LaserSPECKs: Laser SPECtrososcopic Trace-Gas Sensor Networks

Martin Wilske
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What is “LaserSPECks”?

A short introduction...
What is “LaserSPECks”? 

- Laser SPECtroscopic Trace-Gas Sensor
- new technology for gas-detection
- optical detection of gas
- bases on infrared-lasers
- less costs in comparison to traditional devices
What is “LaserSPECks”? 

• How do they look like?
Optical Gas-Detection

or: introducing a possibility for gas-detection...
Optical Gas Detection

- infrared light with a known intensity is emitted
- light is sent through an area where gas might be
- a receiver detects the remaining light intensity
- by knowing the start-intensity gas can be detected by the receiver

\[ I(v) = I_0 \cdot e^{-\alpha(v)L} \]

- every gas has its own special “fingerprint”
What is “LaserSPECks”?

- What does infrared mean?
Optical Gas Detection

- problems:
  - air pressure may vary
  - environment temperature may change
  - usually a distance of 100m is used
  - cells being built for needed tolerances cost $10,000
  - cells are voluminous
Optical Gas Detection

- consequences:
  - sensors need to detect air pressure and temperature
  - more calculations are needed for gas-detection
QuartzEnhanced PhotoAcoustic Spectroscopy - QEPAS

Theory of operation...
QEPAS

- developed at Rice University
- detection of any gas type
- gas is detected by sound-mesurement
- every gas has its own “sound”-fingerprint
- more tolerant to air pressure and temperature
QEPAS

- how does it work?
  - laserbeam hits gas-molecules
  - molecules vibrate and produce heat
  - by deactivation of laser gas “cools down”
  - by cooling down a soundwave is produced
    - physics: gas extends and tightens regarding the temperature
    - during tightening “air-layers” collapse
how does it work?

- the originated sound is recorded by a kind of “tuning-fork”
- tuning-fork oscillates and causes piezo-electric current
- piezo-electric current can be measured and implies the detected gas
• advantages

• laser can tune to the specific gas-wavelength

• low cost:

  mass produced near-infrared laser (SC-diode) &
  $0.30$-tuning-fork is mass produced for watches

• comparatively small sized
Miniaturization

Making QEPAS applicable for wireless sensor networks...
• sensor it self has volume of less than 1 cm³
• problems to be solved:
  • laser-wavelength control (temperature)
  • laser-power fluctuation
  • alignment of optical system
  • handling phase shifts (caused by molecules)
  • power efficiency and noise
• solutions
  • “temperature control loop”
  • laser includes “output power measurement”
  • alignment tool is available
  • quadrature detection for phase shifts
  • special amplifiers for efficient power usage
• alignment-tool for laser-calibration
Architecture

How it is built...
Architecture

• based on GNOMES
• Generalized Network of Miniature Environmental Sensors
• ZigBee radio
• new Architecture is developed for next version
  • combining two boards
• power consumption: 800mA
Architecture

- A block-diagram representing LaserSPECks:
Architecture

- LaserSPECks-Integration on a board:
Applications

Where is it used...
Applications

- industrial monitoring in semiconductor, petroleum and/or pharmaceutical applications
- agricultural monitoring of livestock health
- volcanic emissions
- detection in hazard/quarantine-areas
- breath analysis
- explosives sniffing
Sources & Literature

Where do you find more information ...
Sources & Literature

- LaserSPECks: Laser SPECTroscopic Trace-Gas Sensor Networks – Sensor Integration and Applications
- http://de.wikipedia.org/wiki/Photoakustische_Spektroskopie
- dissertation: “Spektrale Eigenschaften des Quantenkaskadenlasers und seine Eignung für hochauflösende Molekülspektroskopie“
Thank you for paying attention!

Or do you have questions?