Laser spectroscopy solutions.

Coherent light source technology offers several advantages for spectroscopy:

- high spectral density of the radiation – up to 109 times huger than that of a thermal source,
- high radiance of the sources,
- linear polarization of the light,
- coherence,
- wavelength stability and speed of measurements,
- compact build,
- long lifetime,
- low noise,
- compact size and favorable energetic management for portable and mobile applications.

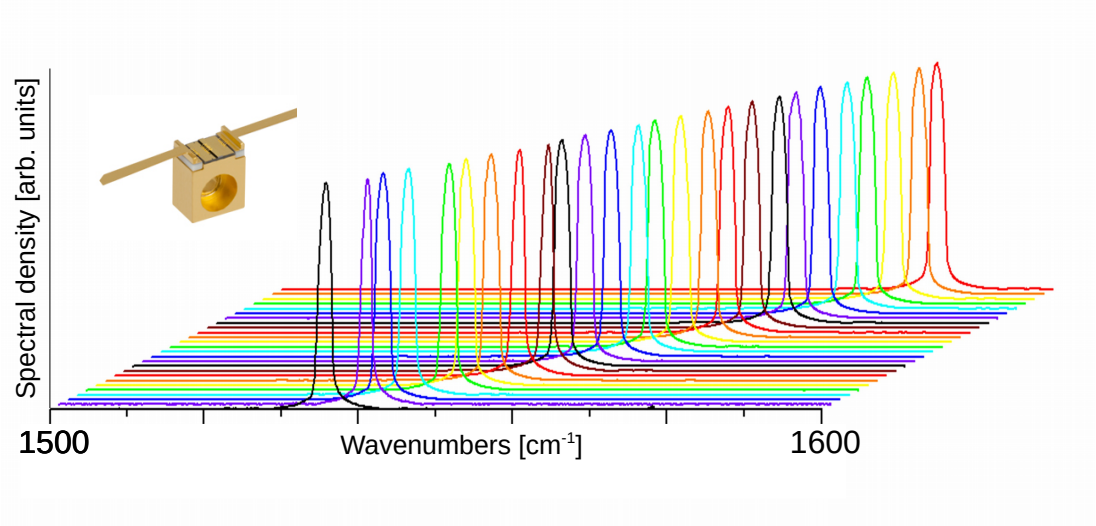

Fig. 1 Example of an emission spectrum of a single mode tuneable laser emitting in the mid-infrared band.

In many cases, a spectroscopic problem can be addressed using laser spectroscopic principle, being complementary to a spectrometer.

How does it work ?

Just like any spectroscopy, a laser spectrometer is following the same basic principle. Light emitted from a coherent source and it is -generally speaking - interacting in some way with the analyzed matter followed by the detection of the residual light after the said interaction, the magnitude of it is evaluated, and covered to the measured quantity (usually concentration).

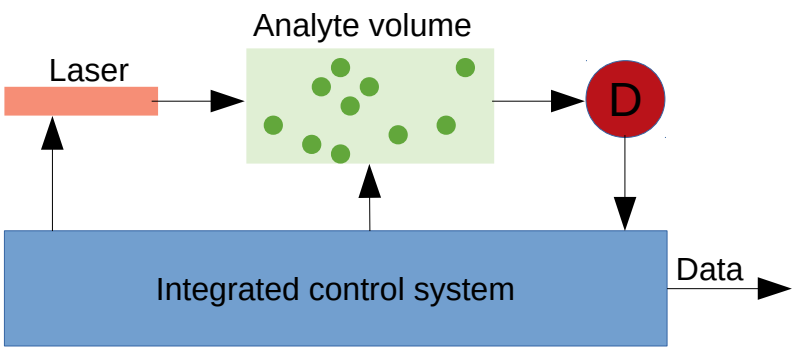

Fig. 2 Generalized scheme of a laser spectrometer.

What to expect from a solution using a laser spectrometer ?

(1) Robust solution.

Although our FTIR spectrometers are designed to be mechanically stable and durable, still, they contain moving parts. Laser spectrometers on the contrary do not contain any of these or very few of them (like shutters or light choppers) being sub-critical for the performance of the spectrometer itself. This results in a robust solution applicable in many areas where presence of excessive accelerations would disqualify a use of an FTIR.

(2) High sensitivity, lower detection thresholds and better signal to noise ratio.

