Optical Fiber Sensors and Systems

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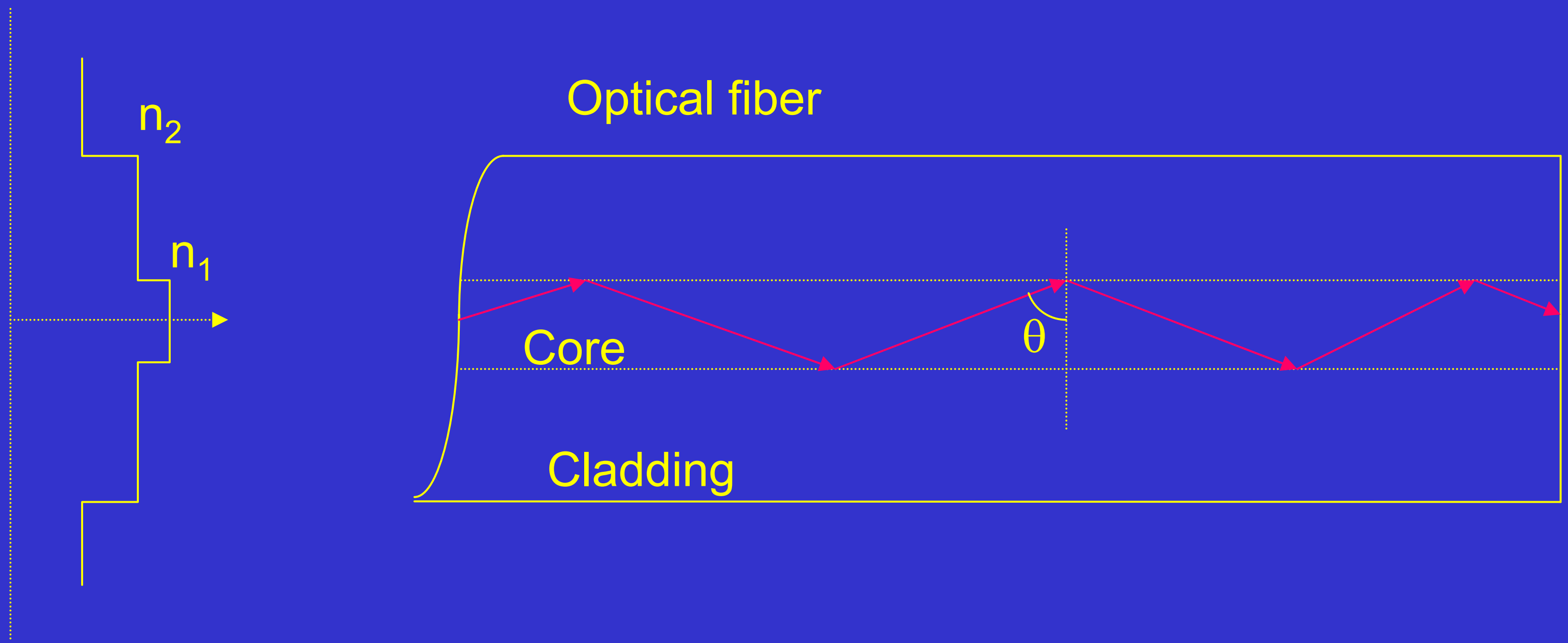
Basic principle of an optical fiber sensor



When θ is greater than $\theta_c = \sin^{-1}(n_2/n_1)$, the light ray can be guided.

Why fiber sensors attractive?

