Visible light communication and lighting using Laser Diodes

Jie Yang[1], Zhe Liu[1,*], Bin Xue[1], Zhou Liao[2], Junxi Wang[1], Jinmin Li[1]
[1]Institute of Semiconductors, Chinese Academy of Sciences, Beijing, 100083,China
[2]Technical Institute of Physics and Chemistry, Chinese Academy of Sciences, Beijing, 100101,China
*Corresponding author: liuzhe@semi.ac.cn

Abstract **— The limitation of LED droop effect makes it difficult to realize high speed visible light communication. Therefore the laser diode as the light source of the visible light communication has attracted considerable interest in recent years. However, if we want to achieve visible light communication and high quality lighting applications, we also face some problems, such as strong directivity, high brightness, harm to the human eyes, not enough high bandwidth and so on. In this paper, we analyzed the factors that influence the bandwidth of the laser diode, proposed and simulated laser beam smoothing method and obtained good results.**

I. RESEARCH MOTIVATION

Visible light communication (VLC) offers a new way of life, that is, combining lighting with communication, meanwhile meeting the requirements of environmental protection and no electromagnetic pollution. It is consistent with the trend of people's demand for wireless communication technology.

Traditionally VLC uses light emitting diode (LED) as light source. However, the bandwidth of the LED is very narrow, which will result that the transmission rate is limited. Moreover, the high injection current density will lead to so-called "efficiency droop" [1]. So that when the LED is used for communication purposes facing an inevitable tradeoff between modulation speed and output power[2].

Since the laser diode (LD) under high current density can achieve high luminous efficiency[1], the visible light communication technology which uses laser diode as the light source has received considerable attention in recent years[3-6]. However, if we want to achieve high speed visible light communication and high quality lighting applications, we also face some problems, such as strong directivity, high brightness, harm to the human eyes; conventional phosphors by laser radiation instantly quenching; the blending share of RGB laser diodes and the design of light path need further exploration.

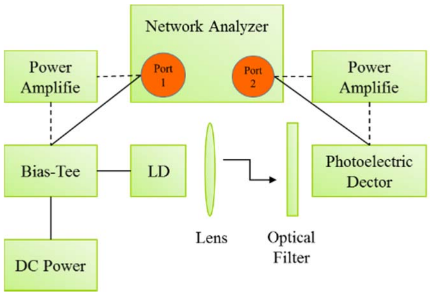

Fig.1 The test platform of LDs' bandwidth

II. RESEARCH METHODS

1) Theoretical analysis, literature review. Analyze the factors that may have effect on the bandwidth of the laser diode.

2) Set up laser diodes bandwidth test platform, as shown in Fig.1; test laser diodes and analyze the results.

3) Preparation of YAG:Ce yellow phosphor, add a plano-convex lens (LA1951-A) in front of the blue laser diode to collimate the laser beams, which excite yellow phosphor to generate white light [7]. Red (Mitsubishi ML101J21), Green (OSRAM PL520) and Blue (OSRAM PL450B) laser diodes are used to generate white light, as shown in Fig.2[4]. In addition, a plano-convex lens (LA1951-A) is placed in front of every emitting device to collimate the laser beams. In order to obtain white light, the beams are aligned in a single path with the help of two dichroic filters. A neutral density filter (NE04A) is placed in blu-ray path to reduce the blue light intensity to obtain good color temperature. Finally a diffuser is employed to form uniform white light.

4) The white light will be converted into parallel beams by optical design, which is illustrated in Fig.3a. At the front of the system, the divergence angle of the laser beams can be reduced

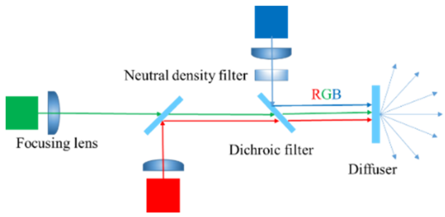

Fig.2 Using RGBLDs to generate white light.

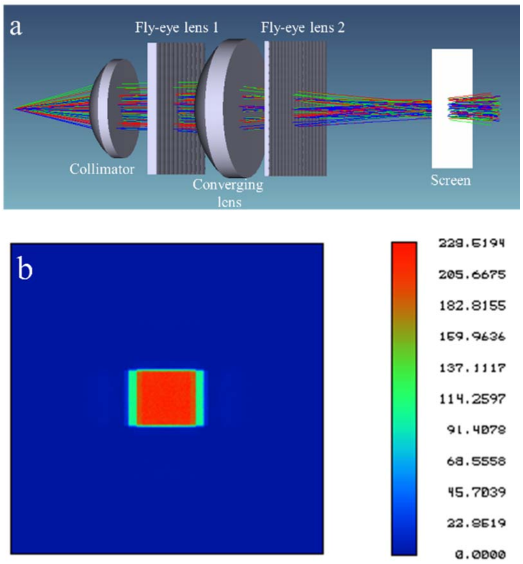

Fig.3 (a) Optical diagram of double fly-eye lens and (b) the simulation results

by adding a collimating lens. The optical path include two modules of fly's eye lens, the first one is used to produce the uniform white light spot, while the second one is used to transform the white light spot into space uniform white beam. Zemax optical design software is used to simulate the uniform illumination systems, as shown in Fig.3b. Then test the bandwidth of the white light and characterize its quality by integrating sphere.

5) Analyze the test results and compare them with theoretical calculation or simulation.

III. Results and Discussions

We have tested frequency response characteristics of a blue laser diode (OSRAM PL450B) and a green laser diode (OSRAM PL520), as illustrated in Fig.4. As we could see, from the figure, frequency response curve of blue LD having -3dB bandwidth of 1.25 GHz and 1.4 GHz at 75 mA and 85 mA, respectively. Fig.5 also shows the frequency response curve of green LD having -3dB bandwidth of 1.58 GHz and 1.7 GHz at 80 mA and 100 mA, respectively.

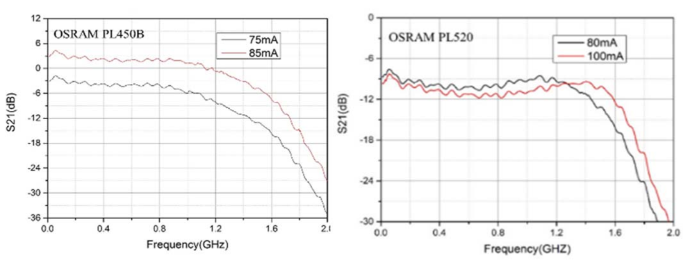

Fig.4 The frequency response curves of blue LD and green LD.

Obviously, -3dB bandwidth increases with current. The reason is that with increasing injected current, carrier density and carrier recombination rate in the active region increased. According to (1)[5]:

$$f_{3dB} \propto \frac{1}{2\pi\tau} , \qquad (1)$$

where f_{3dB} is -3dB bandwidth of the laser diode and τ is the carrier lifetime, we can know the bandwidth will increase.

IV. Summary

VLC can simultaneously achieve lighting and communication applications, with the advantages of high data transmission rate, good confidentiality, no electromagnetic interference, without spectrum certification, etc., and it is one of the ideal indoor high-speed wireless access solutions.

Compared with LED, the laser diode as the visible light communication source has higher response sensitivity, lower power consumption, smaller size. It is in line with people's expectations for future.

Acknowledgment

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