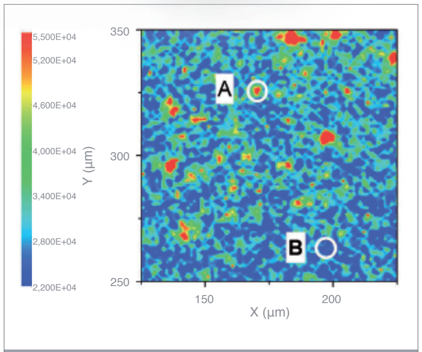
Photon etc
A spectrum of solutions

5795 DE GASPE AVENUE, #222
MONTREAL, QUEBEC, H2S 2X3
CANADA

IMA™

EL IMAGING SYSTEM



PHOTON ETC'S HYPERSPECTRAL IMAGER SOLAR CELL MAPPING
- image courtesy of IRDEP -

Photon etc. offers complex material analysis (GaAs, SiC, CdTe, CIS, CIGS) using hyperspectral imaging of diffuse reflectance, photoluminescence, electroluminescence and Raman signals. Our technology is based on high throughput global imaging filters,faster and more efficient than spectrograph based hyperspectral systems. Imaging from 400 to 1000 nm with a bandwidth of 2 nm, Photon etc's IMA™ is capable of measuring opto-electrical properties such as Voltage Open Circuit and External Quantum Efficiency, and allows precise detection and characterization of defects in materials. Researchers and QC analysts will greatly benefit from this new innovation.

TECHNICAL SPECIFICATIONS

Spectral Range*	400 to 1000 nm
Spectral Resolution	< 2.5 nm
Objectives	20X, 50X, 100X
Camera*	Front-illuminated interline CCD camera
Excitation Wavelengths*	N/A
Microscope	Upright
Spatial Resolution	Sub-micron
Maximum Sample Format	10 cm x 10 cm
X, Y Travel Range	76 mm x 52 mm
Z Stage Resolution	1 µm
Maximum Scanning Speed	150 ms
Wavelegth Absolute Accuracy	0.25 nm
Video Mode	Megapixel camera for sample vizualisation
Preprocessing	Spatial filtering, statistical tools, spectrum extraction, data normalization, spectral calibration
Hyperspectral Data Format	FITS, HDF5
Single Image Data Format	JPG, PNG, TIFF, CSV, PDF, SGV
Software	Computer with PHySpec™ control and analysis software included
Dimensions	≈ 102 cm x 76 cm x 76 cm
Weight	≈ 80 Kg

UPGRADES*	Back-illuminated camera EMCCD Additional excitation wavelengths available	High Resolution Module: 900-1700 nm FWHM < 1 nm Additional excitation wavelengths available	Spectral Range Extension: 250-400 nm, FWHM 10nm Broadband COL Camera: Color Camera EL Probe Station Low-Noise Back-Illuminated camera EMCCD

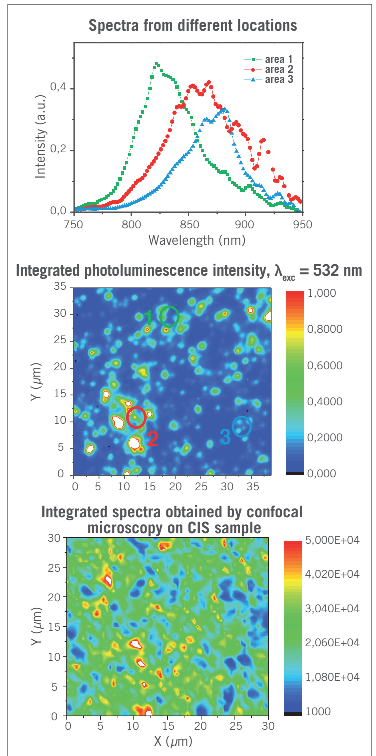
CHARACTERISATION OF SOLAR CELLS USING HYPERSPECTRAL IMAGER

A. Delamarre[1*], L. Lombez1, J.F. Guillemoles1, M. Verhaegen2, B. Bourgoin2
1- Institute of R&D on Photovoltaic Energy (UMR 7174, EDF-CNRS-ChimieParisTech), 6 Quai Watier-BP 49, 78401 Chatou cedex, France
2- Photon etc, 5795 avenue de Gaspé, #222, Montréal, Québec, H2S 2X3, Canada

A new characterization method based on hyperspectral imaging recording spectrally resolved images allows the cartography of electroluminescence (EL) and photoluminescence (PL). From the data acquired, spatial variations of cell properties such as open circuit voltage and transport mechanisms were identified and characterized. Furthermore, the system was compared to a classical confocal microscope, showing significant gains in acquisition time.

