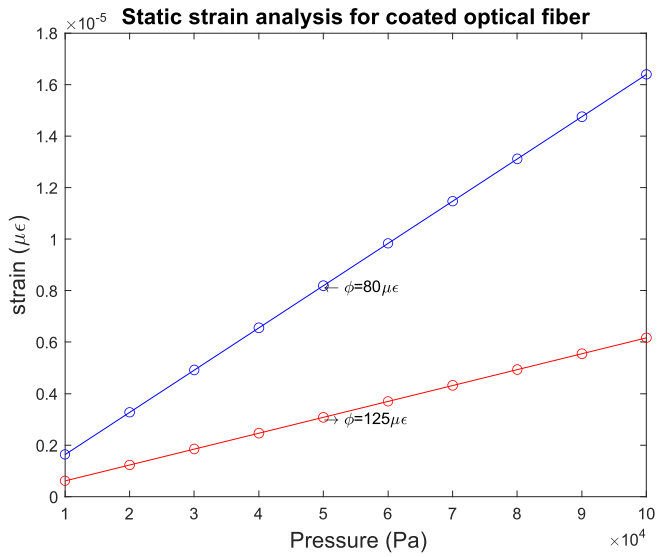
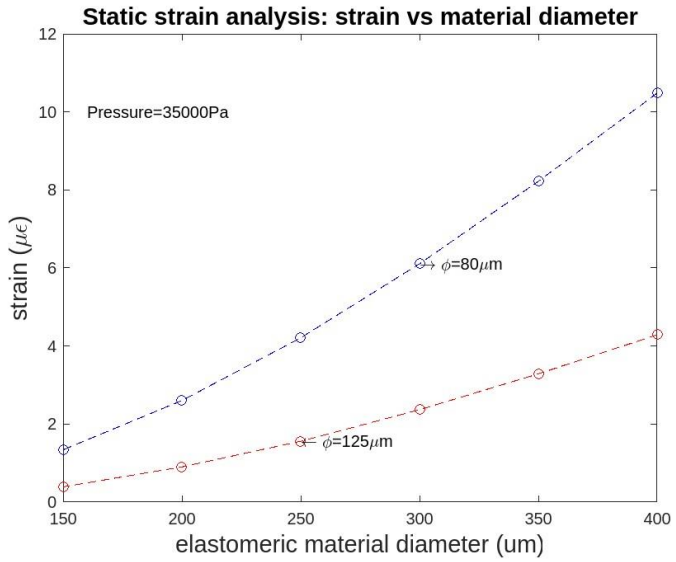
Basic sensor design

- Elastomeric coating on 125µm OF and 80µm OF increases sensitivity by orders of magnitude
- For given pressure, sensitivity increases as coating diameter increases and OF diameter decreases

