Application Note

Spectral measurement solutions for MWIR pulsed laser development and evaluation

Market: Laser   AQ6377E Optical Spectrum Analyzer

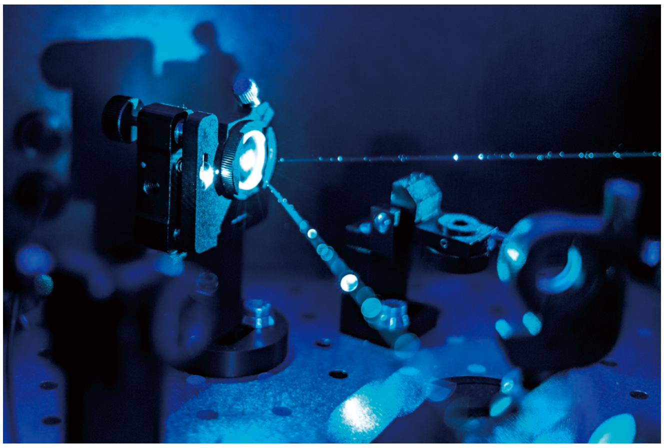

Figure 1. AQ6377E Optical Spectrum Analyzer

1. Introduction

In recent years, there has been swift progress in the research, development, and commercialization of laser technology in the mid-wave infrared (MWIR) region. The MWIR region is known as the "fingerprint region" of molecules, where characteristic infrared absorptions due to molecular vibrations are concentrated. Compared to the near-infrared (NIR) region, the MWIR region exhibits higher infrared absorption efficiency, making it suitable for a wider range of applications. High-sensitivity laser absorption spectroscopy, which leverages this characteristic, is rapidly expanding into various applications such as inline gas monitoring, environmental measurement, security, healthcare, and exhaust emissions analysis.
Additionally, the demand for MWIR pulsed lasers is growing in fields such as microfabrication, remote sensing, time-resolved spectroscopy, as well as applications aimed at reducing damage to surrounding tissues during laser treatments. This demand is driven by the need for high peak energy, minimal thermal effects, and improved temporal resolution.

For the development and fundamental research of lasers suitable for these applications, universities and research institutions are making pioneering advancements in MWIR laser technology with a variety of commercialized lasers continuing to grow. Representative MWIR lasers include quantum cascade lasers (QCL), interband cascade lasers (ICL), fiber lasers with Supercontinuum (SC) sources, and wavelength conversion lasers utilizing nonlinear optical effects, such as optical parametric oscillators (OPO). Accurate optical spectrum measurement is crucial for the research, development, and production of these MWIR lasers.

In addition to continuous wave (CW) lasers, the need for spectrum measurement of pulsed lasers is also increasing. High-performance optical spectrum analyzers that can handle lasers in any oscillation state and accurately visualize their spectra are in demand.

2. Challenges

Although the demand for MWIR pulsed lasers is increasing across various fields, accurately measuring their optical spectra presents several challenges. In particular, the influence of infrared radiation, which is negligible in the near-infrared region, becomes significant in the MWIR region beyond a wavelength of 2 μm, considerably affecting optical spectrum measurements.

For the spectrum measurement of pulsed light, dispersive spectroscopy-based optical spectrum analyzers (OSAs) offer features such as time-averaged measurements, synchronized measurements with external trigger signals, and the ability to retain the peak values of pulsed light.

Among the AQ6370E series OSAs, the three models that cover wavelengths of 2 μm and higher are equipped with a feature to mitigate the influence of infrared radiation, which works effectively when the sensitivity is set to high-sensitivity (HIGH). However, the range of measurable pulsed light characteristics is limited. On the other hand, while pulsed light with broader characteristics can be measured when sensitivity is set to modes other than high-sensitivity (HIGH), the measurement dynamic range is limited due to infrared radiation acting as background noise.

3. Solutions by AQ6377E

- Expand the measurement dynamic range in pulsed light spectrum measurement
- Expand the range of measurable pulsed light characteristics

4. Proposal for Advanced Pulsed Light Measurement Mode

Advanced Pulsed Light Measurement (APLM) Mode

The Advanced Pulsed Light Measurement (APLM) mode is a new function developed to successfully overcome the key challenges of MWIR pulsed light spectrum measurement: 1) mitigating the influence of infrared radiation, and 2) expanding the measurable range of pulsed light characteristics, such as pulse width and repetition period. (Patent pending)

Since the intensity and spectrum of infrared radiation constantly fluctuate with temperature changes, background correction must be performed at intervals shorter than the time it takes for the infrared radiation spectrum to change, to mitigate the influence on measurements. The measurement time of an OSA is determined by the measurement span, the number of measurement samples, and the sensitivity settings.
However, depending on the measurement conditions, the infrared radiation spectrum may change during the measurement, potentially causing the background correction errors such as overcorrection or undercorrection.

