Lighting System for SMD Optical Control

Aleksei Stratev[1], Valentin Videkov[2]

Abstract – **This paper presents the design of a lighting system for optical control of SMD PCBs and the results of its measurements. The main attention is drawn to the co-ordination of the monitoring camera sensitivity, work field and emission diagrams of the light-emitting diodes. Different light-emitting diodes, positions and lightings have been used**

Keywords – **optical control, lighting, SMD, PCB.**

I. Introduction

Visual control methods including automated systems are widely used for SMD assembly control in the last decade [1]. The essential element in them is the system for lighting the objects, which allows the optimal monitoring of different elements. Attention is drawn to the elements themselves, as well as to the solders [2]. The lighters could have different construction and colour [3].

II. Lighting

The objective of the lighter is to get a clear image of the monitored object, a part of a PCB – fig. 1, which has both bulging and flat forms.

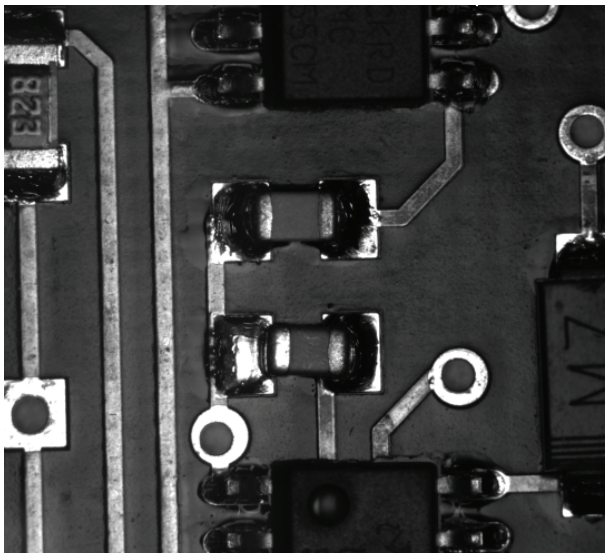

Fig. 1. An image for a visual control.

[1]Aleksey Stratev is with the Faculty of Electronics, 8 St. Kl. Ohridsky blvd. Technical University of Sofia, 1797 Sofia Bulgaria,

[2]Valentin Videkov is with the Faculty of Electronics, 8 St. Kl. Ohridsky blvd. Technical University of Sofia, 1797 Sofia Bulgaria, E-mail: videkov@ecad.tu-sofia.bg

There are two basic types of lighting – with perpendicular and with sideways falling rays in respect to the plane of the PCB. Each one of the methods has its pros and cons. The lighting itself can be carried out with different light. The constructions with light-emitting diodes are widely used lately. The specific thing with them is the need of equal lighting along the monitored surface.

Different constructions of both types were studied in respect to the development of the system – fig. 2.

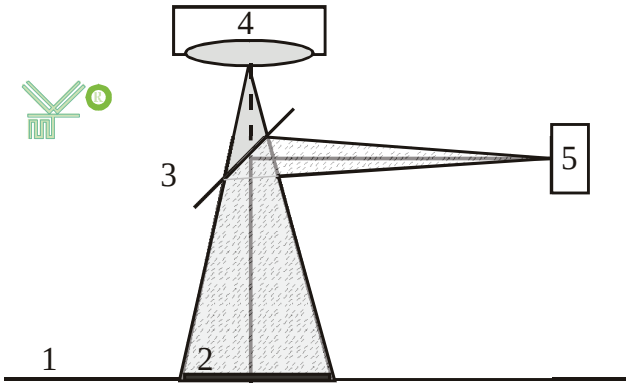

Fig .2. A construction with a vertical lighter. 1 – PCB, 2 – work field of the camera, 3 – light-emitting diodes, 4 – camera, 5 – lighter.

The usage of only one lighter has two drawbacks due to the need of quick operation – lighting inequality and power limitation. The lighting inequality was defined using the emission data diagram of the source (fig. 3.a and fig 3.b.).

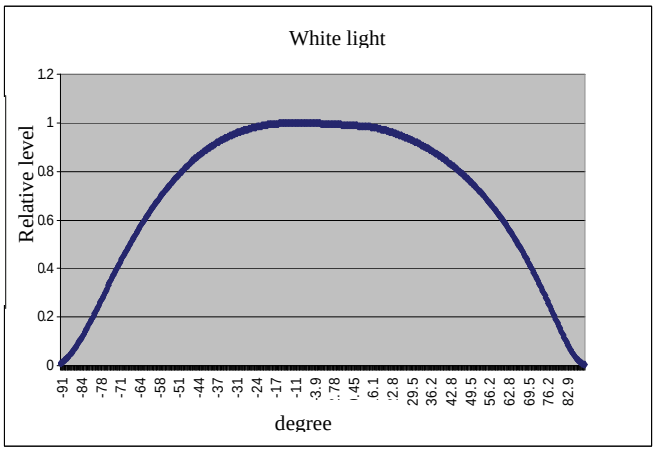

Fig. 3.a. White light-emitting diode diagram.

