In-Line VCSEL Testing

High-resolution array spectroradiometers guarantee high throughput volumes and reliability in industrial environment

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High-resolution spectroradiometer, coupled with, e.g., an integrating sphere, enables fast VCSEL tests in lab and production. (Source: Instrument Systems)

In the mass production of laser diodes such as VCSEL, high-resolution array spectroradiometers are an efficient alternative for in-process inspection in a 24/7 production environment. Compared to established scanning measurement techniques, they also guarantee high throughput volumes and reliability in the industrial environment: their configuration means high mechanical stability and integration times in the order of just a few milliseconds for CCD and microseconds for CMOS detectors. Measurements of laser diodes with a pulsed operating mode are also possible.

The market for laser diodes has recently experienced strong growth. The drivers of the enormous increase in demand are new applications and new technology concepts. Examples are face recognition in entertainment electronics, lidar (light detection and ranging) in the automobile, and high-performance diode lasers that consist of a number of laser diodes and are increasingly replacing conventional laser systems in material processing.

Laser diodes can be subdivided technologically into EEL (edge-emitting laser) and VCSEL (vertical-cavity surface-emitting laser, Fig. 1). EELs are edge emitters that emit horizontally to the chip surface. They cannot be optically characterized until the mirrored surfaces have been mounted on the lateral chip edges. By contrast, VCSELs – analogous to LEDs – are surface emitters and radiate perpendicular to the chip surface. The layer structure already contains the mirror required for the laser cavity. This results in a streamlining of the production process and permits optical characterization of the VCSEL already on the wafer. The production process of VCSELs compared to EELs

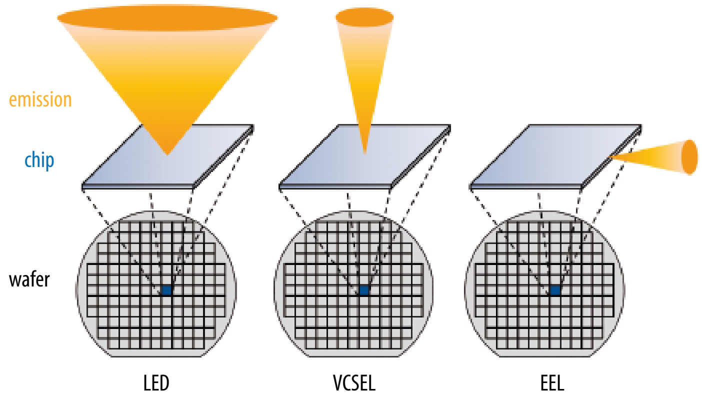

Fig. 1 Schematic comparison of emission direction and spatial radiation properties of light-emitting diodes (left), vertical-cavity surface (middle), and edge emitting lasers (right) relative to wafer and chip surface. (Source: Instrument Systems

is thus more efficient and more suitable for mass production.

Scanning measurement systems

Established optical measurement methods for analyzing the spectrum of laser diodes are scanning measurement systems such as spectrum analyzers, Fourier transform infrared spectrometers (FTIR), and dispersive scanning spectrometers. Their mode of functioning is based on a scanning component, for example a rotating diffraction grating for the scanning spectrometer or a movable mirror for the FTIR. This design permits high spectral resolutions smaller than 0.1 nm accompanied by a flexible choice of spectral range to be measured. Such flexibility makes these measurement techniques highly effective for use in the laboratory, e.g. for product development and specification.

However, mass production of laser diodes, in particular VCSELs, calls for fast and at the same time precise and comparable in-process inspection during which each individual laser diode is checked. In this kind of production environment, scanning measurement methods have certain limitations: Production related vibrations may impair the positioning accuracy of moving components and thus the stability and repeatability of measurement results. The duration of measurement is at least the length of the scanning process, thus severely limiting throughput volume. Spectral measurement requires constant optical performance of the laser diode during scanning, to avoid distortion of the spectrum. Scanning systems are thus unsuitable for the measurement of laser diodes with a pulsed operating mode.

Array measurement systems

In comparison, array spectroradiometers (Fig. 2) – long-established as a measurement solution in LED production – are ideal for use in the production of laser diodes. The fixed configuration of the optical components ensures a high degree of mechanical stability and high repeat accuracy of optical measurements. The spectrum is measured in an instant using an array detector. This enables integration times of just a few milliseconds for CCD detectors and microseconds for CMOS detectors, and thus an extremely high

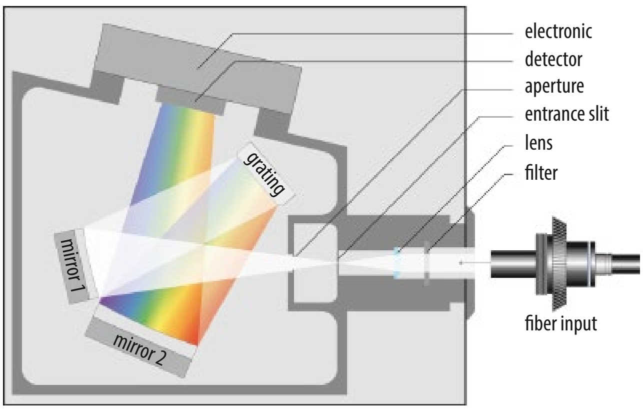

Fig. 2 Schematic design of an array spectrometer with fixed optical components in crossed Czerny-Turner geometry.

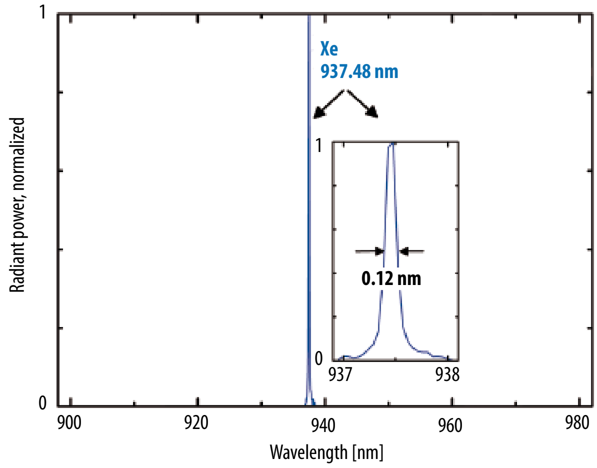

Fig. 3 Spectral radiant flux of a selected Xe emission line, measured with a CAS 120B-HR with a spectral range of 800 – 1000 nm and a spectral resolution of 0.12 nm.

throughput rate. Spectral measurements of laser diodes with extremely short pulses are therefore possible. These are frequently used for array spectroradiometers in the laboratory. In addition, an absolutely calibrated spectroradiometer delivers the performance as an immediate reading, so that no additional photo diode is required for power measurement. Spectral resolutions in the range of 0.1 to 0.2 nm can be achieved with a suitable choice of optical components (Fig. 3).

Array spectroradiometers satisfy the exacting requirements for spectral resolution, throughput volume, and reliability in a production environment. They are thus ideally suited to optical in-process inspection of laser diodes. In addition, array spectroradiometers can also be used for the measurement of pulsed operation laser diodes and are also an effective measurement method for use in the laboratory.

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