Transmission of signals using white and visible LEDs for VLC applications

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Abstract

Recent developments in LEDs allowed them to be used in environmental lighting and have revealed many advantages over incandescent light sources including lower energy consumption, longer lifetime, improved physical robustness, smaller size, and faster switching. Besides this general lighting application, LEDs are now used in other specific fields such as automotive headlamps, traffic signals, advertising, and camera flashes. However another emerging field of application is in advanced communications technology due to its high switching rates. Thus, the visible light spectrum is currently being used in the Visible Light Communication (VLC) technology, taking advantage of the lighting infrastructure based on white LEDs. These energy-saving white light sources devices were enabled by the invention of efficient blue LEDs.

In this paper we propose the use of a multilayered pinpin device based on a-SiC:H to work as a photodetector operating in the pertinent range of operation for VLC (375 nm – 780 nm) using as optical sources white and visible wavelength LEDs [1]. The device consists of a p-i'(a-SiC:H)-n/p-i(a-Si:H)-n heterostructure with low conductivity doped layers, sandwiched between two transparent contacts (Figure 1). It works as an optical filter in the visible range with tunable spectral sensitivity dependent on both applied bias and type of steady state optical bias (wavelength, intensity and direction of incidence on the device).

Optoelectronic characterization of the device is presented and includes with spectral characterization of the optical sources (figure 2), spectral response, transmittance and I-V characteristics, with and without background illumination of the photoddetector (Figure 3). Results show that when the device is biased with front optical steady state light of short visible wavelength (400 nm) superimposed with the pulsed light emitted from the optical transmission sources, it exhibits an increased output current in the long part of the spectrum (550-650 nm), and a reduction of the same photocurrent for the short wavelengths (400-500 nm). An opposite behavior is observed when the wavelength of the background is changed to longer values. A comparison of the performance of white LEDs and visible wavelengths is presented.

Results show that, front background enhances the light-to-dark sensitivity of the medium, long and infrared wavelength channels and quench strongly the low wavelength, depending optical amplification on the background intensity. The change of the impinging side of the steady state illumination produces the reverse effect, as the output photocurrent is enhanced under short wavelength signals and range and strongly reduced it under the long wavelength (figure 4).

A decoding algorithm for the detection of different optical signals is presented and discussed with a self-recovery error procedure. A capacitive optoelectronic model supports the experimental results (figure 5) and explains the device operation. A numerical simulation will be presented.

References

[1] “Home VLC using pinpin a-SiC:H multilayer devices”, P. Louro, V. Silva, I. Rodrigues M. A. Vieira, M. Vieira, Mater. Res. Soc. Symp. Proc. Vol. 1693 © 2014 Materials Research Society, DOI: http://dx.doi.org/10.1557/opl.2014.569

[2] “Viability of the use of an a-SiC:H multilayer device in a domestic VLC application”, P. Louro, V. Silva, M. A. Vieira, M. Vieira, physica status solidi (c), Special Issue: E-MRS 2014 Spring Meeting – Symposium X, Volume 11, Issue 11-12, pages 1703–1706, November 2014, DOI: 10.1002/pssc.201400035

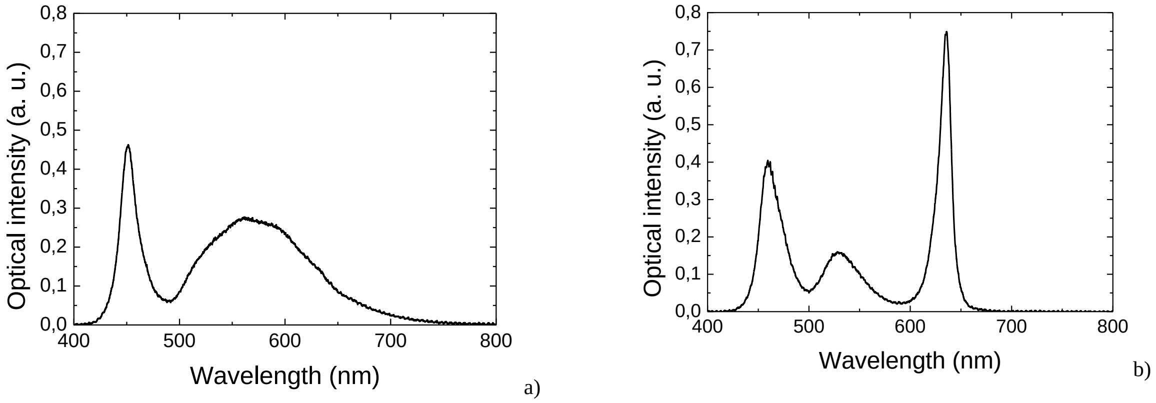

Fig.2 Emission spectrum of the warm white LEDs: a) phosphor based; b) tri-chromatic based.

