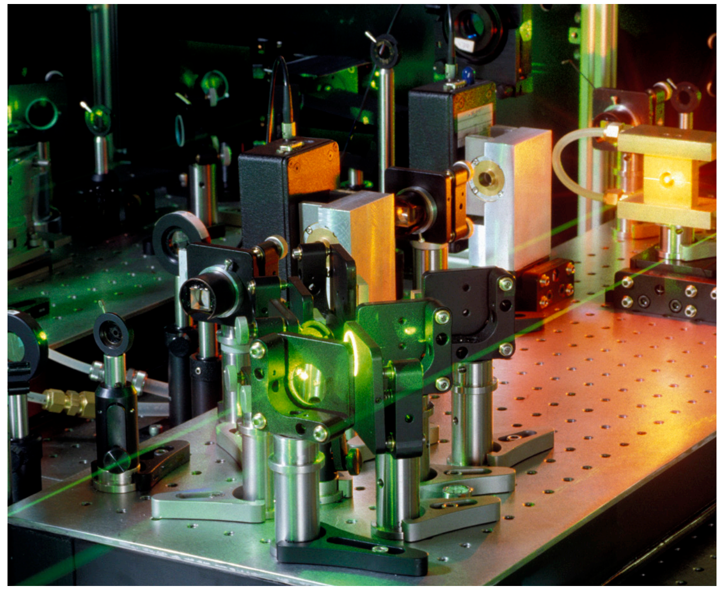
# APPLICATION NOTE:
# MINI SPECTROMETERS FOR LASER CHARACTERIZATION

## Techniques

- UV/VIS Absorbance


## Keywords

- UV/VIS Absorbance
- Analytical Chemistry
- Colloids & Nanoparticles
- Reaction Monitoring

## Introduction

Regardless of whether one is producing low-cost vertical cavity surface emitting laser diodes (VCSELS) for consumer electronics or using a tunable mode-locked Ti:Sapphire laser for multiphoton fluorescence microscopy, having accurate spectral data during the manufacturing process is critical for ensuring quality, repeatable product. Unfortunately, the overwhelming number of laser engineers are still relying solely on large and costly optical spectrum analyzers (OSAs) for spectral testing. While these devices provide excellent spectral resolution and dynamic range, the size and cost often limit their ability to be deployed at multiple points throughout the manufacturing environment [1].

Additionally, the scanning nature of these devices results in extremely low sensitivity and therefore require long integration times, making OSAs a poor choice for high-speed automated production lines [1]. Alternatively, miniature spectrometers take advantage of a fixed grating spectrograph in combination with a linear detector array to enable the entire spectrum to be measured simultaneously at high speeds. While this geometry does not allow for real-time adjustment of spectral range and resolution, it does result in much higher sensitivity when compared to the scanning geometry used in OSAs since it does not require a different acquisition at each measurement point. This speed advantage is not only helpful for fast-paced high-volume testing environments but also allows for more accurate measurements of pulsed laser systems through the use of high-speed triggering. As a result, some laser manufacturers are adopting miniature spectrometer technology as a complementary technology to the more traditional OSA.

This article will explore the benefits of miniature spectrometers for laser characterization in-line as well as in the lab, but first, it is essential to take a step back and briefly review the fundamentals of miniature spectrometers.

## Fundamentals of Miniature Spectrometers

*Figure 1: Typical Avantes spectrometer with the beam path through the Czerny-Turner spectrograph to the detector overlaid*

Like all spectrometers, Avantes' miniature spectrometers are essentially an imaging system which separates the image of the entrance slit into a large number of spatially separated, monochromatic images in the detection plane. In the Czerny-Turner spectrograph design, this is accomplished by first collimating the light from the entrance slit using a concave mirror and directing it to a reflective dispersion grating. As a result, the different wavelengths of light reflect off of the grating at different angles, spatially separating more and more the further away from the grating they travel. This plurality of collimated rays is then focused back down to form an image of the entrance slit at the detector plane by a larger truncated focusing mirror, but as a result of their angular separation, the image of each wavelength is now separated along the axis perpendicular to the orientation of the entrance slit. By placing a linear array in the image plane, each pixel can be calibrated to correspond to a unique wavelength. Figure 1 below shows a schematic diagram for a typical Czerny-Turner miniature spectrometer.

It is important to note that due to the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