- Harsh environment capability

  Intensive EMI, high voltage, chemical corrosion, high temperature

- Small size and light weight

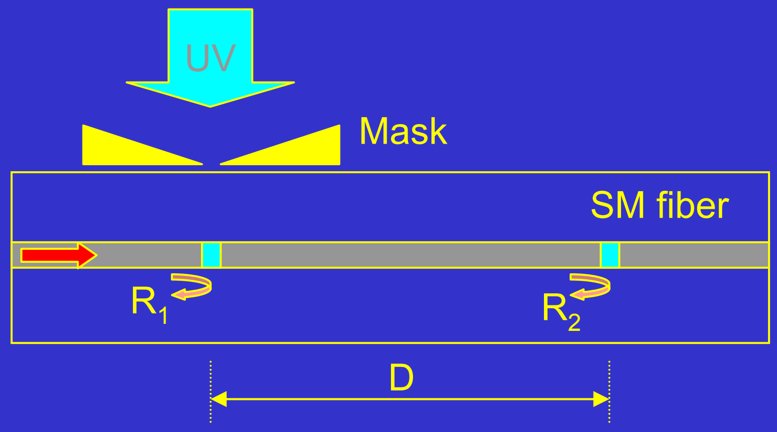
- Long range operation

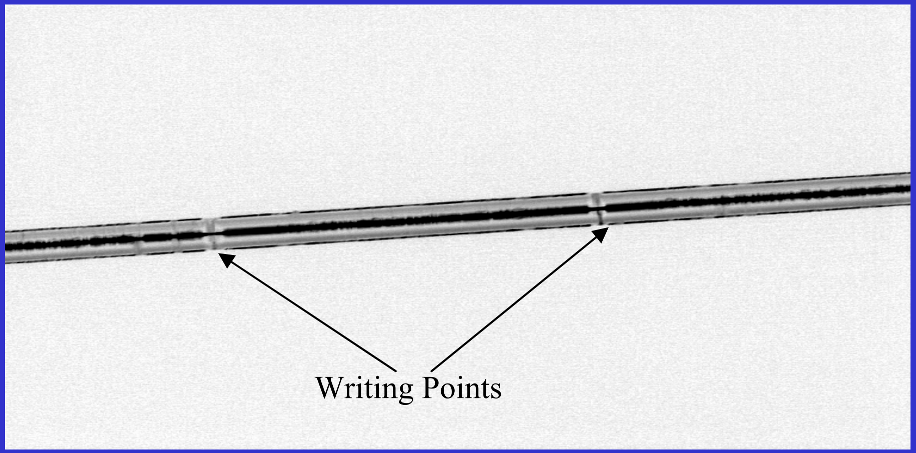
- Multiplexed or distributed measurement

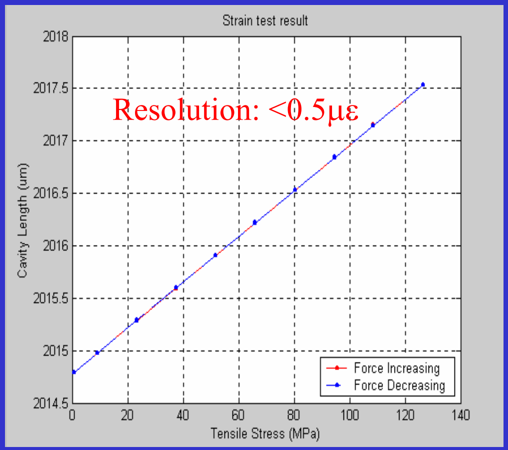
Major Fiber Sensors

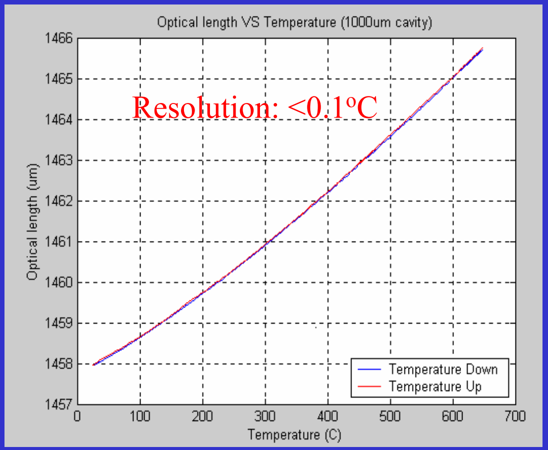
- <u>Point sensors:</u>
  Bragg gratings, long period gratings, Fabry-Perot interferometers
  Maximum temperature can be as high as 1600C.
- <u>Multiplexed sensors</u>
  wavelength and time division multiplexing for as many as 1000 sensor elements along a single fiber cable
- <u>Distributed sensors</u>
  Raman and Brilluion nonlinear scattering systems for temperature and strain measurements with a span of 50km and a special resolution of 15cm
- <u>Chemical, medical and biological sensors</u>
  Often based on the combined use of fiber optics, MEMS and nanotechnology

