QCL-based Ammonia Slip Sensor in Thermal Power Plant DeNOx Process

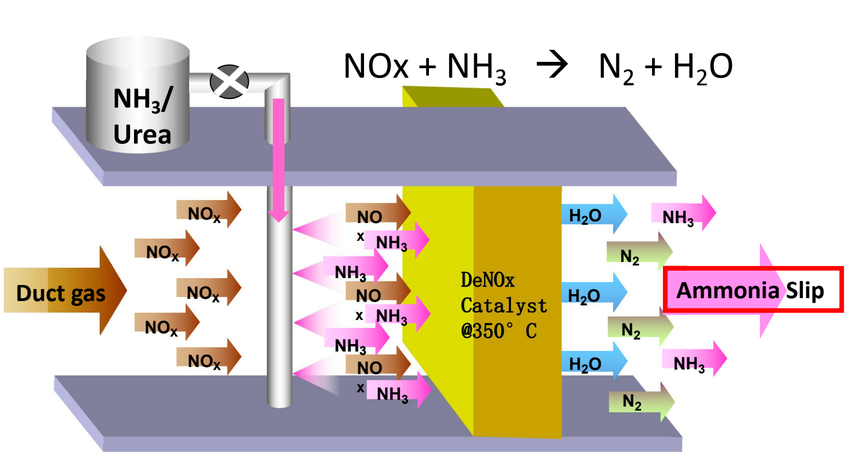
Peng Kang Ph.D., Ting-Jung Lin Ph.D., Yin Wang Ph.D.
Healthy Photon Co., Ltd., Ningbo, Zhejiang, P.R. China
Email: yin.wang@healthyphoton.com Website: www.healthyphoton.com

Introduction

1. Ammonia (NH_3) plays a key role in thermal power plant DeNOx process.
   - Excessive NH_3 (ammonia slip) results in higher costs and air pollution.
2. Limitations of current NH_3 slip monitor products (NIR laser based):
   - Low resolution & unstability due to high dust and high temperature, etc.
3. HealthyPhoton's ultra-sensitive, portable NH_3 analyzer based on MIR QCL spectroscopy:
   - Targeting fundamental transition at 9μm.
   - Resolution up to 0.01 ppmv*m/$Hz^{1/2}$.
   - Improved system stability and robustness.
   - Possible simultaneous Nitric Oxide (NO) detection with an additional QCL.

Ammonia Slip in DeNOx Process

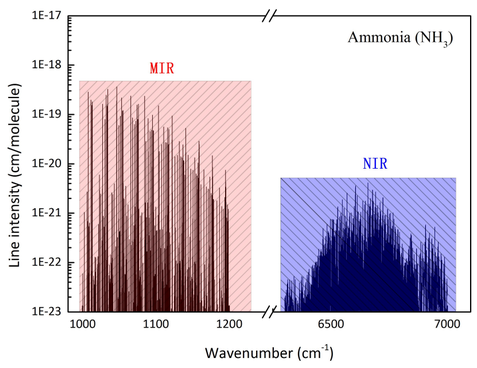
1. NOx in flue gas emissions from fossil fule combustion
   - DeNOx process is needed to meet government regulations
2. Selective Catalytic Reduction (SCR) process
   - NH_3 slip and NO emision determines process efficiency



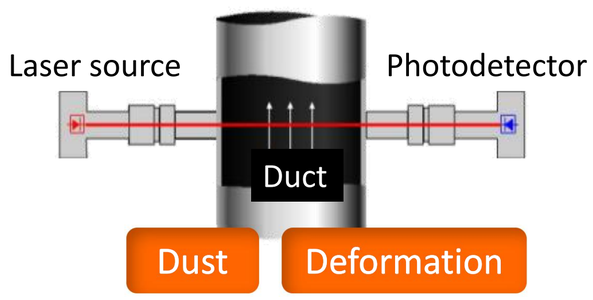
Hazards due to excessive NH_3 slip
- Blockage/corrosion of equipment
- Shorter life of catalyst
- Waste of NH_3
- Air pollution