The calculations revealed that it is not possible to get the needed power and lighting inequality of two adjacent pixels at

the same time in comparison with the level of the camera's discretisation.

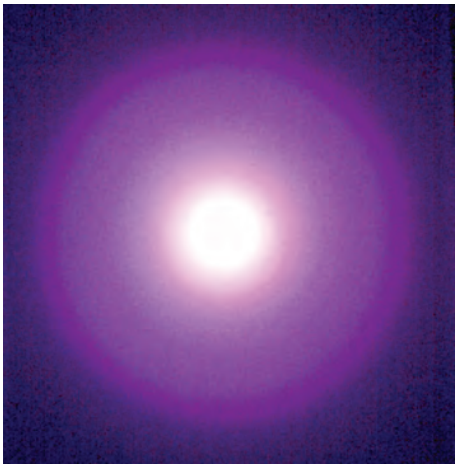

Fig. 3.b. Lighting.

The usage of power light-emitting diodes (F50380) [4] composed of green and red light-emitting diodes also showed a drawback. Colour separation is noticed when using a precise analysis of the image. The image from one light-diode was experimentally taken and stripes with different lighting were notices – fig 3.b. An additional study of the emission diagram of the different colour light-emitting diodes revealed a dislocation of the colours. In the scale of 20 degrees the dislocation reaches 15 degrees (fig. 4) in respect to the normal. A partial correction is possible if applying an individual optical system, but this does not solve the problem with the power.

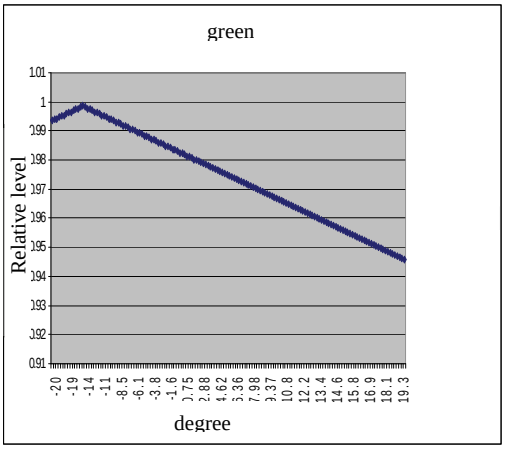

Fig. 4. A spatial diagram of a white light-emitting diode's green specrtum.

One colour is enough for the analysis of the image in a range. In this aspect, it is enough to apply lighting with red light-emitting diode (XLamp_7090), which is well co-ordinated with the camera's sensitivity for the same spectrum – fig. 5.

In order to increase the lighter's power, a matrix one composed of nine light-emitting diodes was developed. The dimensions of the matrix are below 60x60 mm and are well coordinated with the dimension of the plate beamsplitter mirror. It was needed to analyse the dynamic range in relation to the light-emitting diodes' power and camera sensitivity.

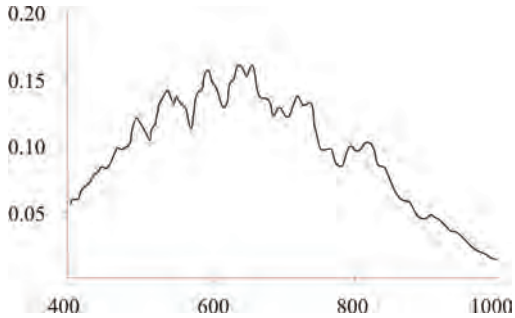

Fig. 5. a. PL 741 camera reception.

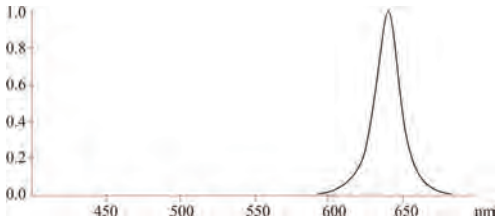

Fig. 5.b. Light-emitting diode's spectrum.

The pictures related to two power levels are shown in fig. 6.a. and fig. 6.b.

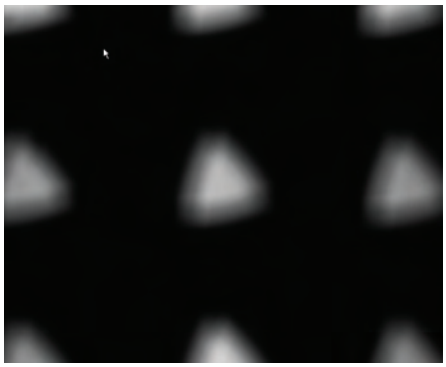

Fig. 6.a. Level one.

