High-Speed High-Resolution 1200 dpi LED Print Head

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Abstract

We have developed a new 1200 dots-per-inch (dpi) light emitting diode (LED) print head for high-quality digital color printers in the next generation. The LED print head is suitable for high-speed color printer print heads. In order to achieve the high performance of the LED print head, we have developed an original 1200 dpi LED array chip with matrix structured wiring. Moreover, the LED array chip realizes a "Low cost LED print head" in which the number of bonding wires and driver integrated circuit (IC) chips on the LED print head has been decreased to less than half, compared to the conventional 1200 dpi print head.

Introduction

The color printer market has been growing rapidly because of the explosive proliferation of computers along with the internet boom. Recently, with the increased use of color documents, the appearance of a high-speed and high-quality color printer is anticipated. In response to this, there is a tandem type electro photographic color printer, which uses LED print heads. Unlike the conventional laser scanner printer print head, the LED print head has no moving parts such as the polygon mirror. As a result, the tandem type color LED printer has excellent high-speed and miniaturization characteristics as compared with the conventional laser scanner color printer. In order to realize even higher-speed and higher-quality color printers, LED print heads with high-emitted light power and high-resolution are required. Moreover, to further reduce costs, a "Low cost LED print head" is needed because of the utilization of four print heads in the tandem type color printer.

To solve these above-mentioned problems, we developed the novel LED print head[1] using the new type LED array chip with very high-emitted light power, a high-density emitter, and matrix structured wiring.

In this paper, we focused on the characteristics of the LED print head we have developed.

The New LED Print Head

Configurations of the LED Print Head

Figure 1 shows the A4 size high-speed high-resolution 1200 dpi LED print head that we have developed. The head consists of a new type of LED array chips, driver IC chips, and a base plate.

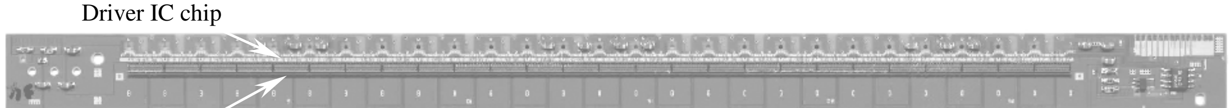

Figure 1. A photograph of the A4-size high-speed high-resolution LED print head.

A LED array chip consists of 384 LEDs adjusted to keep the LED pitch at 21.2 µm. Also the LED array chips and driver IC chips consisting of 26 pieces are mounted in a row together on a base plate in the LED print head. Their wire bonding pads are arrayed at one side of the LED array chip and the driver IC chip, resulting in the decrease of the number of driver ICs by one half. Figure 2 shows enlarged photographs of the main parts of (a) the conventional 1200 dpi LED print head and (b) the new LED print head. The new LED array chip allows for bonding wires to be arranged in a single row with a pitch of 80 µm, one half in comparison to the conventional head. In other words, the number of bonding wires on the new LED print head is decreased to one fourth as compared with the conventional 1200 dpi print head. From these results, the new LED print head realizes low cost in spite of being a high-resolution print head.

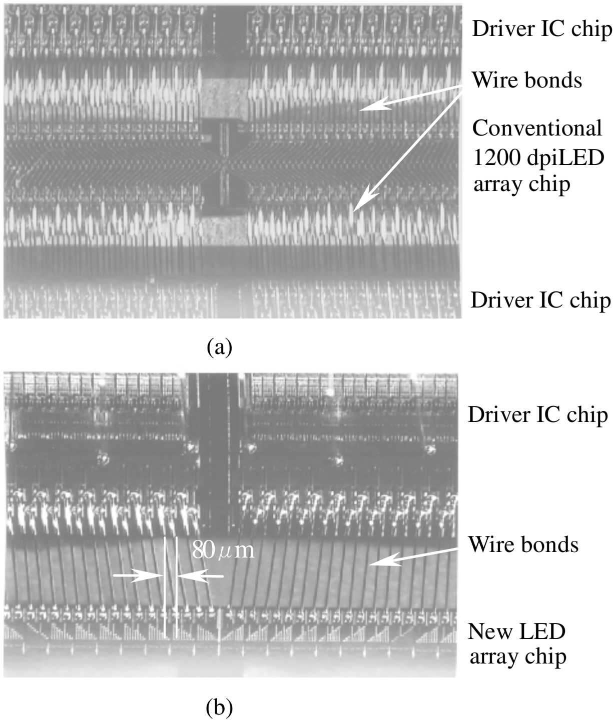

Figure 2. Enlarged photographs of the main parts of (a) the conventional LED print head and (b) the new LED print head.