Spectrally resolved images provide considerable advantages such as, absolute calibration of intensity, micrometer scale resolution, and excitation and detection on a surface (no information loss from lateral diffusion and roughness). In luminescence imaging, absolute calibration is a main concern and is here done in two steps: first, an absolute calibration at a determined point (spatially and spectrally) with a laser, and then a relative calibration on the whole space and the whole spectrum, with a calibrated lamp coupled to an integrating sphere.The images rendered by IMA^{TM} are spectrally resolved luminescence images from multicrystalline CIS solar cell, offering means of studying its spatial inhomogeneities. On high efficiency GaAs solar cells, we got absolute measurements of EL and successfully investigated reciprocity relations. Our next step is to record quantitative maps of CIGS physical properties from PL and EL images, such as VOC , transport parameters and more.

A confocal microscope coupled to a spectrometer provides similar data. The 532nm laser is focused onto the cell front contact, and the cartography of PL spectra is obtained by scanning the sample. The acquisition time with the imager is much faster. 150*150μm^2 at 107 W/m^2 would take hundreds of hours in confocal, but only 8min with IMA. Moreover, surface excitation and detection allow to get rid of diffusion and roughness troubles for quantitative analysis.



PL MEASUREMENT ON ELECTRODEPOSITED $CuInS^2$

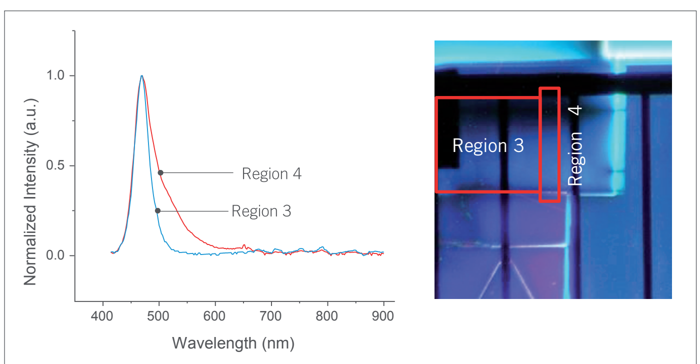
LUMINESCENCE IMAGING OF EXTENDED DEFECTS IN SiC VIA HYPERSPECTRAL IMAGING

Joshua D. Caldwell[1,a,*], Laurent Lombez[2,b], Amaury Delamarre[2,c], Jean-François Guillemoles[2,d], Brice Bourgoin[4,e], Brett A. Hull[3,f], Marc Verhaegen[4,g]
1. Naval Rasearch Laboratory, 4555 Overlook Ave, S.W. Washington, D.C. 20375, USA 2. Chimie ParisTech, École nationale supérieure, 11, rue Pierre et Marie Curie, 75231 Parie, France
3. Cree Inc., E. Corwallis Rd., Research Triangle Park, NC 27709 4. Photon etc., 5795 avenue De Gaspé, #222, Montréal, Québec, H2S 2X3, Canada

Over the past decade, improvements in silicon carbide growth and materials has led to the development of commercialized unipolar devices such as Schottky diodes and MOSFETs, however, much work remains to realizing the goal of wide-scale commercialization of both unipolar and bipolar devices such as pin diodes or IGBTs, for high applications requiring high powers, operating in elevated temperatures or radiation environments or for many fast switching applications.

Here we report on hyperspectral imaging of electroluminescence (EL) from SiC pin diodes, whereby a stack of luminescence images are collected over a wide spectral range (400-900 nm), thereby providing the ability to both image distinct features and identify their corresponding spectral properties. This process is also equally applicable to collecting either photo- or electroluminescence from other materials or devices emitting in either the UV-Vis or NIR, as well as to reflectance, transmission or other imaging techniques.

EL was induced via driving ~28A/cm^2 through 0.93x0.93 mm pin diode. EL was collected 20x 0.4 NA objective. A series of reflecting mirrors focused the EL onto the entrance slit of the hyperspectral imaging filter. By rotating the two volume Bragg gratings with respect to the incident, the output from the filter was narrowed to 2 nm, with the center wavelength of this pass-band varied from 400-900 nm. This output was focused onto a TE cooled CCD detector. Images were collected in 2 nm increments for 30s each. The collection of images were stacked and a rectification process was performed that enables a spectrum from any given feature within the structure to be obtained, thereby providing direct correlation between given structural features and their corresponding spectra within a single acquisition set.



IN-GROWN STACKING FAULTS: INFLUENCE OF PN JUNCTION