# NISTTech

## CHIRPED-PULSE FOURIER TRANSFORM SPECTROSCOPY AT MILLIMETER AND THZ FREQUENCIES

**Trace Gas Detector**

## Description

The invention is a sensor for trace gas detection that can simultaneously detect many different trace gases at a very fast rate with high sensitivity.

The key to the sensor is the use of radiation at "terahertz" frequencies—between infrared and microwaves. Terahertz waves can make gas molecules rotate at rates unique to each type of gas, which implies the waves hold great promise for identifying gases and measuring how much gas is present. The NIST team has developed the technology to rotate the molecules "in phase"—imagine synchronized swimmers—and detect the spinning molecules easily as they gradually fall out of phase with each other.

A major hurdle the technology overcomes is that it is now possible to look at nearly all possible gas molecules instantly using terahertz frequencies. Previously, it was necessary to expose molecules to a vast range of terahertz frequencies—slowly, one after another. Because no technology existed that could run through the entire frequency band quickly and easily, the NIST team had to teach their off-the-shelf equipment to "chirp."

## Applications

- **Medical**
  testing
- **Environmental air pollution**
  detector
- **Bomb**
  sniffer

## Advantages

- **Speed**
  Fast
- **Spectral Resolution**
  Excellent
- **No background correction**
  No need for background correction of the instruent response without sample

## Abstract

A broadband trace gas sensor based on chirp-pulse terahertz spectroscopy. The advent of developed solid-state phase-coherent sources and sensitive heterodyne detectors for the terahertz frequency range has made it possible to generate and detect precise arbitrary waveforms at THz frequencies with ultra-low phase noise. In order to maximize sensitivity, the sample gas is first polarized using  sub-microsec chirped THz pulses generated in an amplifier/multiplier chain (AMC) also referred to as an active multiplier chain. The absorpiton signals and the free inductive decays (FIDs) are then detected on a sub-microsec time scale using a sub-harmonic heterodyne reciever. This approach allows for a rapid broadband multi-component sensing with low parts in 10 degree (ppb) sensitivies and spectral frequency accuracy of <20 kHz in real-time. Such a system can be configured into a portable, easy to use, and relatively inexpensive sensing platofrm. This technique will be applicable to any THz frequency range (including the millimeter range below 200 GHz) where phase coherent souces are available. Currently, AMC sources and sub-harmonic heterodyne detectors (mixers) are commerically available up to about 2 THz.

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## Citations

1. E. Gerecht, K.O. Douglass and D.F. Plusquellic. Chirped-pulse terahertz spectroscopy for broadband trace gas sensing. Optics Express, April 22, 2011, Vol. 19, Issue 9, pp. 8973-8984 (2011), doi:10.1364/OE.19.008973.
2. NIST Docket no. 11-016

## Related Items

- The Secret Behind NIST's New Gas Detector? Chirp Before Sniffing

## Status of Availability

This invention is available for licensing.

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