Intrinsic Fabry-Perot Interferometer









"UV-induced intrinsic Fabry-Perot inteferometric fiber sensor and frequency division multiplexing scheme" submitted to IEEE J. Lightwave Tech.

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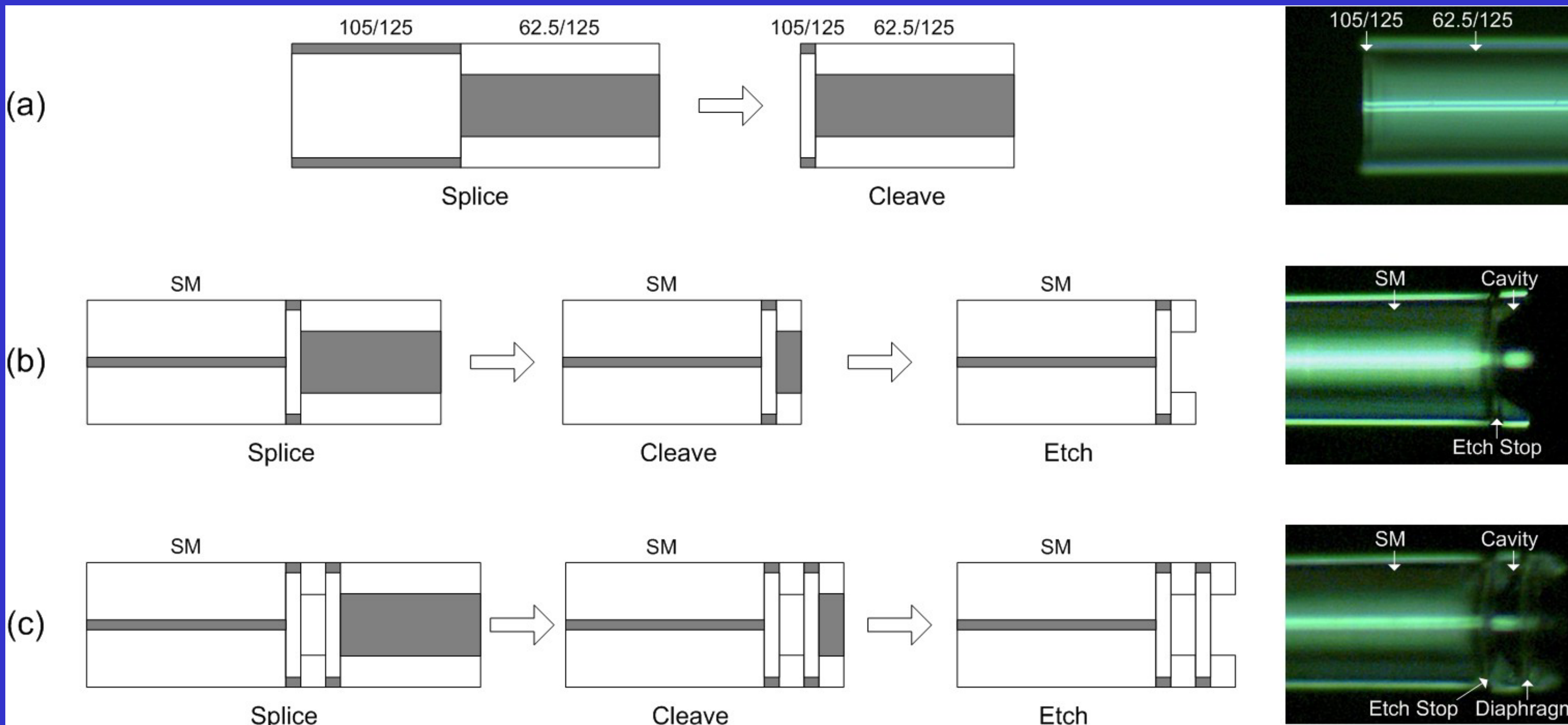
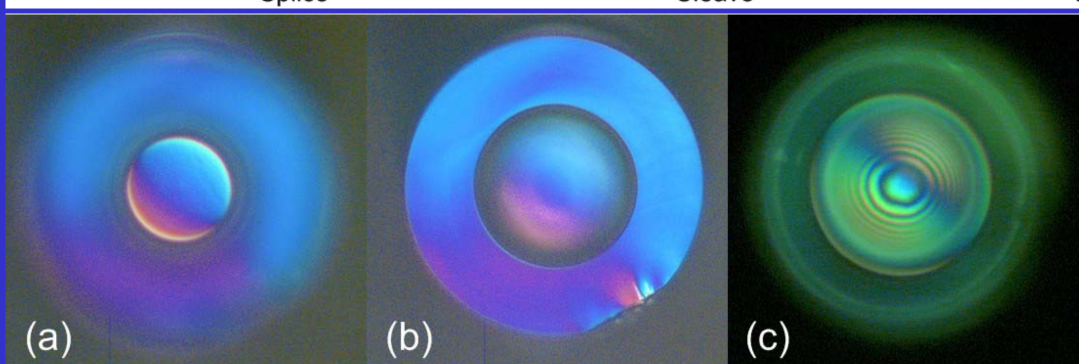
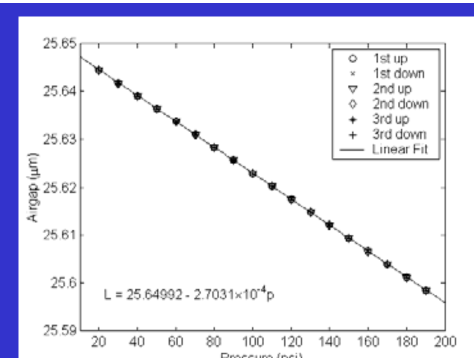
Micromachined Sensors