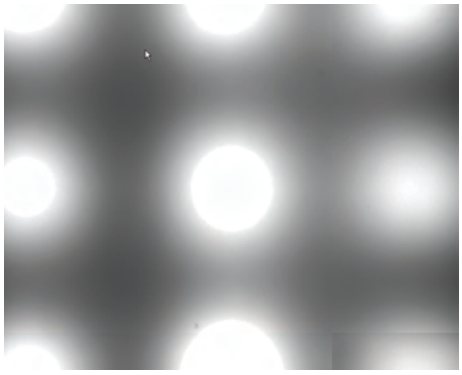

Fig. 6.b. Second level.

A screen in the form of an opaque diffuser, which was placed in front of the light-emitting diodes matrix, was used to improve the lighting equality. The result of the screen brightness and optical way of such a screen analysis is shown in fig. 7.

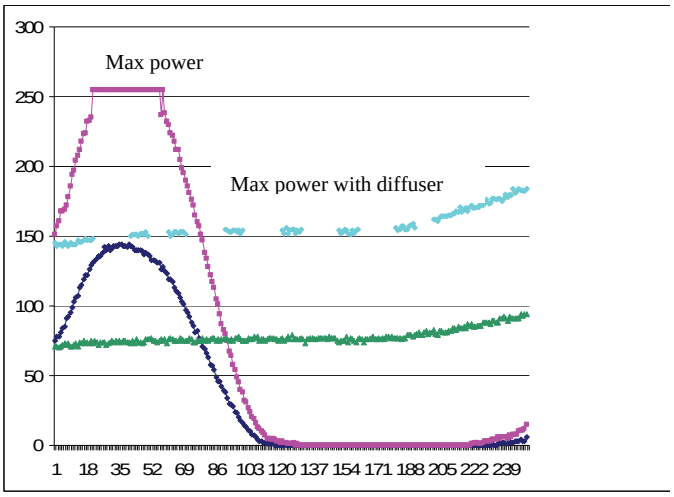

Fig. 7.a. Brightness of the matrix lighter with and without a diffuser.

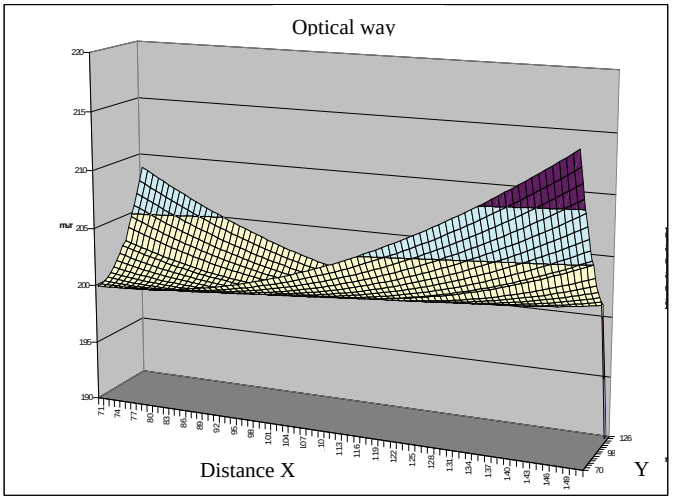

Fig. 7.b. Optical way to object's plane.

The camera was saturated instead of getting an equal white lighting when the diodes' power or exposition time were increased.

After an optimization of the distance between the light-emitting diodes, the diffusion screen and power 2 % equality in the monitored zone was achieved – fig. 8. A certain power loss is noticed – up to 30 % depending on the diffuser, but the equality is significantly increased.

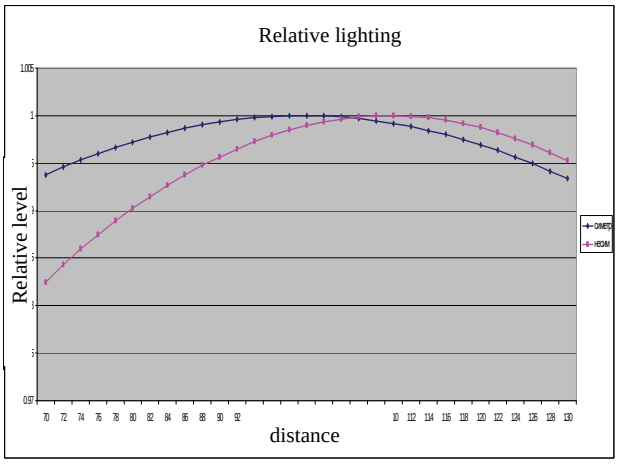

Fig. 8. Equality of lighting with centering and little angle dislocation.

III. Conclusion

A construction consisting of a matrix lighter for perpendicular lighting of PCBs has been developed as a result of the investigations. It is going to be applied to the optical control using a digital camera.

References

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