How does a fiber optic ATR-probe work?

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This Technical Note provides a general description and the basic principles of how an ATR probe works

Overview

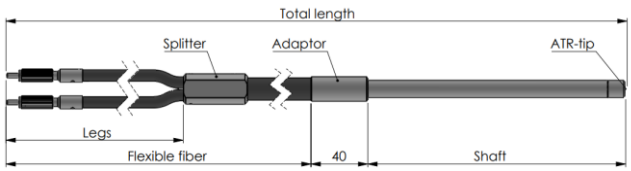
An Attenuated Total Reflectance (ATR) fiber optic probe is a specialized device used for spectroscopic analysis in the infrared (IR) and ultraviolet (UV) regions. ATR probes are used with FT-NIR, FT-IR, or other spectrometers. These probes transmit light from a spectrometer to the ATR crystal and back to a spectrometer, allowing real-time measurements and on-line reaction monitoring.

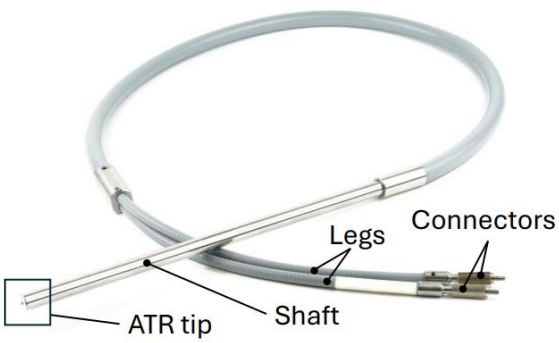
The main parts of a typical ATR probe are as follows:

- **Legs** with optical fibers inside that are connected to a spectrometer to guide the light through the probe

- **Shaft** that protects internal optics and can be immersed in the sample liquid or gel

- **ATR-crystal at the probe tip**, which is in contact with a sample and where the guided light interacts with an analyzed sample.

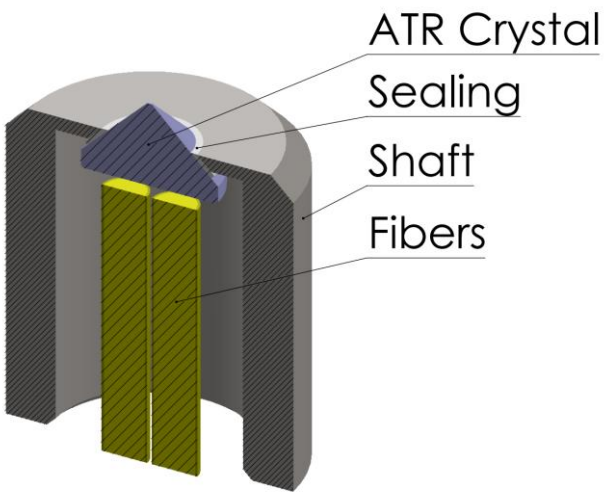




Scheme and photo of a typical ATR fiber probe.

Working principle

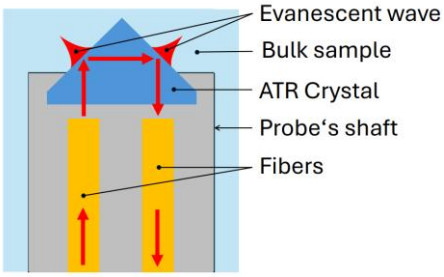
The ATR tip of the fiber probe consists of an ATR crystal, sealing, shaft, and optical fibers. The most commonly used materials for the ATR probe's shaft are PEEK and the highly chemically resistant Hastelloy C22. Sealing materials are chemically resistant PEEK or PTFE or Gold. ATR crystals in fiber probes can be Diamond, Zinc Selenide, Silicon, Germanium, Zirconium Oxide or Sapphire. In the case of loop probes, a polycrystalline silver halide fiber works as the ATR element.



Scheme of an ATR-tip.

The working principle of an ATR fiber probe is Attenuated Total Reflectance (ATR). When an ATR probe is connected to a spectrometer, an optical beam is guided through the optical fiber into the ATR crystal, where it undergoes multiple internal reflections. During these reflections, evanescent waves are generated at the crystal's surface, allowing the beam to interact with the sample in contact with the crystal.

The penetration depth of the evanescent wave is only a few micrometers, meaning that the light primarily interacts exclusively with the sample's surface. In other words, the ATR probe must touch the sample to obtain a spectrum. This makes ATR probes suitable for analyzing liquids, gels, and soft materials, such as biological tissues.



Light guidance in ATR tips.

Connection with a spectrometer

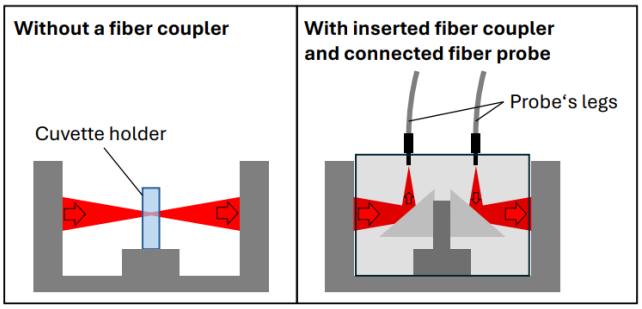
Some spectrometers are already fiber-compatible (e.g., Bruker MATRIX-F or Mettler Toledo ReactIR 702L). For benchtop spectrometers, an additional fiber coupler can be easily installed.

ATR probe connected to the benchtop FTIR spectrometer with installed fiber coupler. ATR probe and fiber coupler are products of art photonics.

The fiber probe coupler is an accessory for a sample compartment. It focuses the optical beam from the spectrometer into the fiber and back from the fiber into the spectrometer.

The ATR fiber optic probe is connected to a coupler or a spectrometer using optical connectors, such as SMA905 connectors. Some spectrometers use special connectors that can be fitted to an ATR probe.

The beam path in the FTIR spectrometer inside of the sample compartment is shown below (the beam path is marked red). It is shown without a fiber coupler (on the left) and with an inserted fiber coupler with a connected fiber probe (on the right).



Beam path in FTIR spectrometer inside of a sampling chamber.

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