MicOS for mapping semiconductor wafers

III-V Wafer Characterization through Photoluminescence Mapping

III-V semiconductors are important to the fabrication of active photonic devices such as light sources and detectors. Successful fabrication of such devices relies on the high quality of the underlying materials and precise deposition of intended geometries on a wafer substrate.[1] Defective materials and imperfections in geometries adversely affect yield, and usually increase cost and development times. The cost and delay penalties are further compounded when such defects in either material or device-geometry are not caught early enough in the cycle.

Photoluminescence (PL) spectroscopy is a robust, non-contact, non-destructive optical technique for determining material quality and geometrical accuracy for many III-V semiconductor-based components. Quality of the material is often obtained by measuring point PL on the bulk material, but geometrical accuracy of the device requires mapping PL over the entire device—or at least a region of interest on the device. Fig. 1 shows a typical PL emission near-IR spectrum of a III-V semiconductor measured at a point on a wafer, using the HORIBA MicOS PL wafer-mapper (Fig. 2).

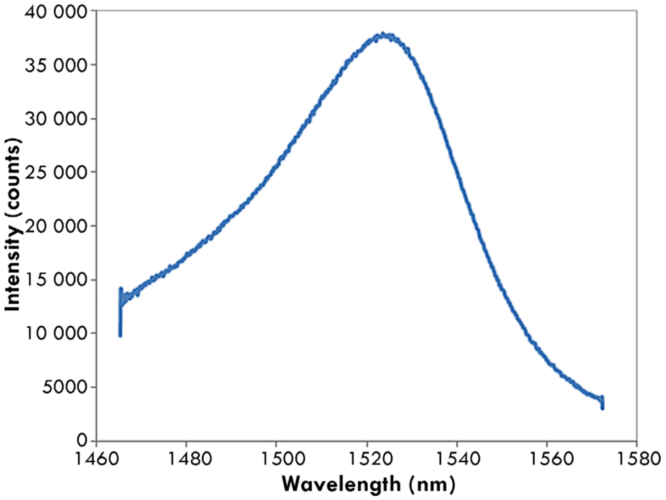

Fig. 1. Typical room-temperature PL spectrum of a III-V semiconductor in the near-IR region of the spectrum following laser excitation at 532 nm. This measurement was carried out on the HORIBA MicOS system (Fig. 2, see right).

The versatile HORIBA MicOS PL wafer-mapper micro-PL system includes a vision camera so the user always sees the region of the wafer under excitation, useful when the wafer has patterned structures. The MicOS head is directly coupled to a triple-grating spectrometer, ensuring the highest throughput and wide spectral coverage (200–1600 nm). The MicOS can also use different excitation-laser wavelengths, and includes an assortment of motorized *xyz*-stages for mapping wafers up to 300 mm. It can measure in a down-looking configuration for standard wafers or

Fig. 2. Down-looking version of HORIBA MicOS with mapping stage.

side-looking configuration for facet-emitting samples.

Included with the MicOS wafer-mapper is LabSpec software, which not only automates data-collection but offers an array of analytical tools for data-processing and interpretation. LabSpec offers a data-collection mode called SWIFT, in which the stage serves as the controller, and triggers detector-acquisition, bypassing the computer. This mode can collect data at high speed so that 2500 spectra can be collected over a two-inch wafer in under three minutes. LabSpec also offers an array of analytical and display tools, including peak identification and fitting, background subtraction, and multivariate analysis.

Fig. 3 displays various PL parameters for wafers (peak intensity, peak wavelength, and FWHM of the emission), all of which can be correlated to material properties of the wafer.

The PL measurements above are critical, and their implementation spans product design to fabrication and manufacturing quality-control, including failure-mode analysis for field failures. In quality-control, where time is critical, performing the mapping measurement quickly is important in order to create a statistically valid sample set, and thus increase the confidence level of the inferences drawn from the measurement.

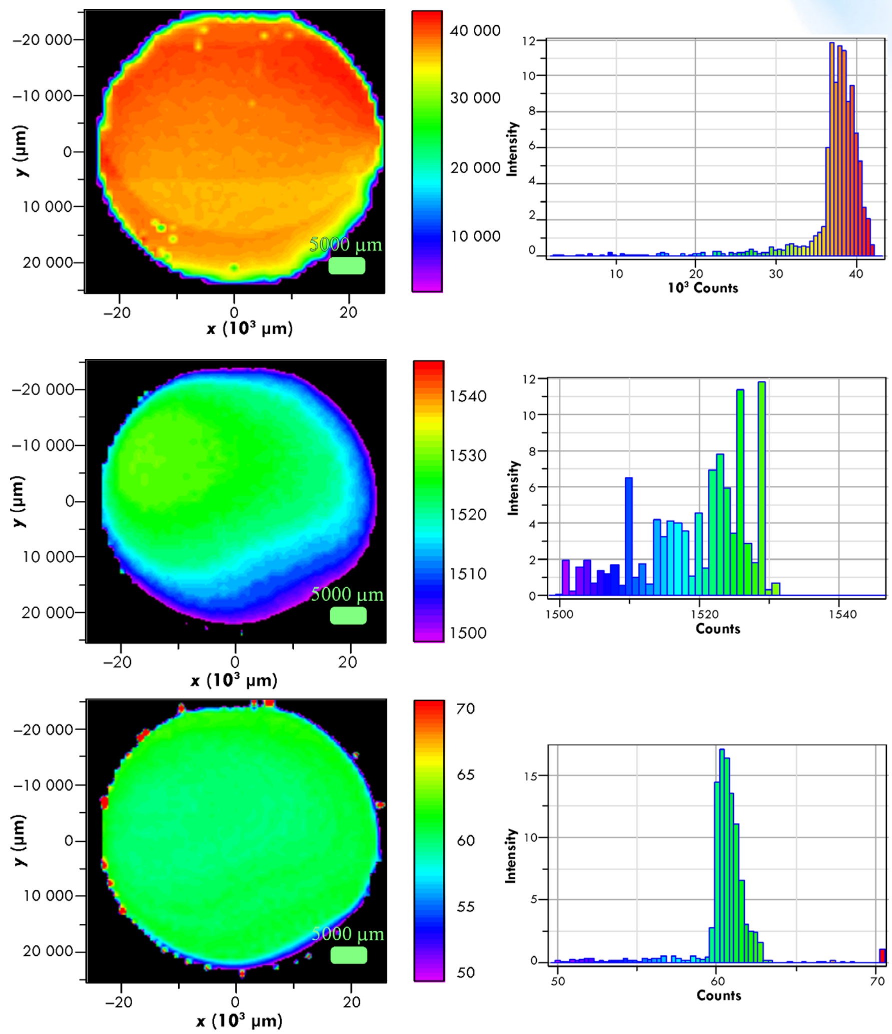

Fig. 3. PL-spectrum parameters. Top to bottom: Distribution of PL peak position, peak wavelength, and FWHM of emission over wafer.

References

1. A. Wójcik-Jedlińska, *et al.*, "Photoluminescence characterization of AlGaAs/GaAs test superlattices used for optimization of quantum cascade laser technology," *Optica Applicata*, **39**(4), 2009.

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