HORIBA
Scientific

EFiS

OSD-EF-01

QUALITY-CONTROL OF SOLAR CELLS

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

High resolution
Fast frame-rate

Inspection of solar cells

Inspection of solar cells relies on imaging the photoluminescence or electroluminescence signals from a wafer for characterization. The peak emission for silicon occurs at about 1150 nm, and about 1330 nm for copper indium gallium diselenide (CIGS) and copper indium diselenide (CIS).

This value is beyond the range of sensitivity for silicon-based detectors, such as CCDs; traditionally their quantum efficiency is only measured up to 1000 nm. The emission peak, however, is actually broad enough to allow deep-cooled CCDs to capture meaningful images using very long integration times (typically minutes). Although interesting, this is insufficient and unpractical for industrial applications.

Alternatively, shortwave infrared (SWIR) InGaAs technology may be used to directly detect the electroluminescence emitted at 1.3 µm by solar cells and ensure their quick characterization (within milliseconds) either during manufacturing or for pre-emptive maintenance operation of a photovoltaic plan. But SWIR cameras offer a low field of view and low resolution (320 × 256 pixels of 30 µm on a side) and can be expensive.

EMCCDs offer an interesting solution by combining a larger field of view and higher resolution (1004 × 1002 pixels of 8 µm on a side) for a better cost than SWIR.
Making use of its high sensitivity in the near infrared (NIR), an EMCCD is able to detect the edge of the electroluminescence signal with exposure times short enough to achieve a capture rate over 10 frames per second.

Figure 1 shows solar cells under a bias current, imaged by an EMCCD camera. The defects are clearly visible.

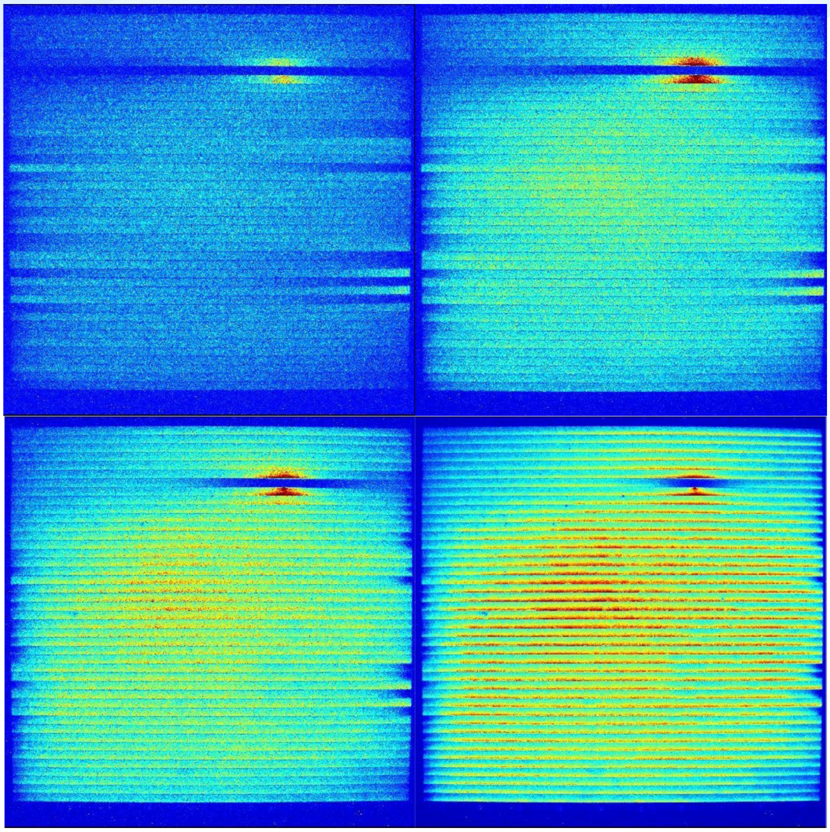


Figure 1: EFiS imaging of CIGS from 80 mA to 600 mA and 500 ms to 300 ms exposure times.