Limitations of Current NIR based Products

1. **Accuracy** lower than required NH_3:3ppm; NOx: 25ppm



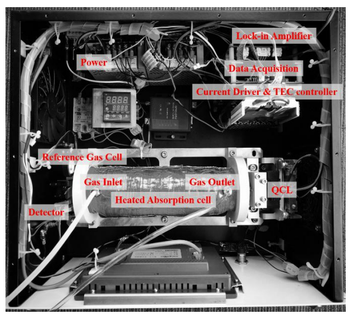
2. In-situ cross-duct spectrometer
   Dust: laser beam cannot penetrate
   Thermal deformation: beam walk-off



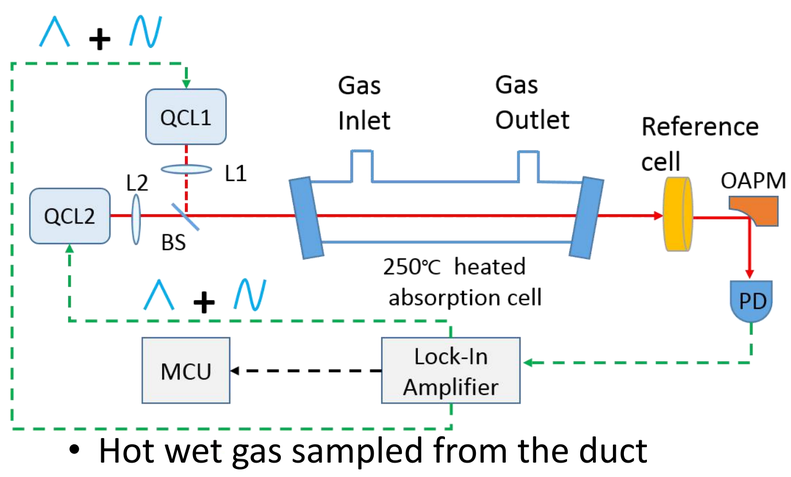
3. Extractive spectrometer using multi-pass cell compensating the weak absorption: **system unstable** under severe working conditions (mirror degradation due to salt&dust)

Our Solution: NH_3+NO Sensor

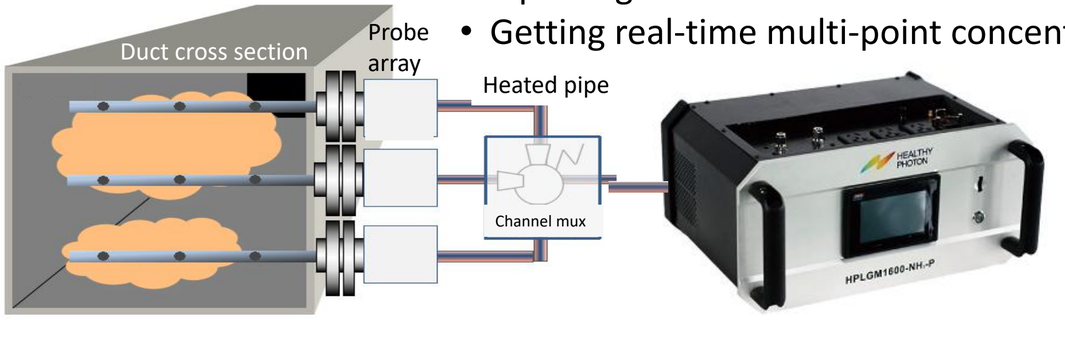
- Target fundamental transition at 9μm -> resolution up to 0.01 ppmv*m/$Hz^{1/2}$
- Simultaneous Nitric Oxide (NO) detection with QCL2 from the same sample



