Novel narrow linewidth 785 nm diode laser with enhanced spectral purity facilitates low-frequency Raman spectroscopy

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INTRODUCTION

Raman Spectroscopy enables fast, sensitive and label-free chemical analysis of a large range of materials and has become a routine analytical tool in a wide range of material science and process-control applications.

As the Raman signal is weak it is critical that the illumination laser has a very high level of spectral purity, for efficient detection of the Raman signal. Most materials can be characterized by studying Raman shifts down to 100 cm^{-1}, but in some cases, for instance for determining the crystallinity of pharmaceutical compounds, it is required to study Raman shifts in the low-frequency regime; <100 cm^{-1}.

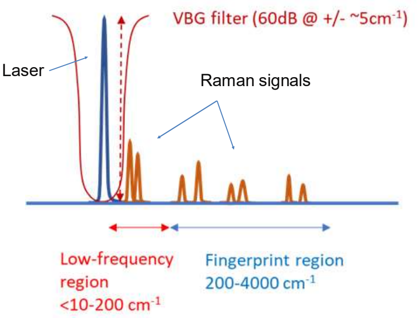
Recording Raman signals in the low-frequency regions is possible using VBG based notch filters, that can provide blocking of >60 dB at as close as 5 cm^{-1} to the laser peak, and by using laser sources with a very high level of spectral purity and stability.

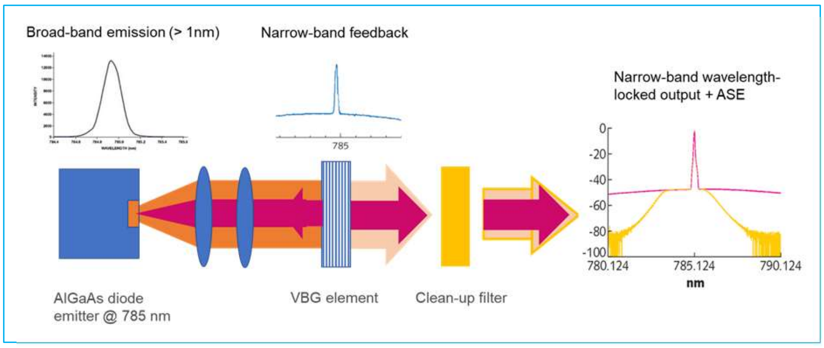
LASER REQUIREMENTS

In addition to a stable narrow linewidth and low wavelength drift over both time and ambient temperature, which is required for high spectral resolution, the laser used for low-frequency Raman needs to have a high level of spectral purity (or low Side-Mode Suppression Ratio, SMSR) very close to the main laser peak.

Laser requirements for Low-frequency Raman:	
Linewidth	<~30 pm
Wavelength stability	<10 pm (over min)
Spectral purity	>60dB @ <5cm^{-1} (~300 pm)

An illumination wavelength around 785 nm is preferred for many materials due to an optimum compromise between Raman signal strength, auto-fluorescence level and detector sensitivity.





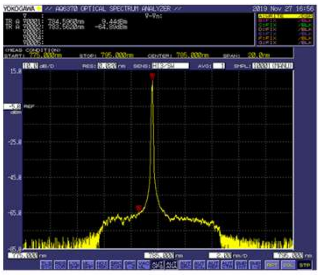
Conventional wavelength-locked diode lasers need external filtering with an additional VBG clean-up filter in order to meet the requirements on spectral purity for low-frequency Raman due to broad-band Amplified Spontaneous Emission (ASE) from the diode.

TECHNICAL SOLUTION

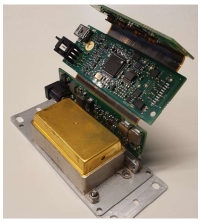
Patent pending

To overcome the challenge with broad-band ASE from wavelength-locked diode lasers we developed a design where we use a highly reflective VBG for locking instead of a partially transmissive one, as in the conventional case.

An intra-cavity polarizing element and a polarizing beam splitter are used to control the level of feed-back from the VBG to the emitter and the output coupling out of the cavity. The output-coupled emission is already cleaned-up from ASE as the ASE still leaks out from the locking VBG. In this way, over 60 dB spectral purity at <300 pm from the main peak is achieved without any further external filtering.

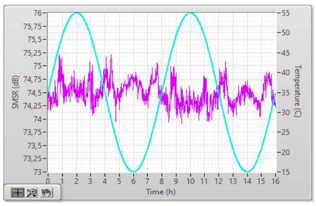


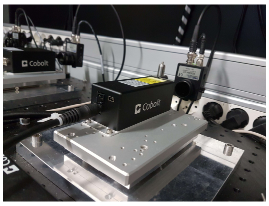
>60dB spectral purity @ < 300 pm without external filtering



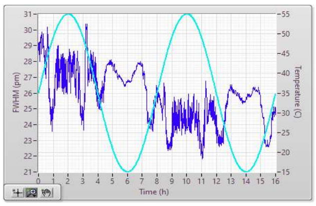
To achieve stable locking and stable spectral performance over time and temperature we used HTCure™ technology for the laser manufacturing; all optical elements are mounted onto a single temperature-stabilized platform and cured with high-temperature adhesives. The optical cavity platform is then mounted into a hermetically sealed package.

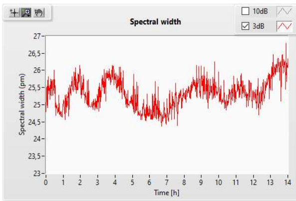
PERFORMANCE



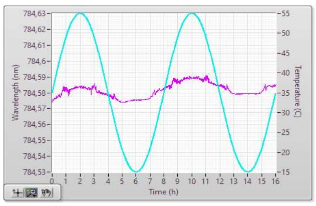


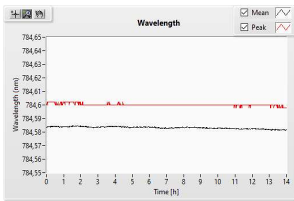
SMSR of >64 dB at +/-300 pm (corresponding to +/-5 cm^{-1}) and >74 dB at +/-1 nm over 15-55 °C temperature cycling





Linewidth (FWHM) of <31 pm (corresponding to 0.5 cm^{-1}) in temperature cycling over 15-55 °C and <27 pm at constant temperature.





Wavelength drift <4 pm at constant temperature and <17 pm in temperature cycling over 15-55 oC

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