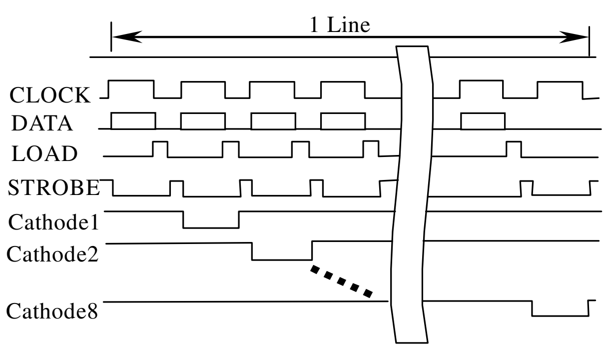

Figure 3. A block diagram of the new LED print head drive control.

Drive of the New LED Print Head

The new LED print head uses a time division drive system. Figure 3 shows a block diagram of the new LED print head drive control. Data are transmitted to a drive control circuit in parallel at 4 bits, 40MHz. As you can see in Fig. 3, each line is written by light emitted eight times per each cathode.

Characteristics of the New LED Print Head

The requirements for an LED print head for a high-speed high-quality color printer are as follows:

1) High emitted light power (high-speed printing)
2) Uniform emitted light power (high-quality)
3) High resolution (high-quality)
4) High accuracy alignment of each LED chips (high-quality)

Optical Characteristics

The new LED print head uses a rod lens array of 20 degrees. Figure 4 shows the corrected emitted light power of the print head under a 1mA drive current. The average emitted light power at 1mA is about 1 μW, having sufficient value for optical writing. Moreover, the deviation of the emitted light power of the print head is about ±1%, which is the value required for a high-quality color printing. Figure 5 shows the modulation transfer function (MTF) values of the print head. The average of MTF values is 70% and the deviation of the MTF values is about ±10% over the whole head. It has sufficient resolution even at the high-density of 1200dpi. Figure 6 shows emitted light intensity distribution when every other LED was switched on. It is clear that the contiguous LED light was separated electrically. The MTF is obtained about 80%.

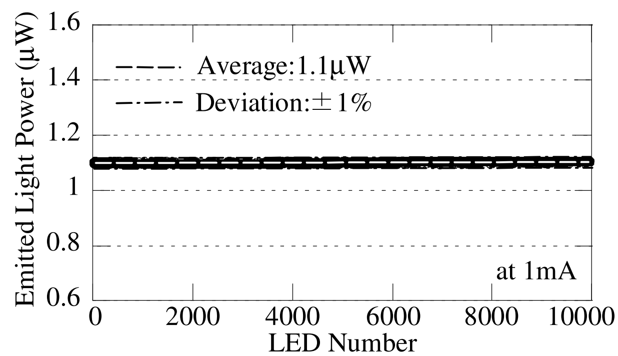

Figure 4. The corrected emitted light power of the LED print head.

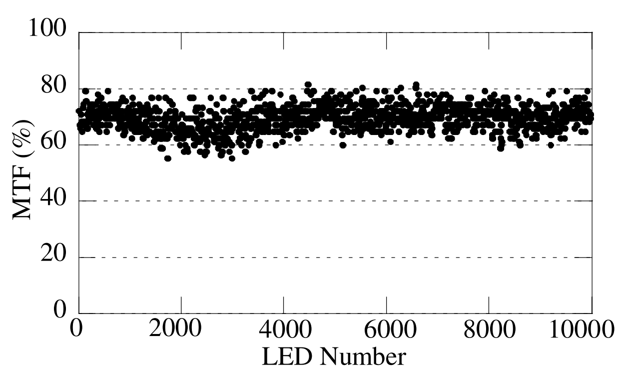

Figure 5. MTF values of the new LED print head.

