Indoor positioning system using a-SiC:H a WDM device

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Abstract — : In this paper, we present an indoor positioning system were trichromatic white LEDs are used as transmitters and an optical processor based on a-SiC:H technology as mobile receiver. The optical processor is realized using a double p-i-n photodetector with two UV light biased gates. The relationship between the optical inputs (transmitted data) and the corresponding digital output levels (received data) is established and decoded. The received signal is used in coded multiplexing techniques for supporting communications and navigation concomitantly on the same channel. The position of the device is estimated using the visible multilateration metodh through the strength of the signal received from several non-collinear transmitters. The location and motion information is found by mapping position and estimates the location areas. Since the indoor position and transmitted data of the different LED light sources is known from building floor plans and lighting plans, the corresponding transmitted data information, indoor position and travel direction of the mobile device can be determined.

Keywords: SiC technology; VLC; indoors positioning system.

I. INTRODUCTION

Indoor positioning has become an attractive research topic within the past two decades. However, no satisfying solution has been found with consideration of both accuracy and system complexity. Recently, research on visible light communications (VLC) offer new opportunities in realizing accurate indoor positioning with relatively simple system configuration and be used as a Cyber Physical System. VLC, using Light Emitting Diodes (LEDs) has become promising in wireless communications [1]. Due both illumination and communication, many investigations have been attracted [2, 3]. Trichromatic white LEDs, are promising solutions, as they offer the possibility to perform Wavelength Division Multiplexing (WDM) which can greatly increase the transmission data rate in the visible range.

In the past, we have developed a WDM device based on amorphous SiC technology. The device multiplexes the different optical channels, performs different filtering processes, and finally decodes the encoded signals, recovering the transmitted information [4]

II. POSITIONING SYSTEM, DESIGN AND OPERATION

The system is a self-positioning system in which the measuring unit is mobile. Trichromatic RGB-LEDs are used together for illumination proposes and individually, each chip, to transmit the channel location and data information. The proposed LED arrangement is presented in Figure 1.

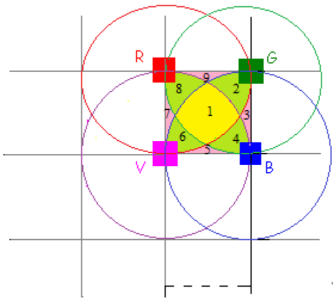

Figure 1 The next closest grid positions

An extra violet LED located at one of the corner was added for error control [5]. A circle around each transmitter on which the device must be in order to receive the transmitted information (generated location and coded data) is used to estimate the distance. To receive the information from several transmitters, the device must be at the position where the circles overlap, producing at the receiver a MUX signal that after demultiplexing acts not only as a positioning system but also as a data transmitter. The grid size was chosen in order to avoid data overlap in the receiver from adjacent grid points. The chips of the RGB-LEDs can be switched *on* and *off* individually in a desired bit sequence.

The receiver consists of two stacked amorphous cells [p(SiC:H)/i(SiC:H)/n(SiC:H)/p(SiC:H)/i(Si:H)/n(Si:H)] and two conductive contacts (Figure 2). The blue sensitivity and the red transmittance were optimized, respectively, through a thin a-SiC:H absorber (200nm) with an optical gap of 2.1 eV and thick a-SiH back absorbers (1000 nm) having optical gap around 1.8 eV. Their thicknesses are a trade-off between the full absorption of the blue light into the front diode and green across both.

An *on-off* code is used to transmit data. The information and the code position of each LED are transmitted simultaneously through the red, green, blue and violet; $\lambda_{R,G,B,V;}$ pulsed transmitter channels (input channels, Figure1). Free space is the transmission medium. The impinging photons at the receiver are absorbed accordingly to their wavelengths (see arrow magnitudes in Figure 2. The combined optical signal (multiplexed signal; received data) is analyzed by reading out the generated photocurrent under negative applied voltage (-8V), with and without 390 nm background lighting, applied either from front or back sides [5].

