Fiber-Optic Temperature Sensors

- The details of a GaAs semiconductor temperature probe. A small prism-shaped sample of single-crystal undoped GaAs is epoxied at the end of two side-by-side optical fibers. The Sensors and fibers can be quite small, comparable with biological implantation after being sheathed. One fiber transmits light from light -emitting diode source to the sensor, where it is passed the GaAs and collected by the others fiber for detection in the readout for the instrument.
- Some of the optical power travelling through the semiconductor is absorbed, by the process of raising valence-band electrons, across the forbidden energy gap into the conduction band. Because the forbidden energy gap is a sensitive function of a materials temperature, the amount of the power absorbed increases with temperature.
- This non-metallic probe is particularly suited for temperature measurement in the strong electromagnetic heating fields used in heating tissue for cancer

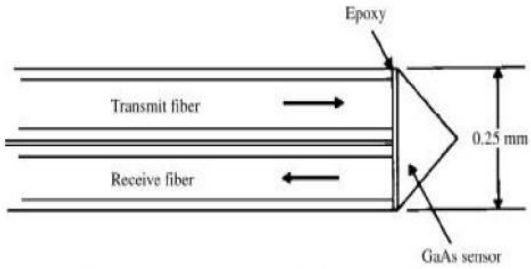


Figure 2.19 Details of the fiber-sensor arrangement for the GaAs semi-conductor temperature probe.

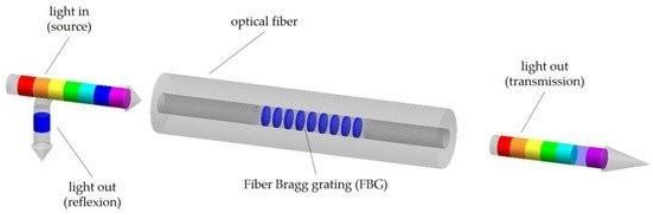
therapy or in-patient rewarming.

- **Fiber optics** are essentially light pipes. The group of sensors known as fiber optic thermometers generally refer to those devices measuring higher temperatures wherein blackbody radiation physics are utilized. The Fiber Optic Temperature Sensors use either WLPIor GaAs technology and can be used in a wide range of applications ranging from cryogenic temperature to high temperature up to 350 degrees
- Lower temperature targets--say from -100°C to 400°C--can be measured by activating various sensing materials such as phosphors, semiconductors or liquid crystals with fiber optic links offering the environmental and remoteness advantages

Fiber Bragg Grating

This type of sensors has been widely applied in the measurement of different parameters, such as physical, chemical, clinical, biomedical and electrical parameters in the energy, aerospace and civil fields. They are simple, intrinsic sensing elements, which can be photo-inscribed into silica fiber and offer all the advantages associated with fiber optic sensors. Typically, a FBG sensor can be seen

as a selective photo-induced modulation of the optical fiber core refractive index. The FBG resonant wavelength (Bragg wavelength), λ_B, is related to the effective refractive index of the core mode (n_{eff})and the grating period (Λ)

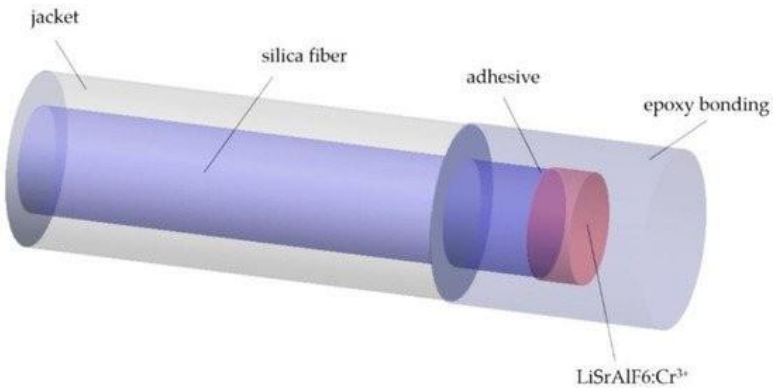


When the grating is illuminated by a broadband optical source, the reflected spectrum presents a sharp peak, which is caused by interference of light with the planes of the grating. Any perturbation on the grating (e.g., external strain or temperature variation) results in a shift in the Bragg wavelength, which can be detected either in the reflected or transmitted spectra.

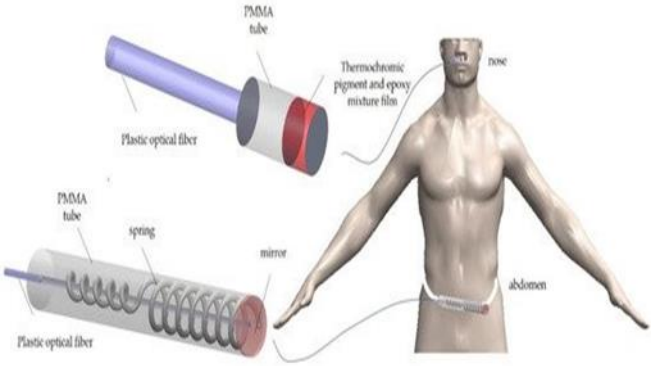
Biomedical Optical Fiber Temperature Sensors

Fiber optic fluorescent techniques have been proposed. The fluoroptic technology uses fluorescent materials, such as rare-earth phosphors or gallium arsenide (GaAs), and an adequate light source to excite them. Temperature can be determined by measuring fluorescence emission decay times in the fluoroptic probes

Solid state materials can also be used for fluorescence thermometry and some schemes have been presented for biomedical purposes, using the ruby and the trivalent-chromium ion doped material



The probe of fiber temperature



Schematic drawing of the structures of the nasal-cavity and abdomen-attached fiber-opticsensors

Advantages of Using Fiber Optics for Temperature Measurements

Whether used for communications or infrared temperature measurement, fiber optics offer someinherent advantages for measurements in industrial and/or harsh environments:

- Unaffected by electromagnetic interference (EMI) from large motors, transformers, welders andthe like;

- Unaffected by radio frequency interference (RFI) from wireless communications and lightningactivity;
  -Can be positioned in hard-to-reach or view places;
  -Can be focused to measure small or precise locations;
  -Does not or will not carry electrical current (ideal for explosive hazard locations);
- Fiber cables can be run in existing conduit, cable trays or be strapped onto beams, pipes orconduit (easily installed for expansions or retrofits);
  - Certain cables can handle ambient temperatures to over 300°C--higher with air or water purging