Case Study

Application	*Atmospheric Lidar*
Product	*M2i.4960-exp: PCIe Digitizer 2 Channels 16 Bit 60 MS/s*

DIAL – Differential Absorption LIDAR

Industrialization in the modern world has become the primary cause of environmental atmospheric pollution. As such, the study of industrial pollution, and its various components, has become a major area of importance. For example, in China the Ministry of Environmental Protection has stipulated the monitoring of atmospheric levels for sulfur dioxide (SO2) and oxides of nitrogen (NOx), which are the common dangerous emissions found near industrial zones. These gasses are considered important as SO2 is known to cause varying degrees of respiratory and eye irritation. SO2 is also the main contributor to acid rain which, along with harming animals and plants, can also produce soil degradation and pollute waterways.

Figure 1. DIAL systems use two lasers with different frequencies to observe absorption differentials, allowing the detection and measurement of airborne pollutants

China's Nanjing Institute of Advanced Laser Technology, together with the Nanjing University of Information Science and Technology, both located in Nanjing, China, have been developing the latest active remote-sensing technology for detecting air pollution. One instrument that is particularly useful for detecting pollution gases is differential absorption lidar (DIAL, see Figure 1). The principle of DIAL is that two different laser wavelengths (commonly called the online and offline wavelengths) are selected so that one of the wavelengths is absorbed by the gas molecules of interest while the other wavelength is not. By measuring the subsequent difference in intensity of the two return laser signals it's then possible to determine the concentration of the molecules being studied.

The block diagram for a DIAL lidar is shown in Figure 2.

The research team chose to focus on the development of a DIAL system that uses mid-infrared absorption (MI-DIAL). Mid-infrared is an atmospheric transmission window so it's perfect for many absorption peaks of gases, including organic and inorganic molecules. In addition, its absorption efficiency is higher than that of ultraviolet, by 2 to 3 orders of magnitude, improving the accuracy and range of measurements to be made.

Key elements of the MI-DIAL system are the VIGO-PVI-4TE detectors, with 5 MHz bandwidth, and a Spectrum Instrumentation M2i.4960-exp PCIe digitizer card that samples the signals from the detectors at 40 MS/s and with 16 bit resolution. The laser itself outputs 20 ns wide pulses at a 500 Hz pulse repetition rate.

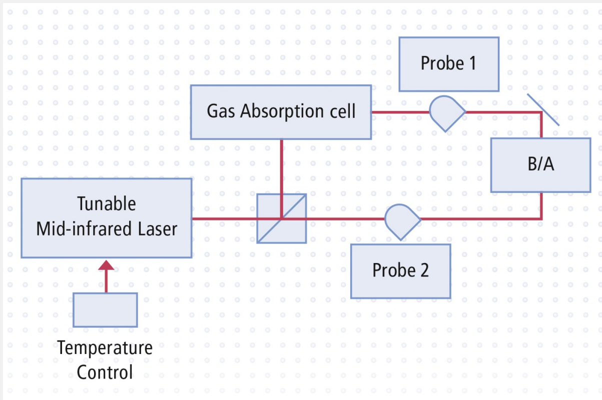

Figure 2. Shows the optical arrangement of the spectrum measurement experiment

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Data collected by the digitizer is then transferred to a PC where it can be analyzed. The process used is a line-by-line method which requires the line parameters data, which are available in the high resolution transmission molecular absorption database (HITRAN). This database records the spectral line position and intensity, pressure drift coefficient, lower energy state rotation quantum number, temperature-dependent coefficient, air-broadened half width, and the self-broadened half width of most gas molecules. Figure 3 shows the line intensity data of three polluting gases and their background gases.

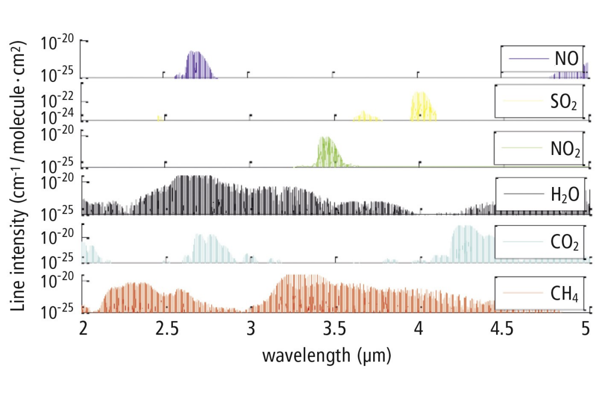

Figure 3. showing the line intensity data of three polluting gases and their background gases.

The full white paper "Spectral Characteristics of Polluted Gases and Their Detection by Mid-infrared Differential Absorption Lidar" as published in Optik - International Journal for Light and Electron Optics · September 2017 is available here:

https://www.researchgate.net/profile/Lingbing_Bu3/publication/319495291_Spectral_Characteristics_of_Polluted_Gases_and_Their_Detection_by_Mid-infrared_Differential_Absorption_Lidar/links/59b529f80f7e9b374354fa18/Spectral-Characteristics-of-Polluted-Gases-and-Their-Detection-by-Mid-infrared-Differential-Absorption-Lidar.pdf