"Miniature fiber optic pressure sensor," IEEE Photon. Techn.Lett. vol. 17, no. 2, 2005.

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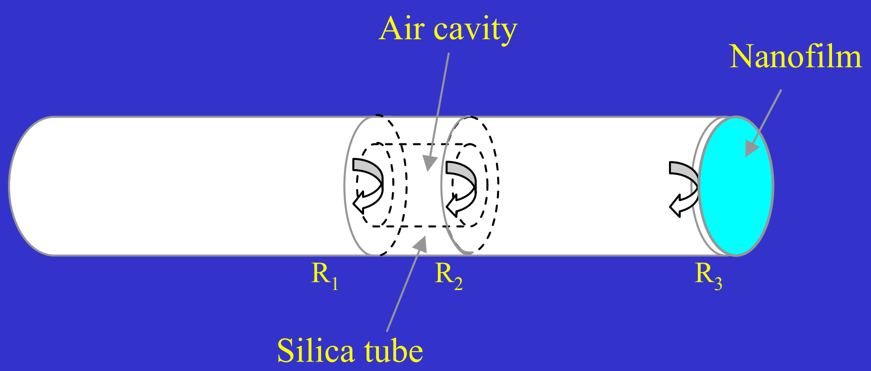
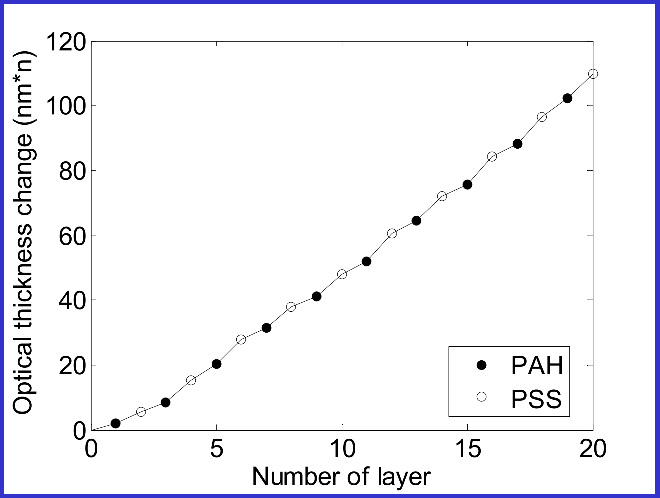
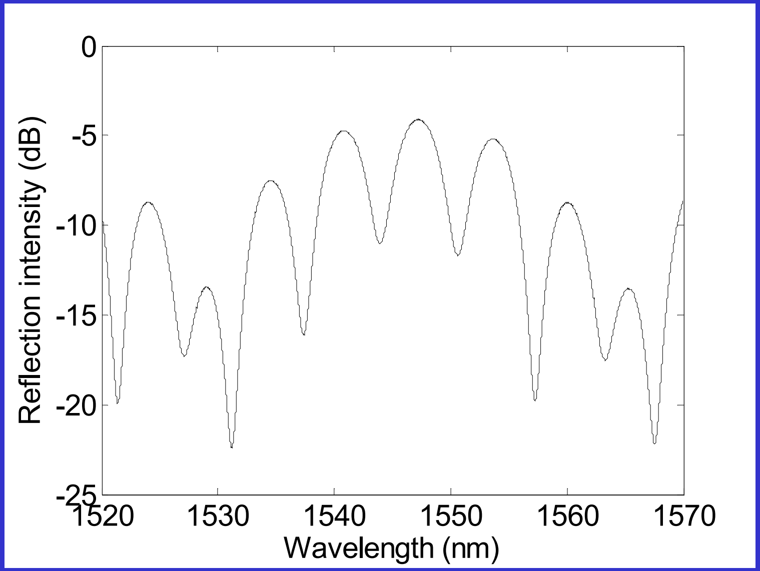
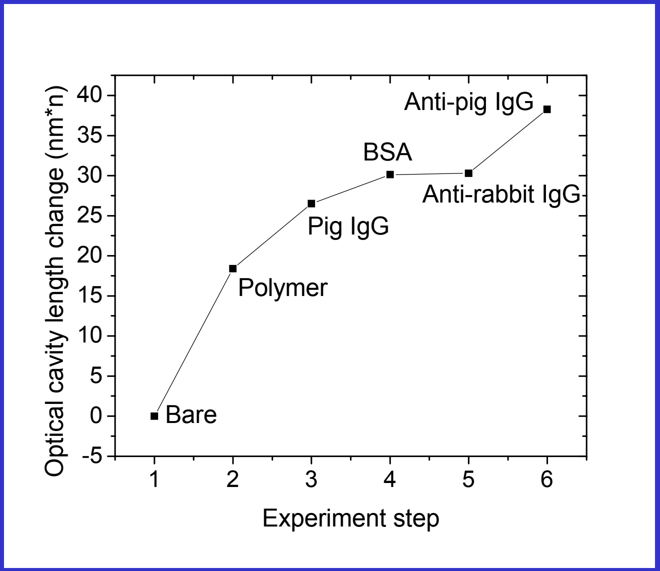
FP-Based Bio-Sensor









"A miniature fiber optic Multi-cavity Fabry-Perot interferometric biosensor" to be published in *Opt. Lett.*

