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Application note

Spectral Characterization of Mid infrared lasers.

Introduction

The mid IR lasers like CO2 lasers or various Quantum Cascade Lasers (QCLs) represent a group of MID- IR sources with a constantly increasing interest for technological applications all around the world. Spectrometers from Arcoptix – especially the recent HD series, featuring a spectral resolution of 0.5 cm^{-1} represent a valuable and cost-effective instrument for spectral characterization of these sources of infrared radiation. The purpose of this application note is to give a user insight into the laser characterization techniques using Arcoptix spectrometers.

Preliminary considerations:

1. **Power and spectral density:**

Any laser – whether pulsed of continuous wave (CW) represent a source with a spectral density typically 5-12 orders of magnitude higher than that of a sunlight or a broadband mid-IR light source. The integral power of a laser can also be several orders of magnitude higher than that of a standard black-body source. **This implies a necessity of the use of a suitable attenuator for the spectral measurement, in order to protect the detector of the spectrometer.**

2. **Pulsed operation and duty cycle of a laser:**

While CW lasers are characterized with ease special care has to be exercised if measuring pulse operated lasers.
Due to the acquisition frequency of the spectrometer detector it is not possible to measure lasers with low repetition rates. Lasers below 10KHz are difficult to measure because of aliasing effects and special signal treatment would be necessary. For very short pulses (like femto seconds lasers) care has to be taken not to burn the detector with too high intensities. Maximal allowed laser power is indicated in the user manual.

3. **Parallelism of the laser emission vector to the optical axis of the spectrometer.**

Arcoptix spectrometers are equipped with optics capable of tolerating certain minor deviation from the optical axis of the interferometer. It is chosen so, in order to facilitate the alignment of some low-intensity light sources. Lasers, being capable of high intensity, can produce signal even under certain small – non-zero angle of incidence into the spectrometers' window. In an extreme case this a decent signal can be detected even from some spurious reflection of the internal parts of the interferometer. This lead to a minor misinterpretation of the wavelength. It is therefore recommended to verify the optical axis using mechanical means (rulers…) to assure a perpendicular incidence of the beam into the spectrometers' window. The wall of the case is used as a reference plane here.

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Measurement example

Recommended Equipment (fig. 1):

(a) Optical bench or a breadboard – recommended - or else a solid table.
(b) Laser with driving electronics.
(c) Collimating element (A parabolic mirror or a lens).
(d) Spectrometer like the FTIR Rocket HD-05-12 (2-12 microns interval, 0.5 cm^{-1} resolution).
(e) Attenuator 3-30 dB (any brand).
(f) Suitable opto-mechanic components, to assure the alignment of the elements (b,c and d).

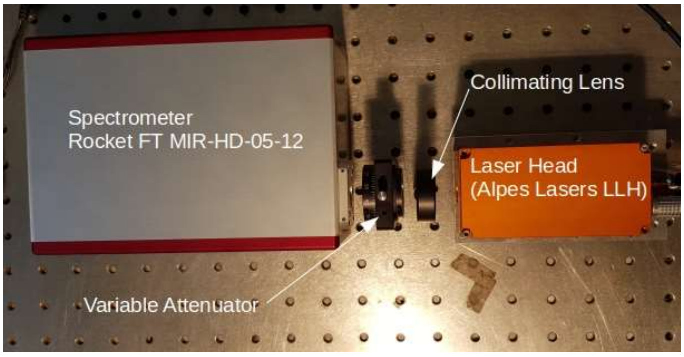

Fig. 1 Recommended minimum setup of for laser characterization.

Work order:

(a) Attach and pre-align (using a ruler): Device Under Test (DUT) laser, collimator (if applies), Attenuator (set to highest attenuation), and spectrometer.
(b) Turn on the spectrometer and start the Arcspectro software. Verify that the spectrometer is scanning and set it to a continuous scan.
(c) Observe the interferogram and check the function of the spectrometer for example by placing hand in front of the mirror. A visible increase of the amplitude shall be observed.
(d) Refer to the manual of the laser, and set the laser to the desired working point (temperature. pulse frequency, duty cycle, amplitude…).
(e) Turn on the interferogram display, and observe, whether some sinusoidal pattern typical for coherent light is present. If so, align the setup in a way to maximize the amplitude of this sinus. Watch for the saturation – in case it occurs increase the attenuation or set the laser to a lower output.
(f) Should you not see any laser related signal, try to align the setup better or gradually decrease the attenuation.
(g) Stop continuous scanning, and set the apodization to <HANN>.
(h) Measure and save the spectra according to the usual procedure with the spectrometer.

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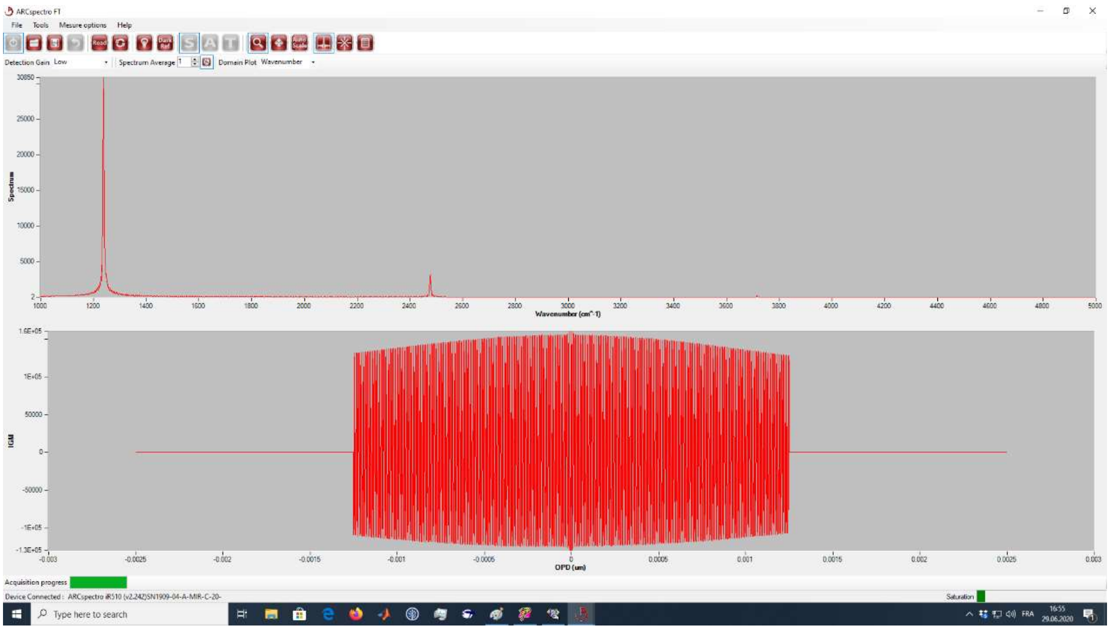

Fig. 2 Spectrum and (zero filled) interferogram corresponding to a mono-mode laser emitting at 1280 cm^{-1} taken with resolution of 2 cm^{-1} (a printscreen from the Arspectro spectral acquisition APP running under Windows 10).