JOBIN YVON
Technology

Maintenance of solar power plants

Another application of solar cell electroluminescence is pre-emptive maintenance of an existing photovoltaic power plant. This requires the ability to quickly identify the solar panels with defective solar cells which are responsible for reducing the overall efficiency.

In this case, a large number of panels are driven under reverse bias and quickly scanned by EMCCD in video mode. The cells which are either damaged or operating at lower efficiency immediately appear, allowing identification of the panels which should be replaced in order to restore the overall efficiency.

Conclusions

In conclusion, EMCCD works well for the characterization of solar cells. It offers solutions to a range of applications and customers' requirements:

EMCCD offers higher resolution and a larger field-of-view as compared to a SWIR camera, plus the added benefit of lower cost.

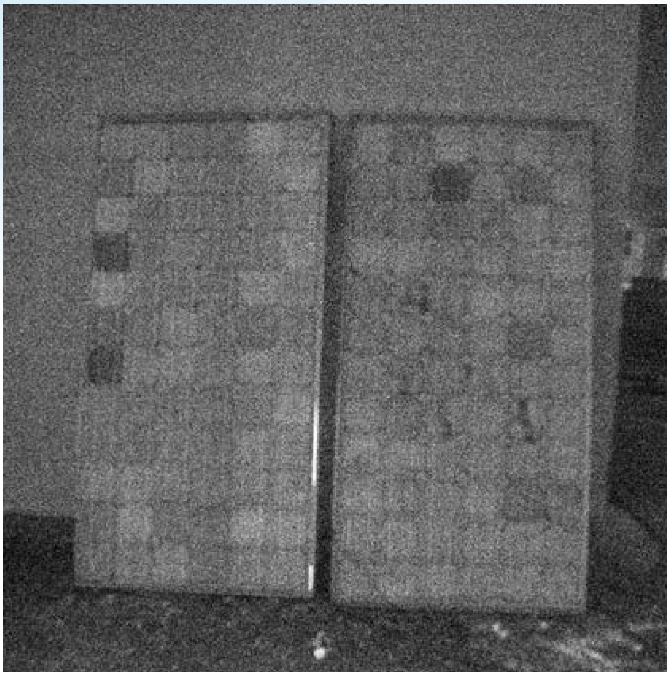
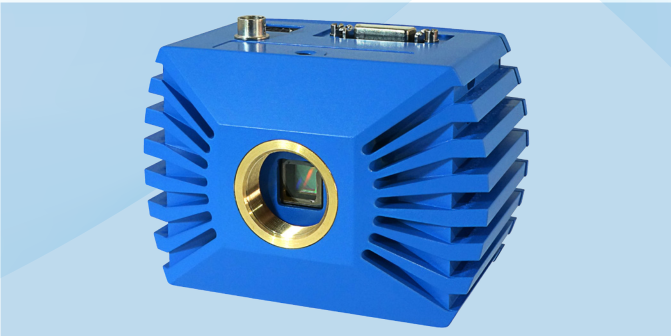


Figure 2: EFiS video frame of a solar panel with variable currents at 20 frames per second. The defective cells are clearly visible. Contrast could be improved using a visible filter.

EFiS Features

- 1004 × 1002 EMCCD sensor. Enables optimum image resolution in low light-imaging applications
- B/W EMCCD technology. Enables high sensitivity imaging with up to 1000× on-chip gain
- 16-bit CameraLink output. Provides wide dynamic range.
- 65% QE from Virtual Phase sensor. Optimum Photon collection.
- No Image intensifier. Optimum B/W image sharpness in ALL light conditions.
- Full Frame Transfer. No mechanical shutter required, vibration-less CCD readout.
- Real-time imaging. Optimum image sharpness in ALL light conditions.
- XCAP software-compatible. Ready-to-run powerful Image analysis software.



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