The AQ6375 optical spectrum analyser

and laser absorption spectroscopy

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Initiatives to reduce greenhouse gases have led to the development of techniques for detecting small concentrations of gas molecules with high sensitivity.

One of these techniques is laser absorption spectroscopy, which measures the concentration by slightly modulating the oscillation wavelength of a laser around the absorption wavelength specific to the gas molecule being detected and then measuring the change in light intensity due to molecular absorption (Fig.1). Most greenhouse gases have relatively strong absorption lines in the short-wave infrared (SWIR) region around 2 µm. The lasers used in absorption spectroscopy require excellent single-mode operation performance, which directly determines the limits of detection. They also have to produce a stable oscillation in the absorption region in order to achieve sensitive detection of the gas of interest.
Existing lasers that support a single vertical mode oscillation in the SWIR region include DFB-LD (distributed feedback laser diode) and VCSEL (vertical-cavity surface emitting laser).

The Yokogawa AQ6375 optical spectrum analyser is suitable for testing the laser sources used in absorption spectroscopy, and is capable of achieving high optical performance for measurements in the SWIR region. Operating over the broad wavelength measurement range from 1200 nm to 2400 nm, it can measure the optical spectra of the semiconductor lasers described above.

‘Yokogawa OSAs are also invaluable for environmental sensing applications’

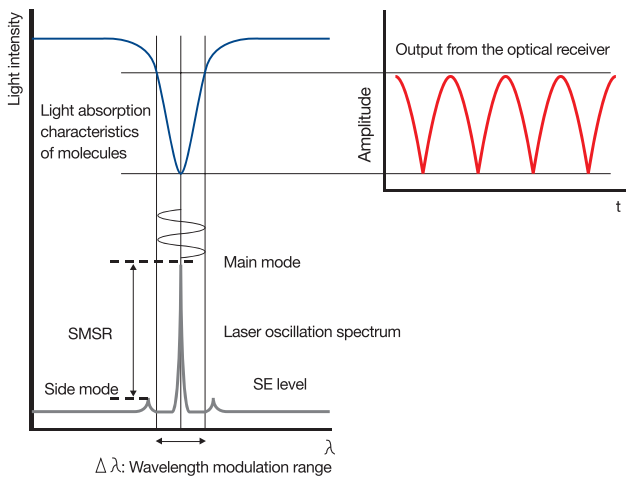

Fig.1 – Laser absorption spectroscopy technique

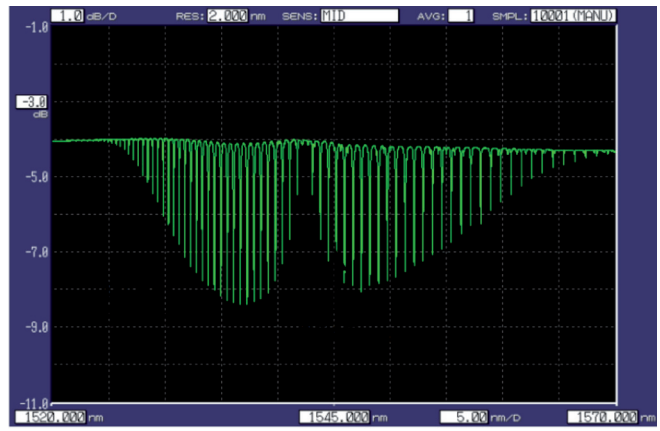

Fig.2 – Hydrogen Cyanide $H_{13}C_{14}N$ absorption spectrum measurement

Important parameters for evaluating the performance of these lasers are the side-mode suppression ratio (the amplitude difference between the main mode and the side mode), and the spontaneous emission level (the amount of background noise light). Both parameters can be accurately and quickly measured by the AQ6375 thanks to its high wavelength resolution (0.05 nm) its high close-in dynamic range (55 dB), its high sensitivity (-70 dBm) and its short sweep time (0.5 sec for any 100 nm span in 'auto' mode).

The AQ6375 can also be used to measure the absorption spectrum of a mixture of gases with different absorption wavelengths, using a tunable laser or a broadband light source like a super-luminescent diode or a super-continuum source to illuminate the gas mixture.
When used with a tunable laser, the AQ6375 can perform a sweep of the wavelength span of interest synchronised with the light source using its 'TLS sync sweep' function, which produces an absorption spectrum similar to that shown in Fig.2. With a broadband light source, the absorption spectrum of the gas mixture will be the result of the filtering action that is performed on the incident light by the high-precision Czerny-Turner monochromator which lies at the core of the AQ6375. The result will be similar to Fig.2, but because the broadband light source has a lower power density (mW/nm) than a laser, the spectrum will be much more attenuated.
In either case, The AQ6375 can clearly measure the low-power absorption spectra of gas mixtures illuminated by broadband light sources thanks to its high sensitivity (-70 dBm) and its special free-space optical input. This input will also accept multi-mode fibres (both GI50 and GI62.5, which can collect and carry more light than a single-mode fibre) without being affected by the high coupling losses characteristic of the common optical input structure adopted by other optical spectrum analysers.