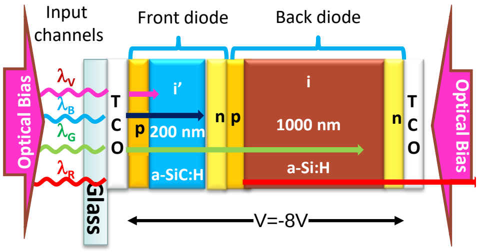

Figure 2. a) Receiver configuration and device operation.

III. ANALYSIS AND DISCUSSION OF THE RESULTS

The received data at position 1, *i.e*. the MUX code signal due to the combination of the four input channels at 3 mA drive current, is displayed in Figure 3, under both front and back irradiations. On the top the MUX signal are decoded. All the four LED are simultaneously modulated in both figures.

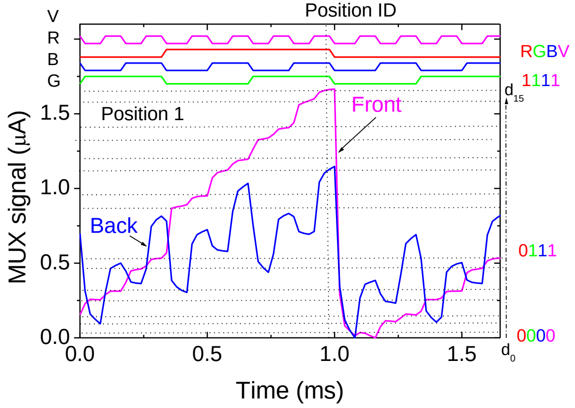

Figure 3. MUX signals under 390 nm front and back irradiation. On the top the transmitted channels are decoded.

Results from Figure 3 show that for each *on/off* state a well-defined level, under front irradiation, is set (horizontal dotted lines, d_0-d_{15}) and can be linked to 4-bit binary code (RGBV) where 0 means color channel *off* and 1 color channel *on*. The algorithms to decode the coded information are simple [6].Under front illumination the red and the green channel are enhanced and the blue and violet quenched, while under back lighting the blue and violet are amplified and the red and green reduced (see arrow magnitude in Figure 2. By combining front and back information the four channels are decoded.]. By assigning each output level to a *n* digit binary code weighted by the optical gain of the each channel, the signal can be decoded. A maximum transmission rate capability of 48 kbps was achieved in a four channel transmission.

In Figure 4, the MUX signal acquired when the sensor was under point 1 (t_1), move to point 3 (t_2), passes through point 4 (t_3) and stops on point 5 (t_4) is displayed. On the top the synchronous information transmitted by the four LED at each corner is decoded. Results show that at each of the analyzed generation regions the MUX signals present different pattern that after decoding give information about the mobile navigation and received information along the time.

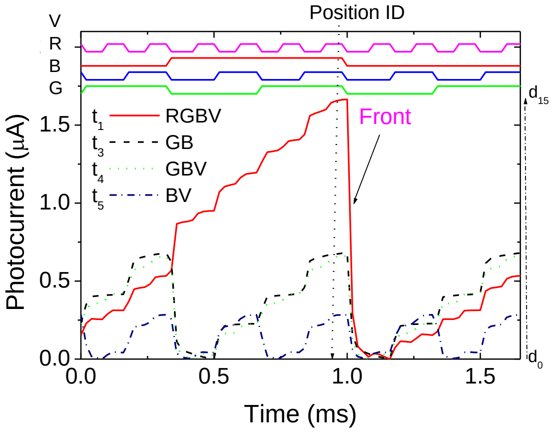

Figure 4 MUX/DEMUX signals under different generation regions (1, 3, 4, 5).

IV CONCLUSIONS

A preliminar indoor positioning system that uses fixed RGB-LEDs to transmit the information, at a given position, and WDM a-SiC:H/a-Si:H pin/pin receiver for decoding it, has been presented. The results showed that it is possible not only to determine the position of a mobile target but also to infer the travel direction along the time and the different messages from the received transmitters.

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