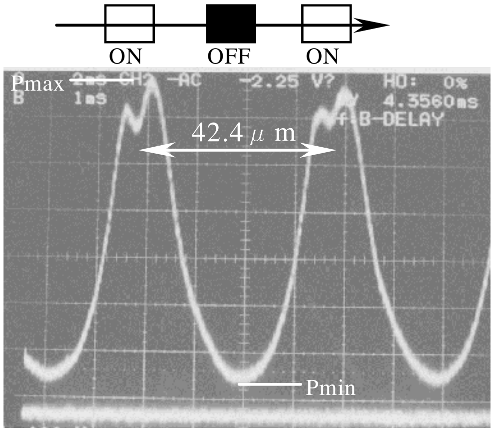

Figure 6. Emitted light intensity distribution from the print head when every other LED was switched on.

Position Accuracy of LED Array Chips

In the tandem type color printer using four LED print heads, the position accuracy of LED array chips affect the image quality. For this, we attained highly accurate mounting alignment of the LED array chips by development of high-accuracy die-bonding technology. Figure 7 shows emitted light spot position errors across the new LED print head in (a) the first scan direction and (b) the slow scan direction. The emitted light spot position errors of both directions of the first scan and the slow scan after die-bonding are within ±6 µm. On the other hand, after attachment of the rod lens array, it obtained high-accuracy alignment. There is ±10 µm in the first scan direction and ±20 µm in the slow scan direction.

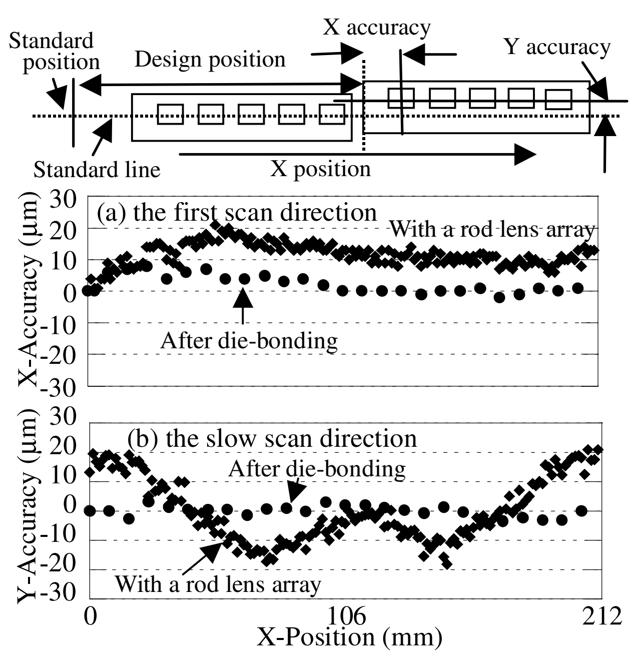

Figure 7. Emitted light spot position errors across the new LED print head.

As a result of the above characteristics, the newly developed LED print head is highly suitable for high-speed and high-quality color printer print heads.

Reliability of the New LED Print Head

Figure 8 shows the average emitted light power variation of the head measured by applying 1mA at 10% duty ratio and room temperature. ηv(%) was deduced as $\Sigma((P(t)-P(0))/P(0))/n\times100$, where P(0) indicates initial P_{LED}, P(t) indicates P_{LED} at time=t, and n indicates LED number. The value of emitted light power variation is within 1%, even after 1000 hours of use. Thus, the new LED print head is sufficiently reliable for use in color printers.

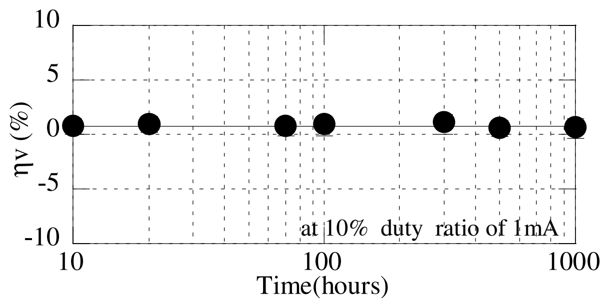

Figure 8 Degradation rate of the emitted light power.