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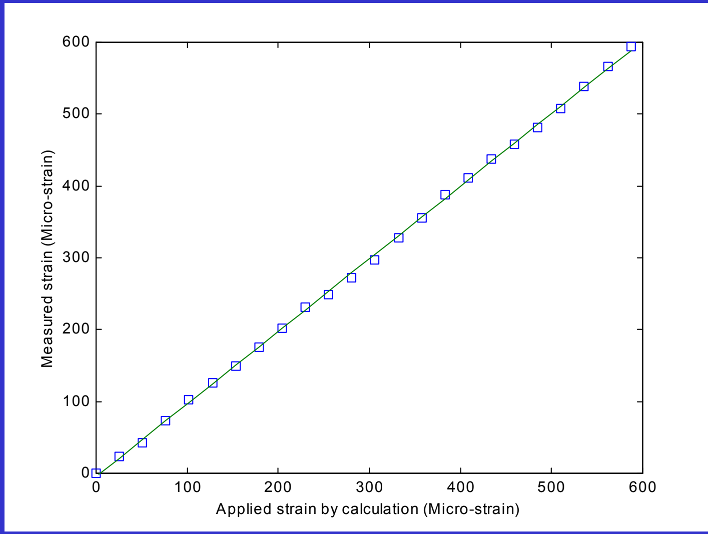
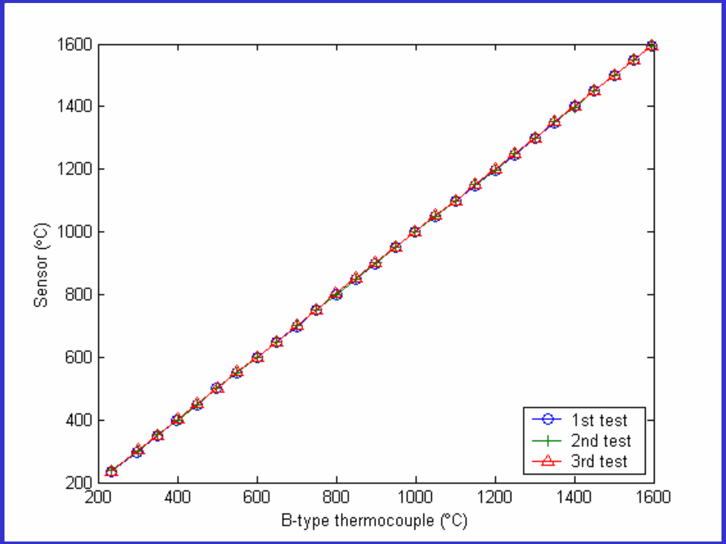
Single-Crystal Sapphire Fiber Sensors

Silica fiber has a limit in maximum operating temperature due to 1) thermal diffusion of germanium dopant and 2) glass creep under stress at elevated temperatures. The maximum is usually between 800 and 900C. For high temperatures, single-crystal sapphire fiber offers an excellent candidate for sensor construction.





"Single-crystal sapphire fiber-based strain sensor for high temperature applications" *IEEE J. Lightwave Tech*., Vol. 21, No. 10, pp2276-83 (2003).

"Sapphire-fiber-based white-light interferometric sensor for high-temperature measurements" to be published in *Opt. Lett*.

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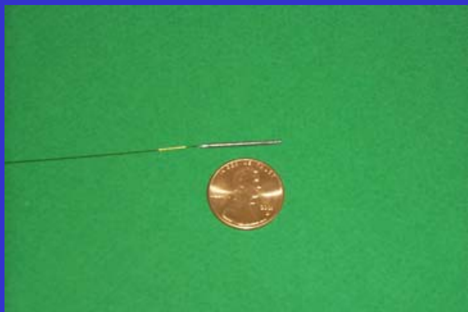
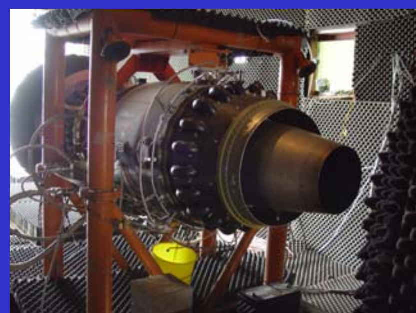
Sensor Applications









The results were published in *Appl. Opt., J. Lightwave Tech., Opt. Lett., and IEEE Photo. Tech. Lett.* in the past several years.

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Future Trends

- Special waveguides, such as photonic crystal fibers, will enable many new sensing mechanisms and sensor configurations;
- Lasers with ultra-narrow line or pulse width will permit longer sensing span and finer spatial resolution;
- Improved micro-fabrication technologies will continue to improve sensor performance, functionality, reliability and capability of harsh environment operation;