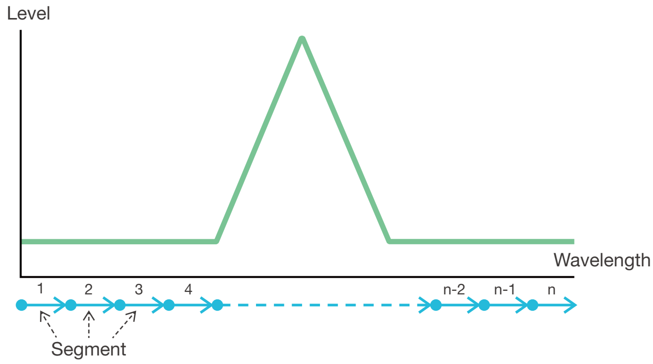

Figure 2. Conceptual Diagram of ALPM Mode

The APLM mode is characterized by dividing the measurement span into 'n' segments, thereby reducing the measurement time per segment and performing background correction for each segment. The number of segments is automatically set to an appropriate number based on the measurement span and the sampling time interval (equivalent to sensitivity setting).
You can also manually set the sampling time interval or the number of segments according to the characteristics of the pulse under measurement.

	APLM	Conventional Pulsed Light Measurement Function	
		(Sensitivity: other than /CHOP)	(Sensitivity: /CHOP)
Supported Range of Optical Pulse Widths	Wide (No Restrictions)	Wide (50 μs ≤)	Narrow (50 ms ≤)
Supported Range of Optical Pulse Repetition Periods	Wide (10 Hz ≤)	Wide (10 kHz ≤)	Narrow (1 MHz ≤)
Influence of Infrared Radiation	Low	High	Extremely Low

Table 1. Comparison of Pulsed Light Measurement Functions

Measurement Dynamic Range

Table 1 shows the supported range of pulsed light for conventional products and APLM mode. The APLM mode offers a significantly broader range of supported pulsed light compared to the conventional products.
Figure 3 shows a comparison of traces between conventional pulsed light measurement function and APLM mode. In conventional pulsed light measurement functions, an offset due to infrared radiation is superimposed on the waveform. In contrast, in APLM mode, this offset is sufficiently reduced that the laser spectrum can be visualized over a wide measurement dynamic range.
This greatly contributes to advancing the performance of MWIR pulse lasers.

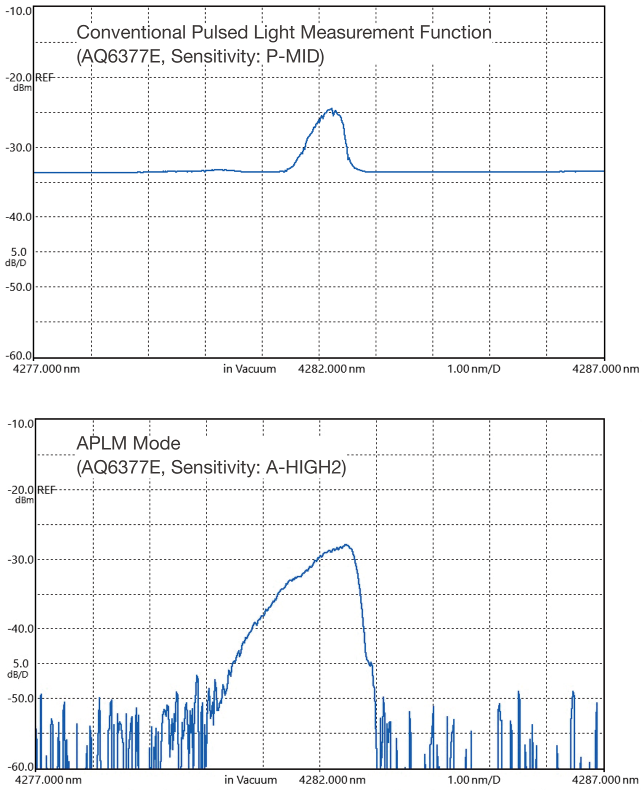

Figure 3. Comparison of Traces between Conventional Pulsed Light Measurement Function and APLM Mode
4.3 μm DFB-ICL (Repetition rate: 1 kHz, Pulse width: 500 μs)

YOKOGAWA TEST & MEASUREMENT CORPORATION
Global Sales Dept. /E-mail: tm@cs.jp.yokogawa.com

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