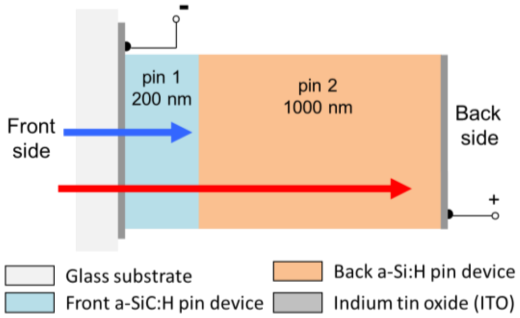

Fig.1 Simplified schematic diagram of the device structure.

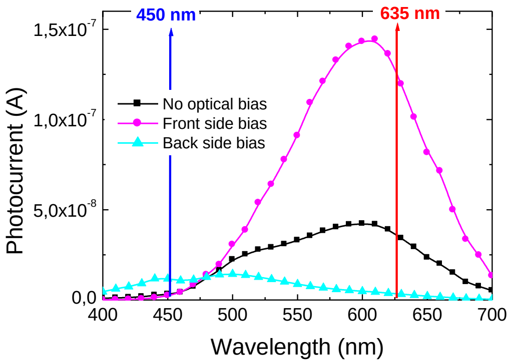

Fig. 3 Spectral photocurrent under dark conditions and using front and back violet light.

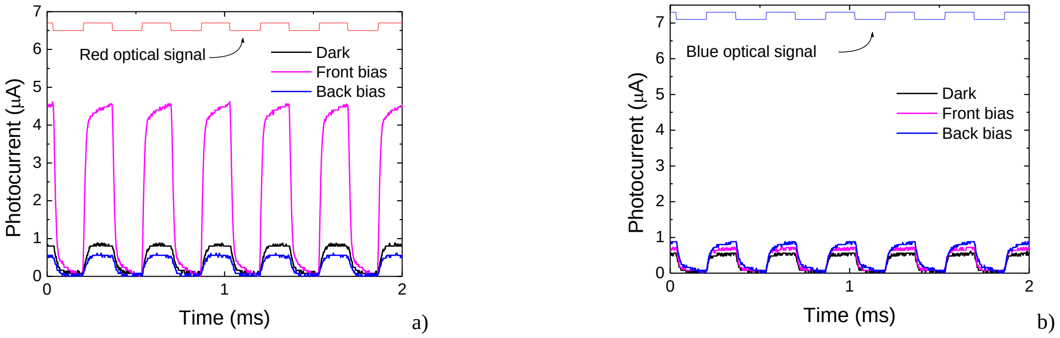

Fig. 4 Transient photocurrent measured under pulsed illumination of the internal LEDs of the tri-chromatic based white LED: a) red and b) blue internal LED, without optical bias and under front and back optical bias.

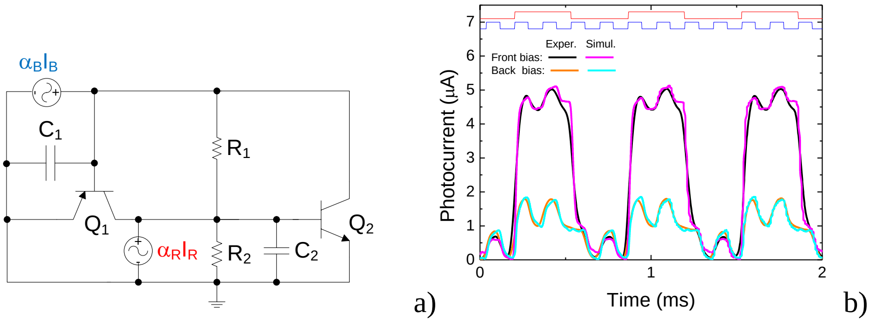

Fig. 5 a) ac equivalent circuit of the optoelectronic device, b) Simulation and experimental data of the combined signal with front and back optical bias (C1=0.8 nF, R1=10kΩ, C2 (front)=0.2 nF, C2 (back)=0.15 nF R2=1kΩ).