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ELEMENTAL ANALYSIS
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Specially optimized for spectroscopy on the micro scale

The MicOS Microscope-spectrometer

Introduction

HORIBA Scientific's MicOS (Fig. 1) microscope-spectrometer is a versatile instrument designed and optimized specifically for spectroscopy using a direct-coupled microscope. Such streamlining is required because this field traditionally has been served by a coupling between a standard imaging microscope and a spectrometer. This combination in many cases has proven to be sub-optimal for spectroscopy. For one, the design considerations that often make a microscope very good for imaging (aberration-correction using glass optics) often prove to be a hindrance for spectroscopy, especially in the UV and IR regions of the spectrum. This hindrance is not only undesirable from a spectroscopic point of view, but also can be expensive. Furthermore, the coupling between the microscope and the spectrometer is often implemented using optical fibers, which is not optimal, for fibers can have significant losses in transmission and coupling for some regions of the spectrum. Not least is the fact that many traditional microscopes do not offer an easy method to couple an excitation laser

Fig. 1. MicOS microscope-spectrometer from HORIBA Scientific.

while maintaining a port for vision, or the flexibility to accommodate different configurations for measuring samples.

The MicOS is a specially-built instrument that places an emphasis on spectroscopy in its design considerations. It offers a direct-coupled microscope with more than a ten-fold improvement in optical throughput compared to some fiber-coupled systems. It offers the flexibility to couple different laser excitation wavelengths without the need for factory- or field-servicing. The MicOS also provides the flexibility to measure the sample in different configurations: down-looking for flat samples such as wafers, and side-looking for such samples such as facet-emitting diodes or samples in upright cryostats.

In this application note, we provide examples of how the MicOS can advance your micro-luminescence research.

Examples

The first example shows how the MicOS may be used to study luminescence of III-V semiconductor materials. GaN and related alloys are important materials used to build short-wavelength light sources (lasers and LEDs). Room- and low-temperature photoluminescence (PL) are used to characterize these materials as well as device performance. These samples usually consist of micrometer-sized structures requiring selective laser-excitation in order to observe the PL emission. Selective excitation means fine control of laser-excitation beam size

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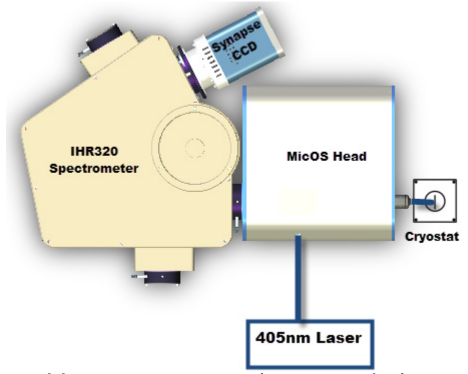

Fig. 2. Typical low-temperature, direct-coupled micro-PL setup. Direct coupling of the microscope's front end increases throughput to the spectrometer (for low-light samples). The system also has flexibility to measure a sample via the side window of an upright cryostat or in a down-looking configuration.

and positioning, as well as ability to see the sample under measurement.[1] In addition, for many such measurements, important electronic structure information can only be revealed at low temperatures. Therefore a PL measurement system must also be compatible with a cryostat. Fig. 2 shows a typical configuration of a HORIBA MicOS measurement system, and Fig. 3, the resultant PL spectra.[2] The MicOS also has the flexibility to accommodate different user-selectable excitation laser wavelengths for III-V material excitation, and includes vision so that the user can readily see excitation position and areas of interest on the sample.

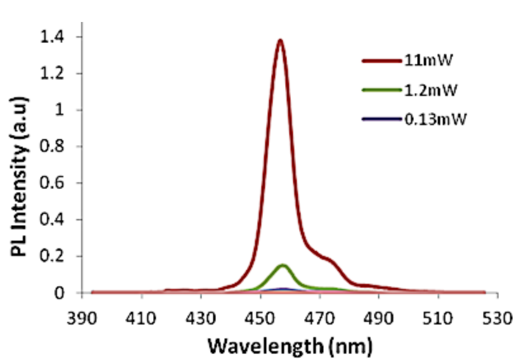

Fig. 3. GaInN PL spectrum taken at 10 K after 405 nm laser-excitation at different excitation power-levels.