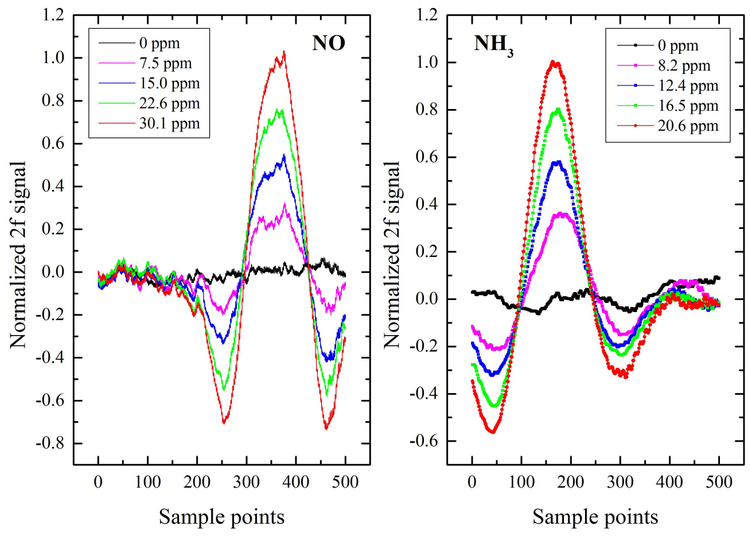
L: Lens; D:Detector;
OAPM: Off-Axis Parabolic Mirror; BS: Beam Splitter



- Hot wet gas sampled from the duct
- Pipe length < 3 meters ensures real-time data
- Getting real-time multi-point concentration



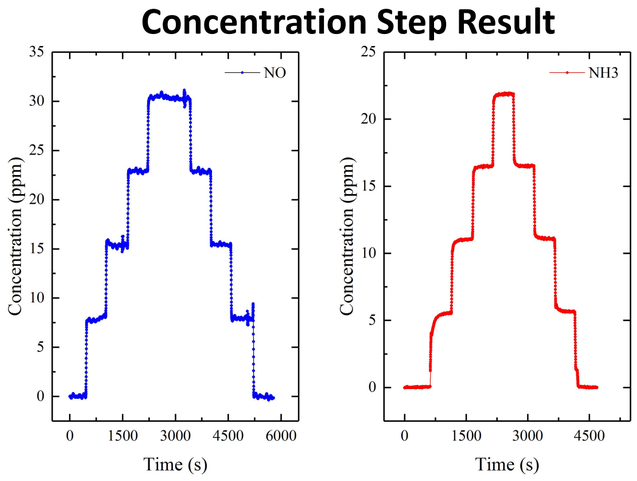
System Performance



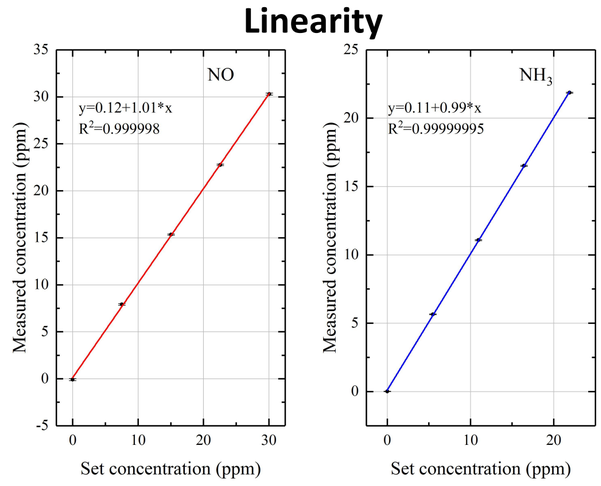
Absorption lines selection and 2f demodulation results

1. Spectrum at a known concentraion was simulated and saved.
2. Using least-square fitting of acquired spectrum to retrieve the unknown concentration.

