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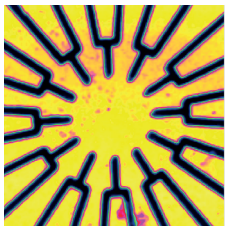
200 YEARS 1819-2019 HORIBA JOBIN YVON

Raman Spectroscopy

LabSpec6 option for Laser Beam Induced Photocurrent / Photovoltage and Electroluminescence Mapping



Technical Note

RA TN-06

Introduction

HORIBA Scientific developed an interface which allows LabSpec6 spectroscopy software to read data from a SMU2450 and automatically display photocurrent or photovoltage maps within its graphical user interface, and easily compare it with Raman or Photoluminescence maps.

In addition, using the Keithley interface, one can also generate easily global or spatially and spectrally resolved electroluminescence (EL) maps for further characterization.

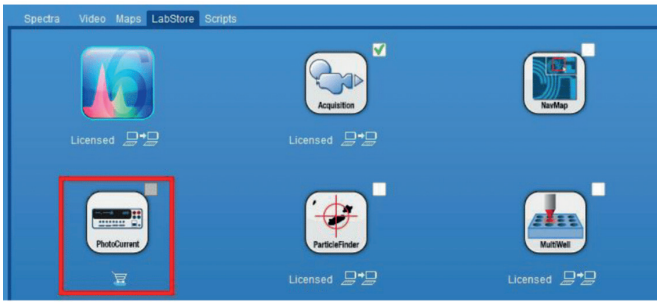
This technical note highlights the different capabilities of the new LabSpec6 option, available in the Labstore from LS6.5 64bit version, on any HORIBA Raman microscope.

The SMU2450 is the Source Meter Unit (SMU) for everyone: a versatile instrument, particularly well-suited for characterizing modern scaled semiconductors, nano-scale devices and materials, organic semiconductors, printed electronics, and other small-geometry and low-power devices.

General description of LabSpec6 photocurrent/voltage mapping interface and measurement system

Hardware requirements:

- 1 Keithley SMU2450 Source Meter Unit
- 1 Raman/PL confocal microscope equipped with high brightness laser,
- XYZ mapping stage
- Sample with dedicated holder and electrodes (in the example presented here, a III-V photovoltaic cell provided by IPVF, the Ile-de-France Photovoltaic Institute)



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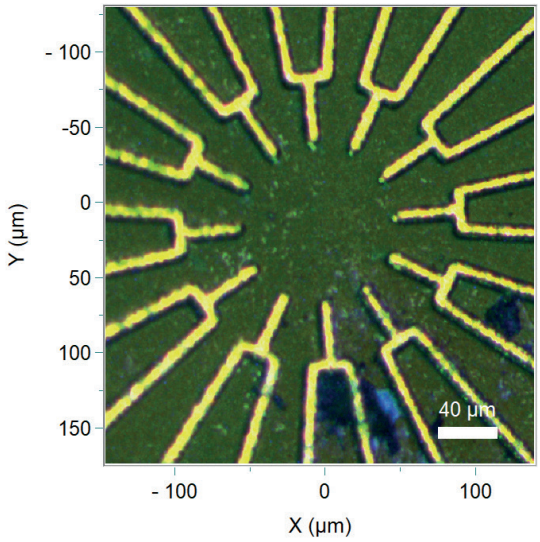
Photocurrent, Photoluminescence and Electroluminescence images

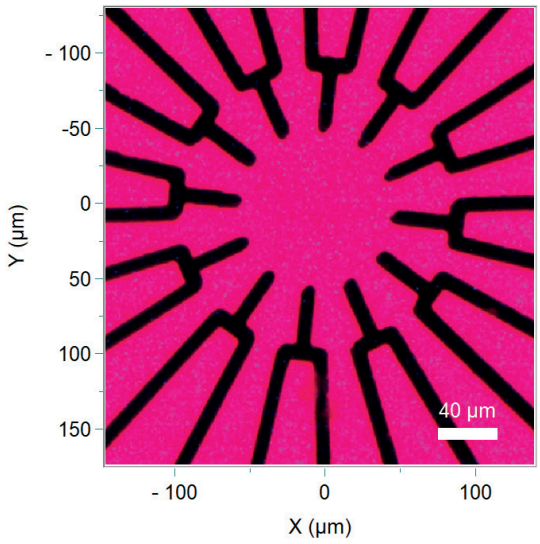
Measurements of the current-voltage (I-V) characteristic of an optoelectronic device are important in determining its total performance and efficiency; in case of a faulty device, it usually doesn't reveal precisely where the default comes from.

