# Detekce elektroluminiscence fotovoltaických článků pomocí levné digitální zrcadlovky

Jiří Vaněk / Pavel Lepík
Department of Electrotechnology
Faculty of Electrical Engineering and Communication
Brno University of Technology
vanekji@feec.vutbr.cz / pavel.lepik@vut.cz

# Usage of Low Cost Digital Camera for Detecting of Silicon Solar Cell Electroluminiscence

*Abstract* – **This article analyses the existing methods both practically and theoretically used to detect defected surface area in solar cells. Various methods were used but by using an upgraded camera with CMOS sensor for carrying out the electroluminescence method, this has proven to have a very crucial impact on the results. Given the overall results and the acquired information, a procedure with a simple parameter can be setup to carry out the measurements. In addition to this a catalog was formed showing the defects occurring in mono and polycrystalline solar cells.**

*Keywords – CMOS Camera; Defect Detection; Diagnostic Methods; Elektroluminiscenc; Photovoltaics; Photovoltaic Cell; Solar Cell; Silicon.*

## I. INTRODUCTION

Luminescence is the property of some substances with a suitable electron structure to emit electromagnetic radiation in a near or visible spectrum. It is caused by the quantum transition of electrons in atoms from higher energy levels to lower levels after receiving a certain amount of energy after, for example, in the form of ultraviolet light (photoluminescence) or electrical energy (electroluminescence).

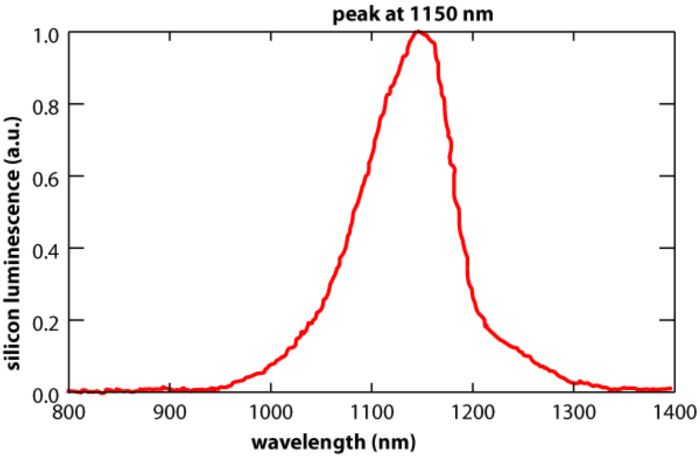



*Figure I.* **Silicon illuminates near infrared spectrum light[1]**

The silicon illuminates near infrared spectrum radiation. Depending on the structure of the used silicon material, these are wavelengths in the range 1050 - 1150nm. This property was first seen on silicon carbide in 1907 [1].

## II. DETECTION OPTIONS FOR LUMINESCENCE RADIATION

Due to the silicon luminescence spectrum, the most suitable detectors are made by using the InGaSe-based technology as shown in Figure 2.

These detectors have the advantage of detecting only luminescent radiation and zero sensitivity of interfering with the visible radiation, unfortunately the cost of these detectors is high for common usage of students. On the contrary, the silicon CCD detectors can be purchased today at a low cost. That's why we decided to design a silicon luminescence detection system based on a silicon CCD or CMOS technology.

