

GaAs

THE PRINCIPLE

FISO's fiber optic temperature probes for medical applications are based on white light absorption/transmission by a GaAs (gallium arsenide) semiconductor. The effects of the temperature variations on this semiconductor are well-known and predictable. As the temperature of the semiconductor increases, the semiconductor's transmission spectrum (i.e. the light that is not absorbed) shifts to higher wavelengths. At any given temperature, transmission essentially jumps from 0% to 100% at a specific wavelength. This jump is called the absorption shift, and the relationship between a specific wavelength -where the absorption shift takes place- and the temperature is therefore predictable.

Why does this shift occur? The physical explanation for this phenomenon is found in the variation that occurs into the semiconductor's energy band gap. This "gap" refers to the energy required to bump the electrons in the material into an excited state (as opposed to the relaxed, steady state). As more energy enters the semiconductor, in the form of heat as its temperature rises, the gap gets narrower -which means that less additional energy is required to excite an electron. The photons (particles of light) entering the semiconductor are what actually excite the electrons. If a photon is carrying enough energy to get an electron across the gap, it will be absorbed. If it does not carry enough energy, then it will be transmitted. The shorter a photon's wavelength is, the more energy it carries. Since the band gap narrows as the semiconductor's temperature increases, less energy will be required to jump across the gap, and photons with less and less energy (longer and longer wavelengths) will be absorbed "by the band", as they say. Consequently, measuring the position of the absorption shift gives a measure of the semiconductor's temperature. It is important to note that this technology is wavelength dependent instead of intensity dependent.

THE TEMPERATURE SENSOR

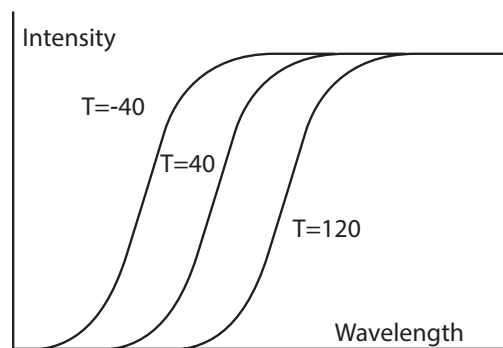
FISO's temperature probes are based on the direct contact of temperature measurement. Traditional temperature sensors such as thermocouples and RTDs (resistance temperature devices) work on the same principle. In other words, the semiconducting material must be touching the object or be immersed in the liquid or gas



to be measured in order to give a reading. The more intimate the contact and the smaller the thermal mass of the sensing tip are, the faster the semiconductor will respond to changes in temperature. The further step is to be able to deliver light to the semiconductor and measure what is absorbed. That is the exact function of the optical fiber.

A tiny GaAs semiconductor is bonded to one end of a well-polished optical fiber. On one side of this semiconductor, a reflective dielectric film (material that does not conduct electricity) is installed. All the materials share this property ("high dielectric strength"), which is one of the principal advantages of FISO's sensor technology over traditional temperature which use wire to convey an electrical signal.

The length of the optical fiber is covered with a protective sheath (made of nylon, polyimide or PTFE namely), making it very resistant to handling and chemical environments. The entire distal end assembly (semiconductor and end of the fiber) is then embedded in biocompatible adhesive to protect the sensor (the semiconductor) from chemical and mechanical aggressions.



The computation of the absorption shift does not depend on signal intensity for this particular technology, but only the wavelengths of the light are of interest. Thus, the various factors that contribute to the attenuation of the optical fiber (fiber length, number and quality of connections, fiber diameter and composition, bending) do not impose any serious constraints to the system. FISO's approach gives reliable, repeatable temperature measurements without the errors that may result from a loss of power in the connectors or a sharp bend in the optical fiber.



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