Unlike I-V, Photoluminescence, Electroluminescence (EL) and Photocurrent Microscopy (PCM) are powerful tools that can probe the underlying mechanisms of minority carrier lifetime, diffusion length, parasitic resistance, as well as charge generation and transport in optoelectronic devices at the micron scale. There has been significant progress in the use of these techniques, providing critical insights into the underlying materials and operation of the devices.

Video image of ROI (Obj. X10)



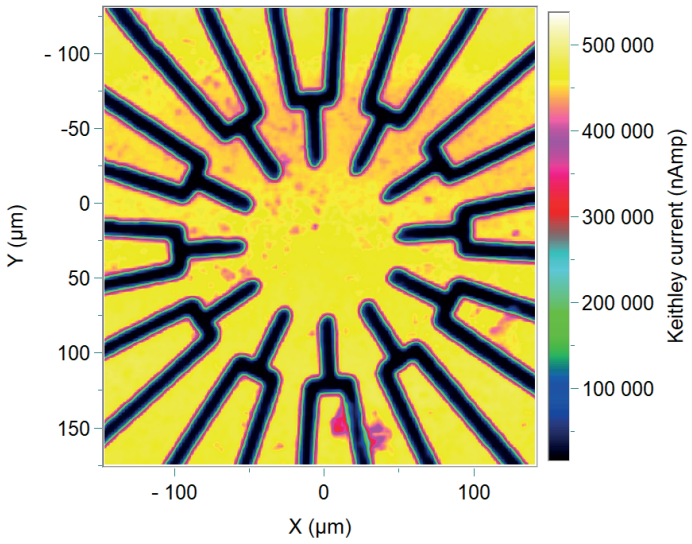
Electroluminescence image of ROI on video camera



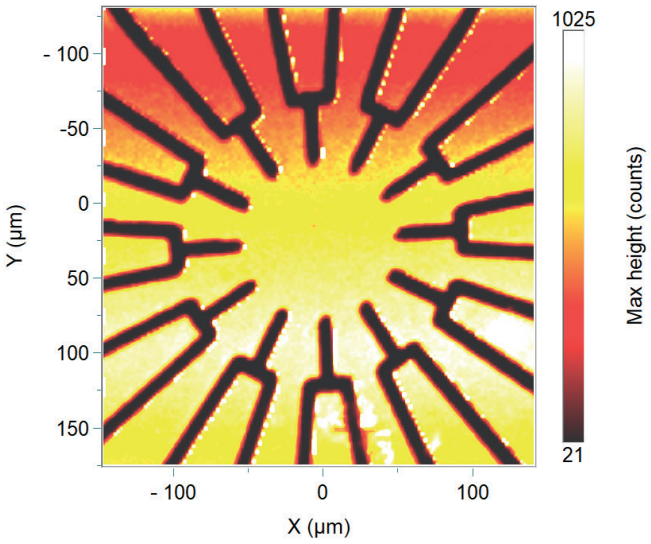
Acquisition parameters:

- Laser 532 nm 1,04mW
- Objective X10
- Grating 300gr/mm
- Acq. time 1ms per point
- XY map dimensions: 288 x 304µm
- Step resolution: 2µm

Photocurrent intensity



Photoluminescence intensity



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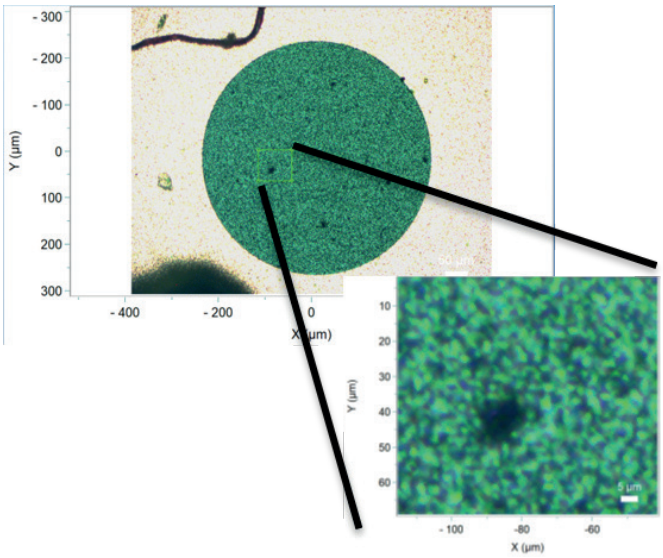
Defect analysis on CIGS sample