The high radiance of coherent light sources allows in general for realizations with significantly longer optical paths compared to those with FTIR spectrometers. This in return results in a considerably lower detection thresholds - for certain substances down to huger ppt (parts per trillion) range as compared to sub ppm (parts per million) typical for the solutions with FTIRs.

(3) Remote measurements,

The high radiance, together with the high spectral density as well as the coherence of the emitted light allows for realization of remote detection schemes. Distances over several hundreds of meters in free space can be covered, allowing for measurements across areas with a restricted access. Detection schemes involving transmission or reflection as well as lidar solutions are to be envisaged when needed.

(4) Inherent selectivity.

The high spectral density – especially that of single mode coherent sources is inherently offering selectivity for a substance of choice – especially if the absorption to be observed is in the fingerprint region, where distinct absorption of various chemical species are located.

(5) Measurement speed up to thousands per second.

While FTIR spectrometers are limited in speed to a typical value of spectrum per second (in extreme cases to one tenth of that), laser spectrometers can provide measurements in rate of several kilohertz. If rapid variations of concentrations is to be followed (e.g. monitoring of a combustion cycle of an engine) laser spectroscopy offers an ultimate solution to that.

(6) Compact build

Although latest generation of FTIRs like our Rocket, are of a very compact build - less than 2l, (1/2gal) volume and wight about 2 kg (4 lbs) a compact size of a laser allows for a significantly smaller solution in spectroscopy, depending on the application. Laser spectrometers can easily be built in a handheld form, which might be welcome in some applications.

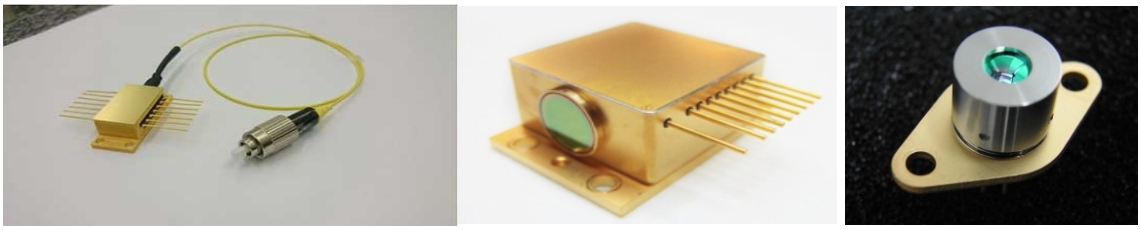

Fig. 3 Various styles of IR lasers -from the left: pigtailed, HHL, and TO3 with a collimating lens

What the laser spectroscopy can not do.

(1) Limited spectral range of lasers

A typical single mode laser with a distributed feedback grating is built to be stable at one wavelength. In fact slight variations of the refractive index with the temperature (in the order of 10^{-5} per Kelvin) allow for slight tuning either by the operation temperature or by operating current. However the tuning range of these lasers is very limited. Therefore a laser spectrometer addressing severa substances needs a separate laser for each and every of the components being targeted. The method itself is thus referred to as a target spetroscopy.

External cavity diodes and frequency combs allow for much larger tuning ranges even over several hundreds of wavenumbers, however the range tuning range of any single tunable laser does not even approach to tahat of an FTIR spectrometer. These instruments can cover even 4 octaves of frequencies with ease.

This character (along with some other characteristics) of the laser spectroscopic schemes leads to a necessity of made to measure solutions in each sensing task. In other words, there is nothing like a universal laser sperctormeter, which is not the case for an FTIR.

(2) Speckles and interferences.

Monochromatic and expecially coherent light allows for intereference effects leading to a possibility of gereneration of spurious signals in form of speckles and intrferneces. This puts additional requirements on the design of the optical scheme, and on the optics qulality, since such a spurious signal can eliminate all the advantages that the laser light offers.

(3) Non linear effects.

Although the high spectral density of the laser light facilitates the realization of highly sensitive sensing schemes, there is a possibility of observing non linear light- matter interactions which in some cases is limiting for realization of a sensing scheme. Besides that a saturation or even a physical destruction of a detector can occur if a spectrometr is not designed properly.

Our team offers technical realization of laser spectroscopic systems based on all kinds of lasers including the mid and far infrared quantum cascade lasers.

Have a technical problem ?

Let's have an infrared look at it !

Arcoptix S.A.