

Contaminant Monitor Laser

Earth's delicate and protective biosphere can be surveyed using precisely tuned lasers that can detect various chemical compounds and atmospheric pollutants.

Supported by a Langley Research Center Small Business Innovation Research (SBIR) contract, OPOTEK, Inc. of Carlsbad, California developed a laser transmitter for remote sensing of water vapor in the upper atmosphere. The major challenge of the NASA SBIR contract was to develop a solid state laser transmitter which is tuned to a specific wavelength with an extremely narrow spectral linewidth.

A transmitter that can generate very short pulses of continuously tunable laser radiation can be applied to the study of particulate matter within the atmosphere.

Differential Absorption Lidar (DIAL) is a remote sensing technique in which two beams are sent towards the target area. The wavelength of one beam is tuned to match the absorption of the target compound. The second beam is tuned to "miss" the absorption line. The signals are scattered back by the DIAL system by the particles (aerosols) in the atmosphere, and they are detected and analyzed at different arrival times. The ratio of the amplitude of the two return signals, together with the arrival time, provides quantitative information regarding the concentration and the location of the interrogated compound within the atmosphere.

As a leader in developing and using DIAL systems to monitor ozone and water vapor in the atmosphere, NASA was interested in upgrading the capabilities of its airborne laser systems.

At the heart of OPOTEK's work with NASA was an Optical Parametric Oscillator (OPO) that converts a fixed wavelength laser into a tunable source. The output of the OPOTEK MagicPrism™ OPO, which consists mainly of non-linear crystals in a ring cavity, can be tuned continuously over a wide spectral range. This can be done by changing the angle between the optical axis of the crystal and the direction of the beam.

An OPO-based system could replace NASA's current use of dye-laser systems. For OPOTEK to meet NASA's requirements, the OPO was seeded by a narrow-line diode laser, tuned to the absorption lines of water vapor.

OPOTEK is exploring the application of its NASA work to industrial settings. Laser Induced Fluorescence (LIF), for instance, is a powerful technique to monitor chemical processes in extreme environments. As a direct spinoff from its NASA-supported research, OPOTEK began eyeing this technique for industrial applications. In the LIF approach, the laser is tuned to a specific absorption line of the compound which needs to be

monitored. Quantitative information is collected by observing fluorescent light emitted from the chemical as a result of the irradiation by the laser beam.

The laser transmitter developed for NASA was used for measuring water vapor in the infrared region. By broadening this concept to other wavelengths, OPOTEK believes a range of industrial applications can be met. A host of other government uses for the technology are also being examined as follow-up by the company.

OPOTEK's tunable laser systems can be used by the Drug Enforcement Administration for discerning the by-products from illegal drug manufacturing. OPO technology has a wide range of applications for Department of Defense in the post cold war era, particularly for local conflicts and terrorism.

Lastly, lasers are in great demand by universities and industrial laboratories. By tuning the laser to interact with specific elements or chemical compounds, it can be used for basic research in photo-chemistry, photo-biology, as well as for diagnostics and monitoring various chemical processes. OPOTEK estimates that the market for scientific lasers alone is on the order of \$150 million, of which approximately \$70 million are tunable lasers.

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Tunable laser systems built by OPOTEK can monitor Earth's atmosphere for contaminants.