Photon etc
A spectrum of solutions

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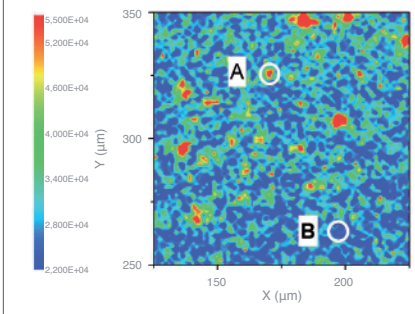
CANADA

IMA™

PL 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	IMA PL VIS	IMA PL SWIR
Spectral Range*	400 to 1000 nm	900 to 1700 nm
Spectral Resolution	< 2.5 nm	< 4 nm
Objectives	20X, 50X, 100X	20X, 60X, 100X
Camera*	Front-illuminated interline CCD camera	Photon etc. InGaAs Camera
Excitation Wavelengths*	532 nm	808 nm
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

APPLICATIONS

CHARACTERISATION OF SOLAR CELLS USING HYPERSPECTRAL IMAGER

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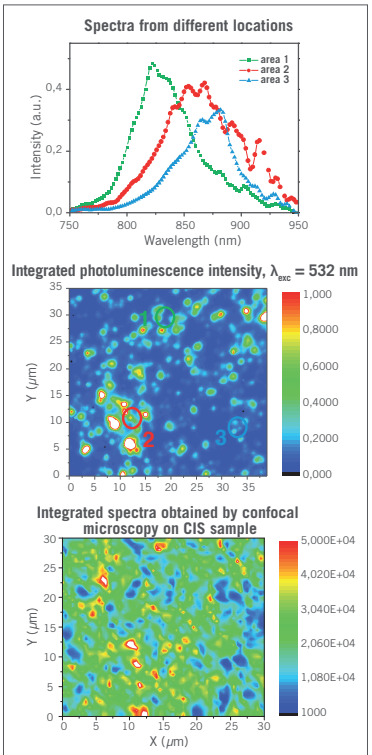
A new characterization method based on hyperspectral imaging recording spectrally resolved images allows the cartography of electroluminescence (EL) and photoluminescence (PL). From the data acquired, spatial variations of cell properties such as open circuit voltage and transport mechanisms were identified 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™ 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*150µm² at 107 W/m² 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 $CuInS_2$

IDENTIFICATION OF SINGLE NANOPARTICLES IN CANCER CELLS BY DARK FIELD HYPERSPECTRAL IMAGING

Dark field illumination is commonly used for the analysis of biological samples containing nanomaterials that significantly scatter light. When combined to hyperspectral imaging, it becomes an exceptional tool to also detect the composition and the location of nanomaterials embedded in cells. IMA™, Photon etc.'s hyperspectral imager, can be equipped with a highly efficient dark field condenser and generate high contrast images of biological samples.

The high throughput of Photon etc.'s hyperspectral filter allows the rapid acquisition of spectrally resolved high resolution images. Since the camera captures the whole area in the field of view, it is possible to collect spectral and spatial information in real time, with the possibility of recording spectrally resolved videos to follow the dynamics of cells and luminescent nanoscale components. PHySpec™, Photon etc software, enables principal component analysis (PCA) in order to identify the smallest variations of single and aggregated nanoparticles.

With the purpose of showing the capabilities of IMA™ to analyse nanomaterials in biological systems, a sample of MDA-MB-23 human breast cancer cells has been tagged with 60 nm gold nanoparticles (GNPs) and exposed to a dark field illumination on the entire field of view (Figure 1). With a 60× objective, an area of 150×112 µm was imaged, with a step of 2 nm and an exposition time of 2 s per wavelength. The complete analysis took only a few minutes, for more than one million spectra, each of them covering the whole visible spectrum.
Cells typically have a flat scattering spectrum, whereas GNPs show a sharp peak around 550 nm. Figure 2 illustrates the 550 nm image extracted from the dark field hyperspectral cube of the breast cancer. The GNPs are marked with a green colouring after PCA software processing. The magnification of a breast cancer cell (Figure 3a) and the spectra of the regions containing GNPs (some examples in Figure 3b) confirmed the presence of single 60 nm NPs (peak at 550 nm) and their aggregates (peaks red-shifted). The hyperspectral camera did not detect any GNPs in the areas between the cells.

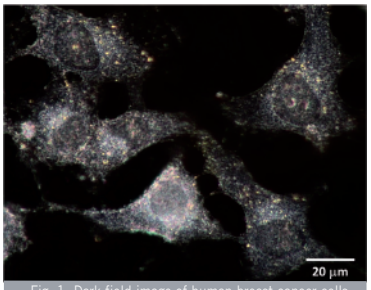


Fig. 1: Dark field image of human breast cancer cells tagged with gold nanoparticles (60 nm size)

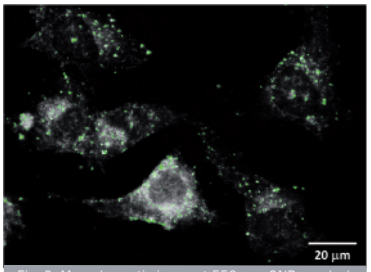


Fig. 2: Monochromatic image at 550 nm. GNPs marked in green after PCA

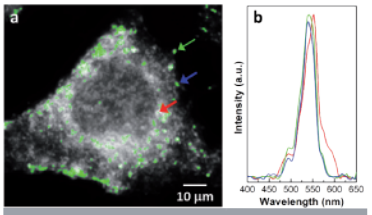


Fig. 3: Magnification of a breast cancer cell (a) and spectra of GNPs in different areas (b).

Results kindly provided by: David Rioux, Éric Bergeron and Michel Meunier, at École Polytechnique, Canada.