

## Photoluminescence of Semiconductors OSD-104

ELEMENTAL ANALYSIS
FLUORESCENCE
GRATINGS & OEM SPECTROMETERS
OPTICAL COMPONENTS
FORENSICS
PARTICLE CHARACTERIZATION
RAMAN
SPECTROSCOPIC ELLIPSOMETRY
SPR IMAGING

Characterization of structure, composition, and impurities

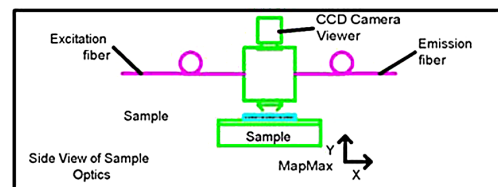
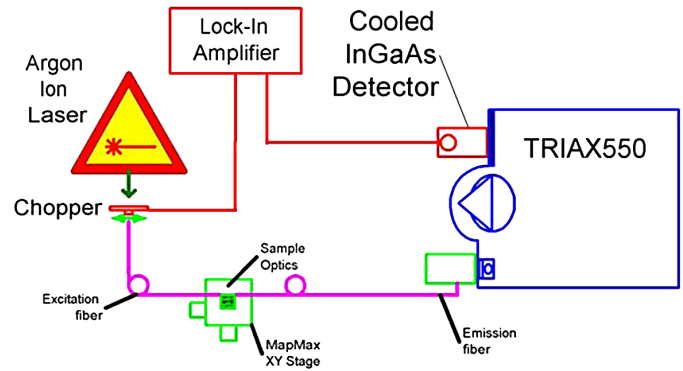
### Introduction

Photoluminescence spectroscopy (PL) is a powerful optical method used for characterizing materials. PL can be used to find impurities and defects in silicon and group III-V element semiconductors, and to determine semiconductor band-gaps. A material absorbs light, creating an electron-hole pair; an electron from the valence band jumps to the conduction band leaving a hole. The photon emitted upon recombination corresponds to the energy-difference between the valence and conduction bands, and is hence lower in energy than the excitation photon.

### Experimental setup

In order to measure photoluminescence of semiconductors, there are various requirements: (a) a stable, powerful monochromatic light source, (b) optics to focus light on the sample, (c) sample holder, (d) collection optics, (e) monochromator, and (f) detector for spectral analysis. Actual sample excitation and collection optics used depend on the type of samples and experimental conditions required. For some samples, excitation and collection are optimal at 90°. In some cases it is also important to map an entire semiconductor wafer to analyze impurities found in different areas of the sample. Computerized mapping can be done with a precision x-y stage, and here usually the optics are positioned at zero degrees to the sample.

Various experimental parameters derived from the spectra such as peak symmetry, FWHM of the peak, center position of the peak, and fine structure, can give information about the structure and composition of doped semiconductors. This type of analysis can also be used to evaluate growth methods using different input gas mixtures.



### Features

500 to 2000 nm operation

Integrated sample optics and viewer

Precision xy sample positioning

Specifically designed for use with cryostat

Integrated data-collection and analysis

### Benefits

Unique system for continuous monitoring from visible to IR without realignment

Optimize collected signal and accurately target sample

Automated mapping facility

Ambient and low-temperature capabilities

Completely automated PL system

Figure 1 shows the optical and mechanical arrangement of the photoluminescence system for analysis and mapping of a semiconductor sample. The sample is placed on the MapMax x-y translational stage and fixed in



position in the sample holder. The HORIBA Scientific Macro Illuminator allows light to be focused on the sample while the image is displayed on the monitor. An Ar<sup>+</sup> laser is used as the excitation source. Light from the laser is focused into a fiber, which goes into the input channel of the HORIBA Scientific Macro Illuminator. The photoluminescence from the sample is collected, goes through the output channel of the HORIBA Scientific Macro Illuminator, into a fiber, and finally into the TRIAX550 monochromator for analysis.

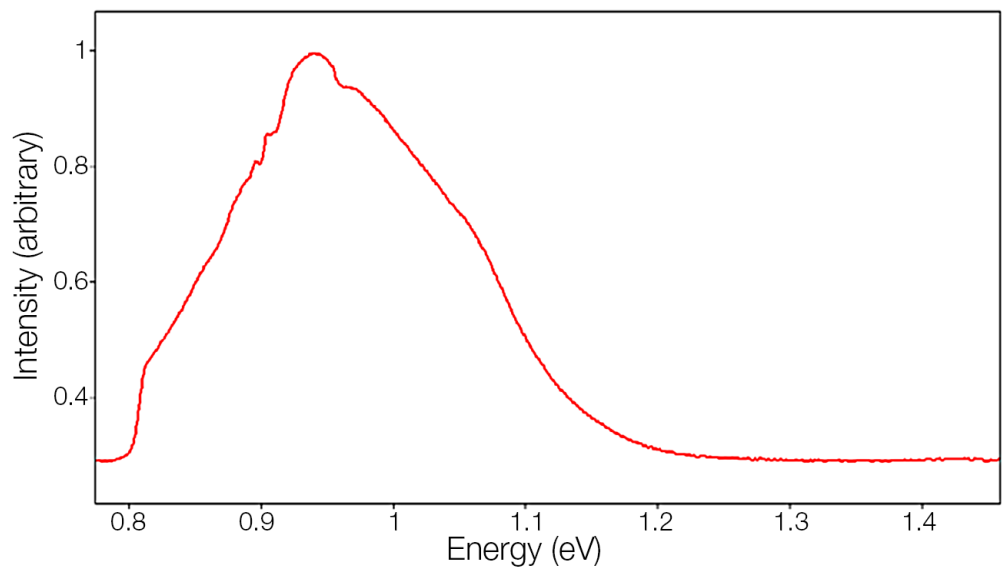


Figure 2. Photoluminescence spectrum of doped GaAs.

The excitation light is chopped, so that a lock-in amplifier can be used with an InGaAs detector for data-acquisition. After the initial system alignment is fixed, the experiment itself is controlled by computer using SpectraMax for Windows<sup>®</sup> spectroscopy software.

## Results

An example of a typical doped semiconductor photoluminescence spectrum obtained with a HORIBA Scientific system is shown in Fig. 2. Here, a liquid-nitrogen-cooled InGaAs detector was used, for optimal sensitivity and low noise. The entire experiment is controlled by SpectraMax for Windows<sup>®</sup> software, which provides easy data-acquisition and analysis.

## Conclusions

A complete, nearly turn-key system for photoluminescence measurements from HORIBA Scientific is shown to produce spectra with high signal-to-noise ratio, for diagnostic testing of semiconductors and other materials. A HORIBA Scientific photoluminescence system provides a comprehensive solution for characterization of semiconductor materials.



[info.sci@horiba.com](mailto:info.sci@horiba.com)

[www.horiba.com/scientific](http://www.horiba.com/scientific)

**HORIBA**  
Scientific

**USA:** +1 732 494 8660  
**UK:** +44 (0)20 8204 8142  
**China:** +86 (0)21 6289 6060

**France:** +33 (0)1 69 74 72 00  
**Italy:** +39 2 5760 3050  
**Brazil:** +55 (0)11 5545 1500

**Germany:** +49 (0)89 4623 17-0  
**Japan:** +81 (0)3 6206 4721  
**Other:** +33 (0)1 69 74 72 00