Finite element static strain analysis

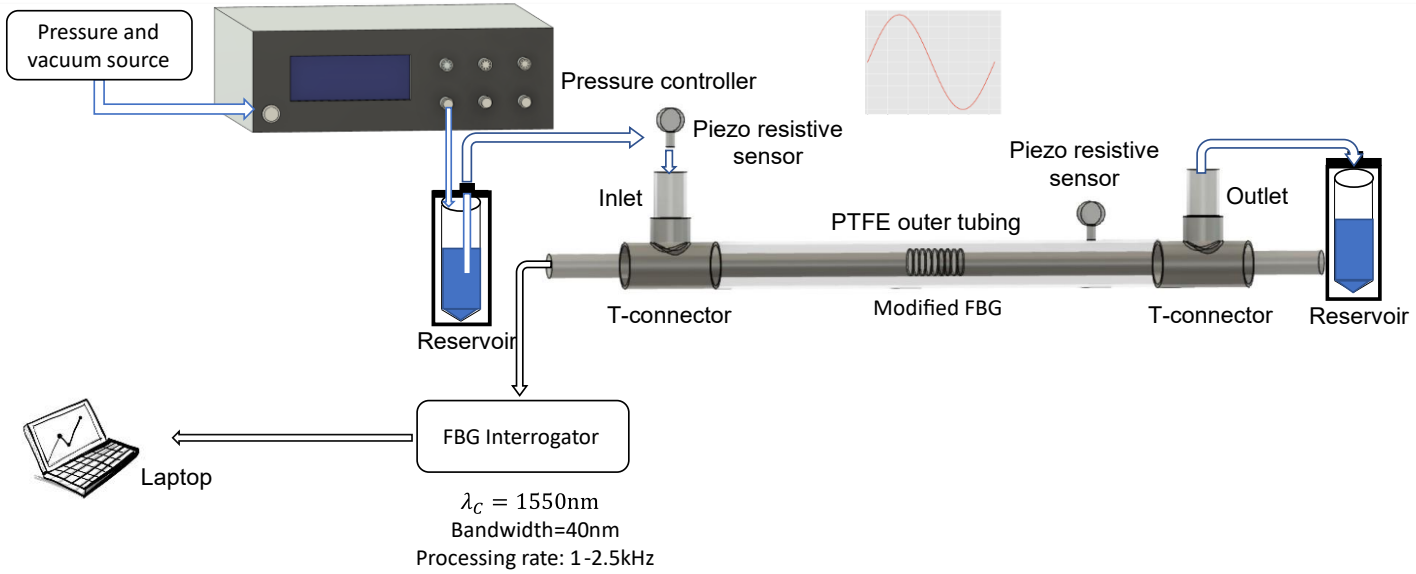






Experimental setup

- Test bench for validating optical fiber pressure sensor
- Dynamic pressure sensing: Sinusoidal pressure pulse profiles with different frequencies and amplitudes (10^4–10^5 Pa) were applied on polyimide and acrylate-coated standard FBGs and their sensitivities were noted using frequency selective signal processing algorithm.



Interrogators

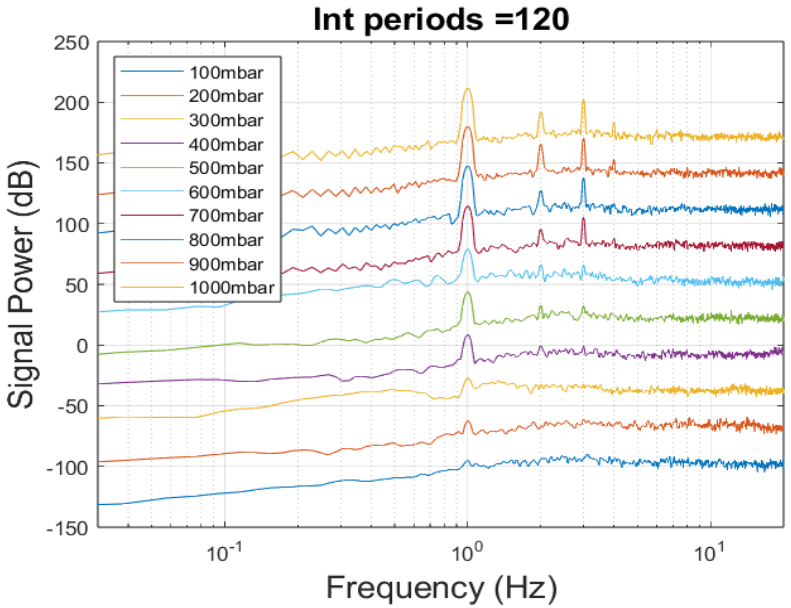
Smart scan

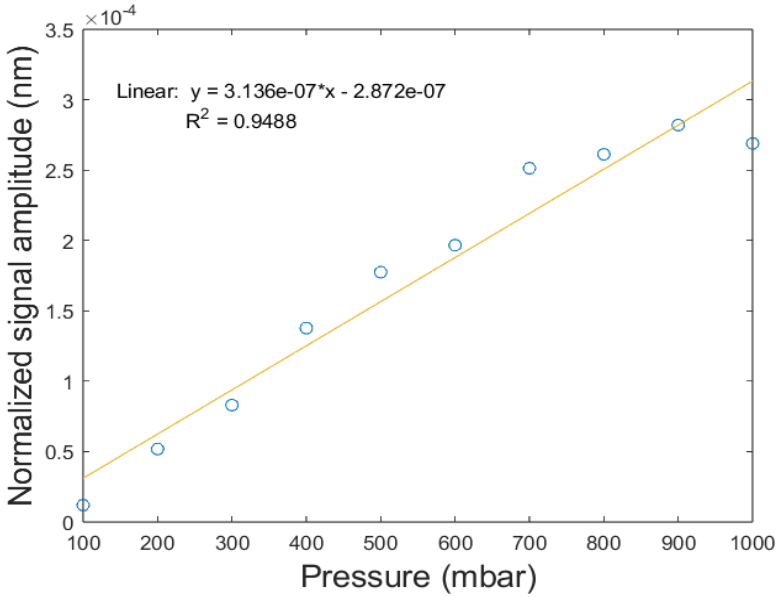
Hyperion si155

Parameters	Smart scan	Hyperion- si155
Wavelength range	1528-1568nm	1500-1600nm
Data processing rate	2.5kHz	1kHz
Dynamic range	37dB	25dB

Results

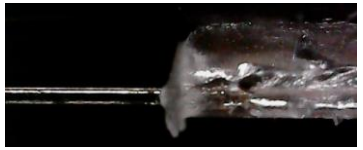
Linear relation between signal power and sinusoidal pressure





Preliminary outcomes of coated optical fiber using 3D printed molds

800µm



500µm

Frequency	Pressure sensitivtiy of polyimide FBG(pm/MPa)
1Hz	3.14
3Hz	2.47
0.33Hz	0.82

Type of FBG	Pressure sensitivity (pm/MPa) for different data processing rates	
	1kHz	2.5kHz
Acrylate coated	1.41	1.55
Polyimide coated	3.14	3.40

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