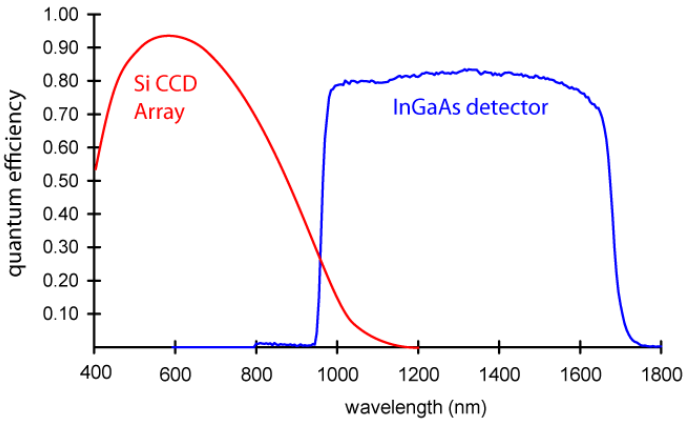



***Figure II.*** **Comparison of Spectral Response of Silicon CCD Chip and Chip from InGaAs**

The silicon CCD chip technology is most commonly used for imaging chips in compact cameras. Production is relatively simple but still expensive. The CCD chip output is not digital but analog, and therefore the CCD chip must follow image digitization circuits (A / D converter), which means higher power consumption and slower data flow.

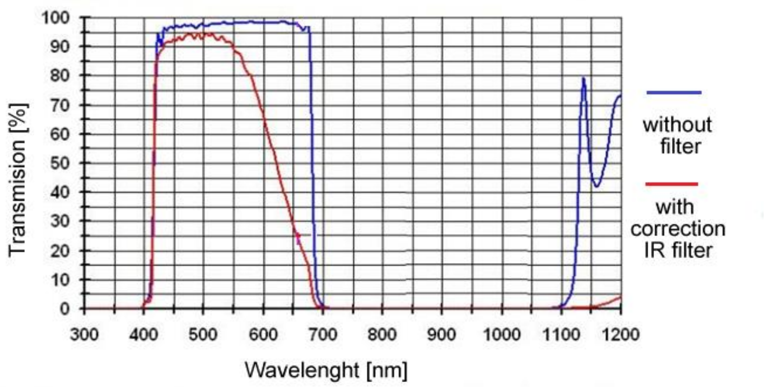



***Figure III.*** **Influence of inbuilt correction IR filter to optical system spectral transmission characteristi**

The silicon CMOS chips are dominantly used with digital SLRs and are slowly expanding into digital compact cameras. The CMOS chip is structurally a very complex matter, but it is cheaper to manufacture because it is manufactured in the same way as a computer processor. Circuits, that digitize the CCD image for all the pixels in sequence, are already part of the CMOS chip - each light-beam cell has these own circuits inbuilt. The digitization of the image is thus performed in each individual light cell separately and therefore at one point. This reduces the amount of time required to read the CMOS image and reduce power consumption.

## III. WORKPLACE DESIGN

The modified Canon EOS 40D camera with CMOS sensor technology was used for the silicon solar cell luminescence detection system. The CMOS chip itself is sensitive to a wide range of spectra: The standard component of digital camera is a filter restricting the part of the spectrum to the visible component corresponding to human eye sensitivity, see Figure III and IV, V. This filter is inbuilt to camera just before the chip (in the body of the camera) and for electroluminescence detection is important it’s removing.

