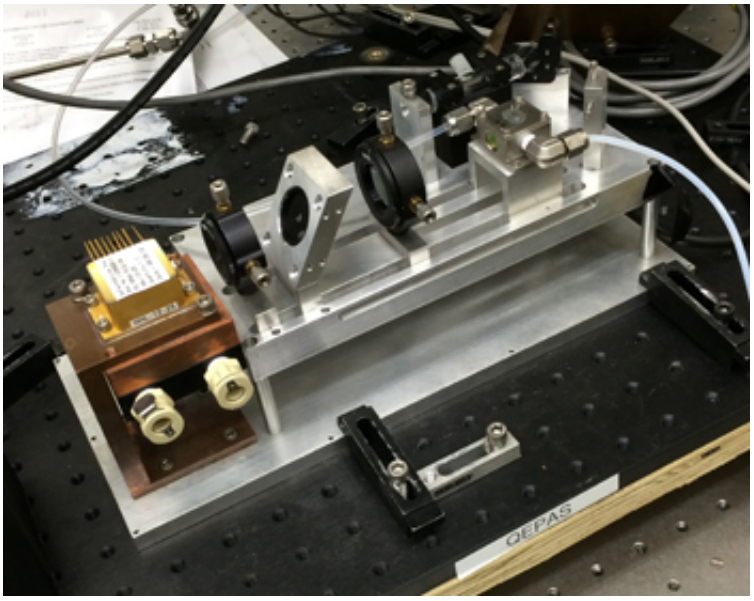
Compact device has sensitive nose for greenhouse gases

January 22 2014, by Mike Williams



The QEPAS sensor, seen in a Rice University lab, is capable of detecting trace amounts of methane and nitrous oxide. The portable unit was tested during NASA's recent DISCOVER-AQ survey of Houston air quality and proved itself the equal of far larger instruments. Credit: University Laser Science Group

(Phys.org) —Rice University scientists have created a highly sensitive portable sensor to test the air for the most damaging greenhouse gases.

The device created by Rice engineer and laser pioneer Frank Tittel and his group uses a thumbnail-sized quantum cascade laser (QCL) as well as tuning forks that cost no more than a dime to detect very small amounts

of nitrous oxide and methane.

The QCL emits light from the mid- to far-infrared portion of the spectrum. That allows for far better detection of gases than more common lasers that operate in the near-infrared.

The technique called "quartz-enhanced photoacoustic absorption spectroscopy" (QEPAS), invented at Rice in 2002 by Tittel, Professor Robert Curl and their collaborators, offers the possibility that such devices may soon be as small as a typical smartphone.

The Rice team's device was detailed this month in the Royal Society of Chemistry journal *Analyst.*

Tittel's team tested the small device at a Houston dump and found it capable of detecting trace amounts of methane—13 parts per billion by volume (ppbv)—and nitrous oxide—6 ppbv.

"Methane and nitrous oxide are both significant greenhouse gases emitted from human activities," Tittel said. "Methane is emitted by natural sources, such as wetlands, and human activities, such as leakage from natural gas systems and the raising of livestock.

"Human activities such as agriculture, fossil fuel combustion, wastewater management and industrial processes are increasing the amount of nitrous oxide in the atmosphere. The warming impact of methane and nitrous oxide is more than 20 and 300 times, respectively, greater compared with the most prevalent greenhouse gas, carbon dioxide, over a 100-year period. For these reasons, methane and nitrous oxide detection is crucial to environmental considerations."

The small QCL has only become available in recent years, Tittel said, and is far better able to detect trace amounts of gas than lasers used in

the past. Previous versions of the QCL are just as effective, but far too bulky for mobile use.

What makes the technique possible is the small quartz tuning fork, which vibrates at a specific frequency when stimulated. "The ones we use are made for digital watches and are very cheap," said Rice postdoctoral researcher and co-lead author Wei Ren. "The fundamental theory behind this is the photoacoustic effect."

The laser beam is focused between the two prongs of the quartz tuning fork. When light at a specific wavelength is absorbed by the gas of interest, localized heating of the molecules leads to a temperature and pressure increase in the gas. "If the incident light intensity is modulated, then the temperature and pressure will be as well," Ren said. "This generates an acoustic wave with the same frequency as the light modulation, and that excites the quartz tuning fork.

"The tuning fork is a piezoelectric element, so when the wave causes it to vibrate, it produces a voltage we can detect. That signal is proportional to the gas concentration."

The unit can detect the presence of methane or nitrous oxide in just a second, he said.

To field test the device, the Rice team installed it on a mobile laboratory used during NASA's DISCOVER-AQ campaign, which analyzed pollution on the ground and from the air last September. (Results from DISCOVER-AQ were discussed in a meeting of air quality scientists at Rice in January.) The lab analyzed emissions from a Houston landfill, and the QEPAS sensor's findings compared favorably with the lab's much larger instrument, Tittel said.

"This was a milestone for trace-gas sensing," Ren said. "Now we're

trying to minimize the size of the whole system."

Tittel said a smaller QEPAS device will be added this year to the mobile monitoring van currently carrying out a Rice/University of Houston survey of pollutants in the city.

More information: pubs.rsc.org/en/content/articl … n01452e#!divAbstract

Provided by Rice University