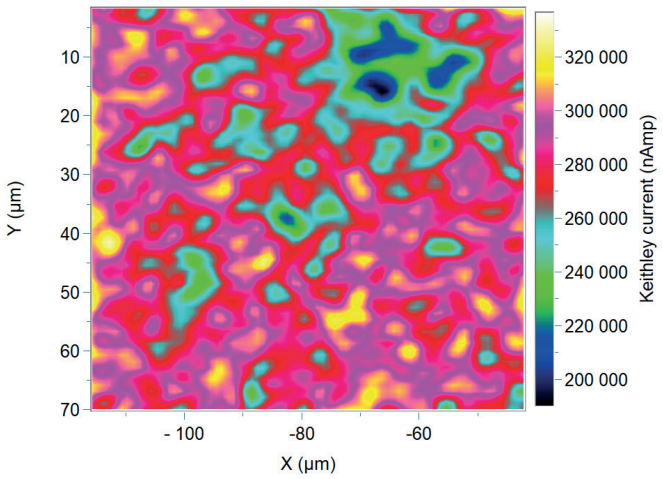
By combining the photocurrent scans with Raman maps on the same region of the sample we can determine possible variations in composition within the interfaces and between the grains, which is extremely useful for characterizing the material.

A direct correlation between the various interfaces and the transport properties of solar cells can be established by measuring photocurrent and Raman at the exact same location.

Video image of ROI (Obj. X10)



Photocurrent map



Acquisition parameters:

- Laser 532nm 650µW
- Objective X10
- XY Map dimension 74x68µm size
- Step resolution: 1µm

With Photocurrent mapping app on LabSpec6, one can easily localize defects on CIGS sample that are not appearing on the video image. Raman map then helps characterize interfaces at grain boundaries (not shown here)

Key Features of the Keithley SMU2450

- Five-inch, high resolution capacitive touchscreen GUI
- 0.012% basic measure accuracy with 6½-digit resolution
- Enhanced sensitivity with new 20mV and 10nA source/measure ranges
- Source and sink (4-quadrant) operation
- Four “Quickset” modes for fast setup and measurements
- Built-in, context-sensitive front panel help
- Front panel input banana jacks; rear panel input triaxial connections

Model 2450
V-Ranges: 20mV - 200V
I-Ranges: 10nA - 7A
0.012% Basic Accuracy
Wideband Noise 2mV$_{rms}$ Typ.
Sweep Types: Linear, Log, Dual Linear, Dual Log, Custom, Source-Memory (SCPI 2400 Mode)
>250,000 Point Reading Buffer
>3000 Readings/Sec.
SCPI (2400 + 2450) + TSP Programming
GPIB, USB, Ethernet (LXI)
Front: Banana Jacks, Rear: Triaxial

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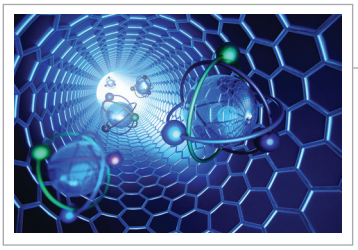
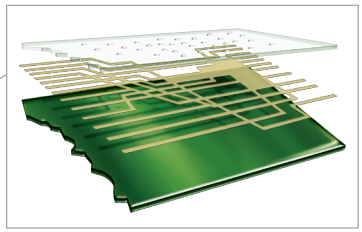
Conclusion

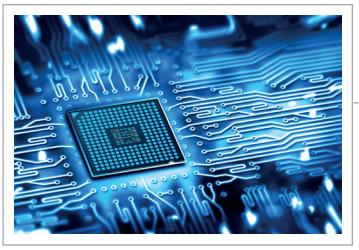
Combination of confocal Raman/Photoluminescence with current/voltage properties is ideal for characterization of a wide range of modern electronics and semiconductor devices, including:



Nanomaterials
- Graphene
- Carbon nanotubes
- Nanowires
- Low power nanostructures

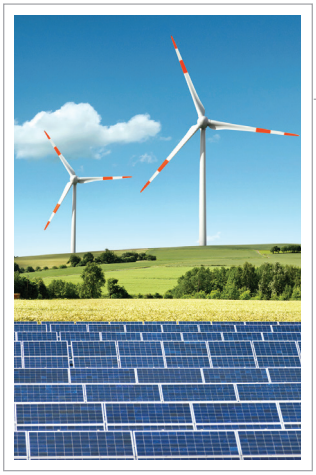


Semiconductor Structures
- Wafers
- Thin films



Organic Materials
- E-inks
- Printable electronics

Energy and Lighting
- LEDs / AMOLEDs
- Photovoltaics / Solar Cells
- Batteries



Discrete and Passive Components
- Two-leaded: resistors, diodes, zener diodes, LEDs, disk drive heads, sensors
- Three-leaded: Small signal bipolar junction transistors (BJTs), field effect transistors (FETs), and more

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