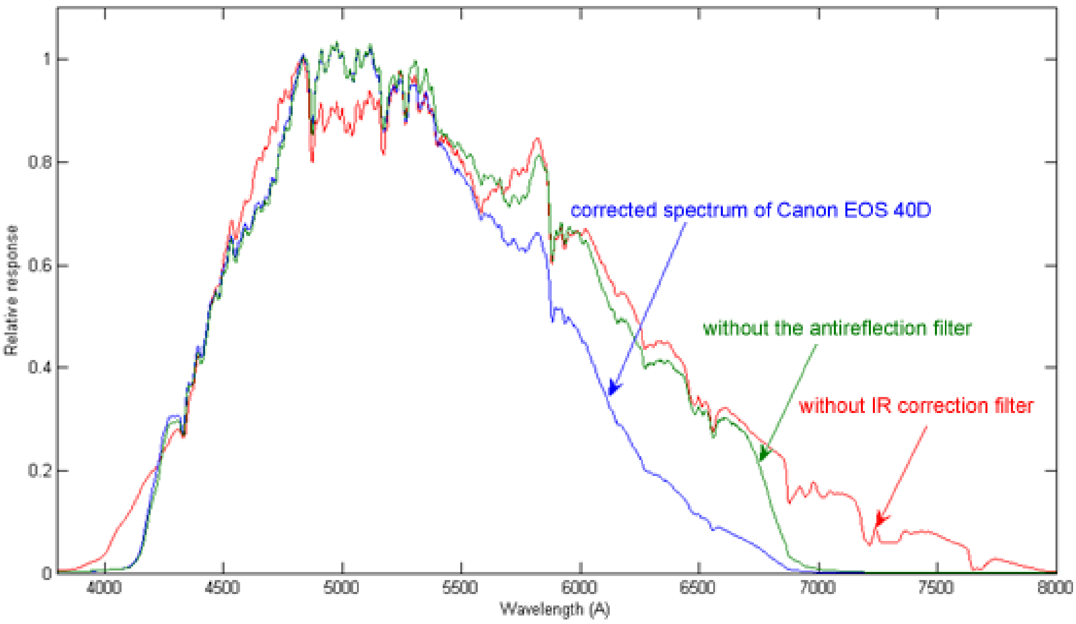
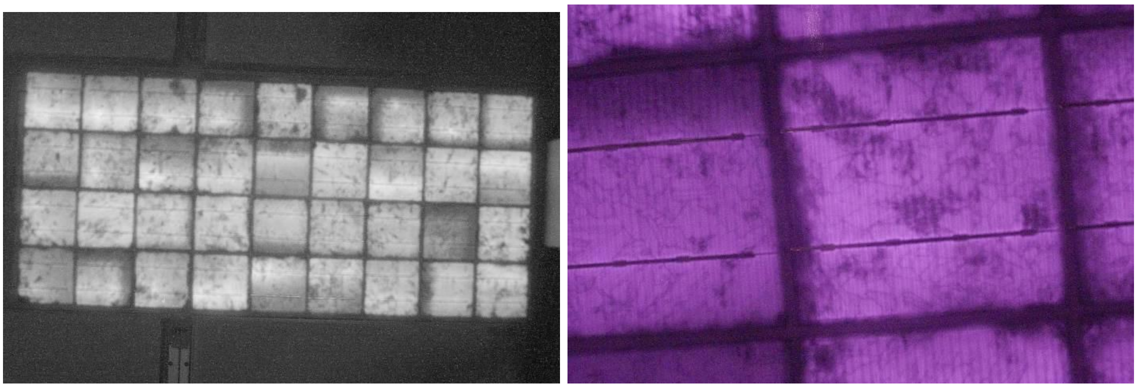



***Figure IV.*** **Influence of inbuilt correction filters to response of Canon EOS 40D CMOS chip**

In order not to detect disturbing visible light, the system was supplemented with a Hoya R72 IR photographic filter, which allows to detect light only in the area of silicon luminescence. [1]

The realization of the low-cost device for detecting the electroluminescence of the photovoltaic cell and module was done according to the block diagram shown in Figure V. This device allows the detection of electroluminescent radiation and the results can be seen in Figure VI.



a) b)

***Figure V.*** **Display of electroluminescence radiation a) after conversion to a BW range, b) in the original RGB spectrum of the CMOS detector**

## IV. CONCLUSION

A low cost electroluminescent detection device based on a detector made by Si CMOS detector technology has been implemented. This device is capable of displaying the electroluminescent radiation of photovoltaic modules in a relatively good quality and displaying their defects.

## V. ACKNOWLEDGMENTS

This research work has been carried out in the Centre for Research and Utilization of Renewable Energy (CVVOZE). Authors gratefully acknowledge financial support from the Ministry of Education, Youth and Sports of the Czech Republic under NPU I programme (project No. LO1210) and intern project for supporting students- scientific conferences SVK-2017-008.

## REFERENCES

[1] LEPÍK, P. Inovace systému pro detekci defektů solárních článků pomocí elektroluminiscence. Brno: Vysoké učení technické v Brně, Fakulta elektrotechniky a komunikačních technologií. Ústav elektrotechnologie, 2017