For the second example, we use the MicOS to observe electroluminescence from a micro-LED (Fig. 4). The MicOS is particularly suited to this type of measurement because it allows measurement in a down-looking configuration with long working-distance objectives, for samples such as VCSELs, in which the user may need to introduce probe pins under the objective, as well as a side-looking configuration for planar waveguide structures such as SiGe integrated IR waveguide sources. These latter structures are facet-emitting and suited to measuring in a side-looking configuration.[3,4]

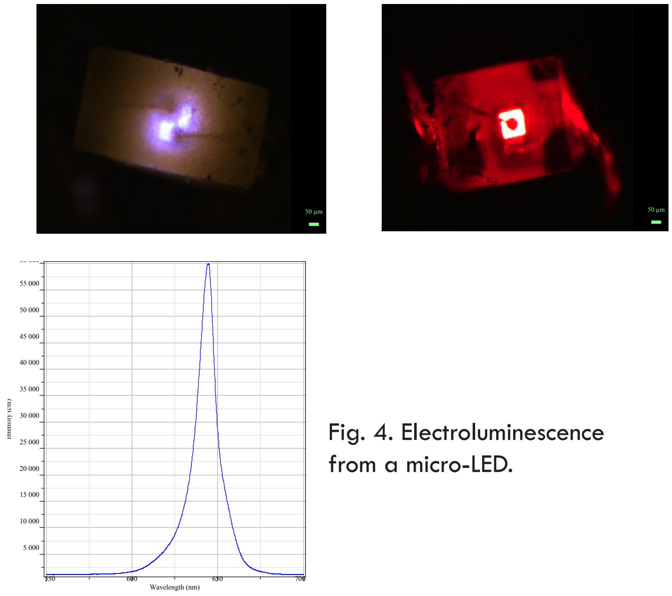

Fig. 4. Electroluminescence from a micro-LED.

Finally, the MicOS also comes with an optional motorized stage for photoluminescence-mapping, in which the user is not only interested in the measured spectra but also in the spatial distribution of emitting centers on the sample. The map information is generated by a two-dimensional translation of the mapping stage so that PL data is collected at an array of points coincident with the tightly focused excitation beam (Fig. 5).

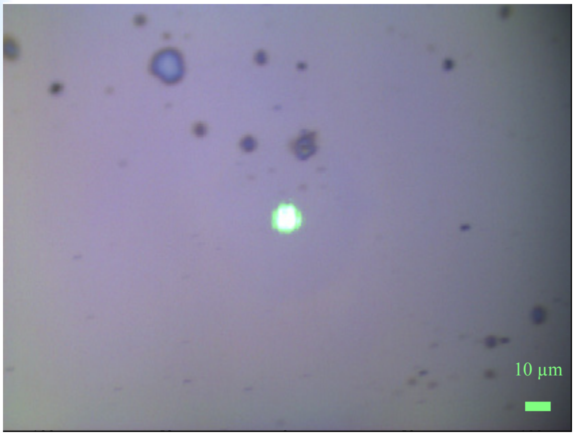

Fig. 5. Tightly focused excitation laser spot on the sample. This spot excitation is scanned across a region of interest in a raster fashion to generate a 2D map.

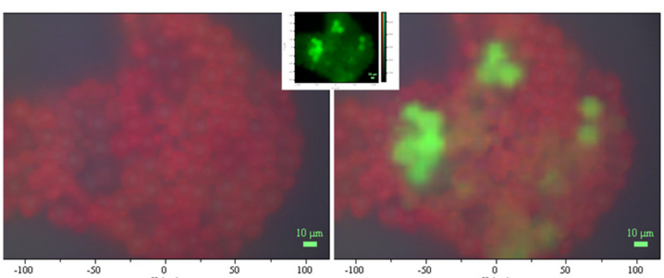

Fig. 6. (left) 50× image of a distribution of fluorescent beads; (inset) Fluorescence map at 737 nm; (right) Overlay of the fluorescence map upon the visual image, showing regions of sample responsible for fluorescence.

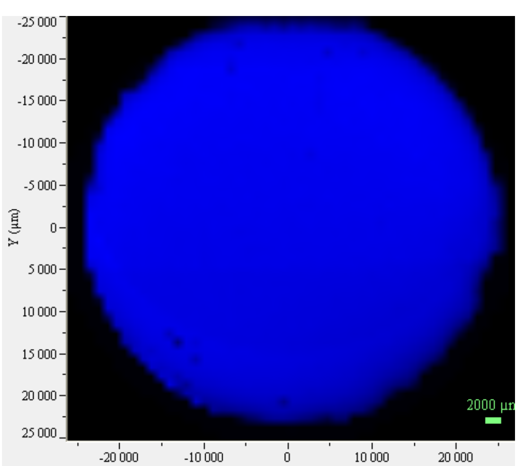

Fig. 7. 2D map at an array of points over a wafer.

This spatial distribution information is relevant in diverse applications such as in isolating biological species (Fig. 6), as well as maps of wafer homogeneity in quality control in the semiconductor industry (Fig. 7).

Conclusions

To sum up: The MicOS from HORIBA Scientific is a valuable tool for studying the spectroscopy of microscopic structures across a variety of fields, from biology to materials science to quality control. The MicOS is a great improvement over the traditional experimental scheme of coupling a standard microscope to a spectrometer. The system can construct a complete map of luminescence over a surface, as well as examine in detail a particular spot of interest on a sample.

References

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