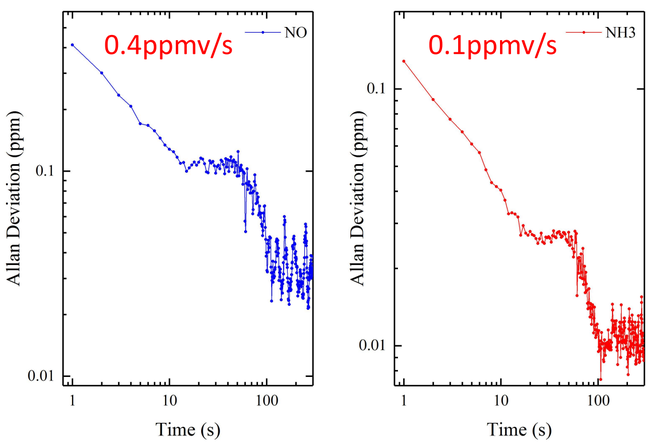
Concentration Step Result

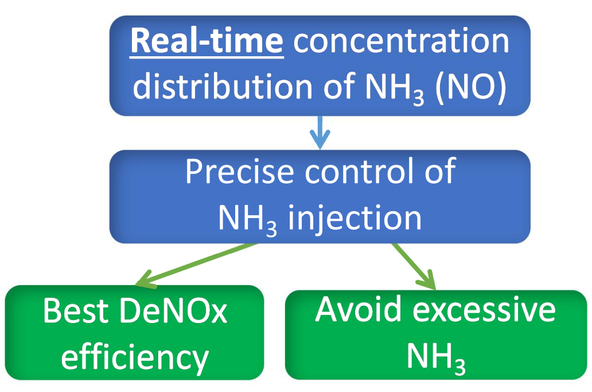


Linearity



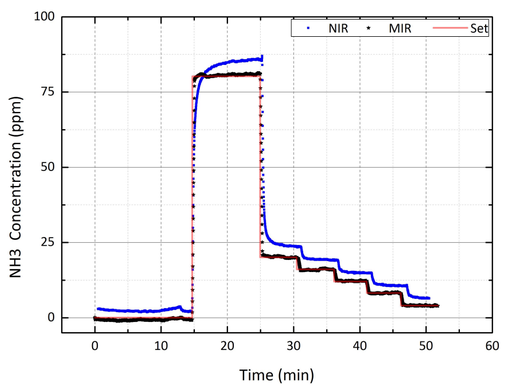
Allan Deviation

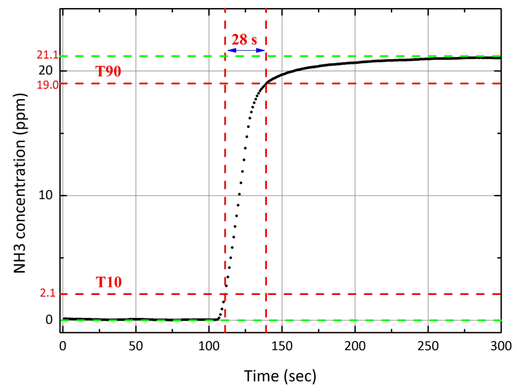




Comparison against Axetris' NIR Ammonia Analyzer

- Showing the same trend
- Better accuracy and faster response time





Conclusions and Future Work

1. A QCL based NH_3/NO sensor was developed for DeNOx process monitoring
   - NH_3: 0.1ppmv/s; (NO: 0.4ppmv/s)
2. Compared with traditional NIR sensors:
   - Better accuracy/robustness/reliability in real field condition.
3. The system ensures real-time monitoring and optimization for DeNOx process.
4. Collaborations with power plants all over China and worldwide.

QCL-based spectrometer modules for the NH_3/NO sensor prototype, industrial and scientific research applications

QCL/ICL laser

MCT detector

Current/TEC driver

OPEN FOR COLLABORATIONS!

References

[1] Institute of Clean Air Companies (ICAC). White Paper. Selective Catalytic Reduction (SCR) Control of NOx Emissions from Fossil Fuel-Fired Electric Power Plants. May 2009.
[2] United States Environmental Protection Agency. EPA Air Pollution Control Cost Manual. 2016.
[3] National Energy Administration, China. Electric Power Industry Standard. DL/T 296-2011 The Thermal Power Plant Flue Gas Denitrification Technology Guidelines. 2011.