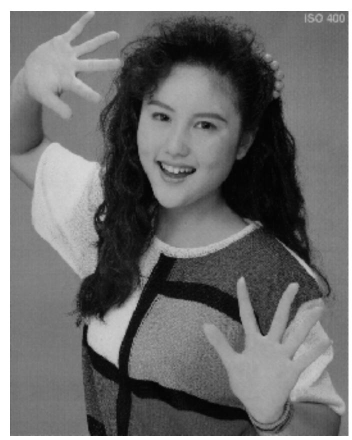

Figure 9. A print sample of the new LED print head. (After reading with an image scanner of 100 dpi.

Printing Sample of the New LED Print Head

Figure 9 shows a print sample printed by 21ppm and the new LED print head. (After reading with an image scanner of 100dpi) It was found that the new LED print head achieved high quality color printing.

The New LED Array

Composition of LED Array

Figure 10 shows an enlarged photograph of one block of the new LED array chip. The LED array chip consists of 384 LEDs, made up of 6 blocks of 8 dots x 8 cells =64 dots per unit. Moreover, each block consists of eight cells, and each cell consists of eight LEDs. Each cell is separated electrically.

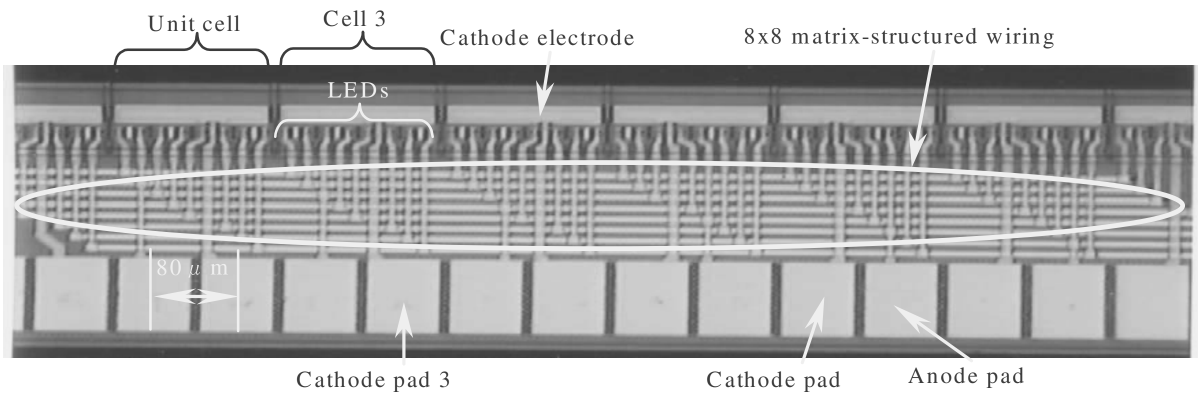

Figure 10. An enlarged photograph of the one block in the new LED array chip.

Matrix Structured Wiring

One anode pad is connected through 8x8 matrix structured wiring to eight LEDs of the different cells in each block. Moreover, a cathode electrode is formed for every cell and the cathode pad is taken out. Therefore, to make the LED of cell 3 emit light as shown in Fig. 10, current is applied to each LED in a block through the matrix wiring in accordance with the data. Then, selecting cathode pad 3 causes LEDs to emit light in accordance with the data. Repeating this operation 8 times completes the light emitting operation for one line.

Characteristics of the New LED Array Chip

The new LED array chip needs to emit light in a shorter time than the conventional LED array chip in order to function with the time division system, especially with the matrix structured wiring. Therefore, in order to attain high-speed printing, a very high-power light must be emitted.

Figure 11 shows emitted light power in relation to drive current for the new LED and the conventional GaAsP LED. The new LED attained high-power[2,3] emitted light and high-density[4,5] by fusing heterostructure wafer technology with a solid-phase diffusion technique.[6] An n-type AlGaAs epitaxial wafer consisting of a cladding layer, an active layer, and a cladding layer on GaAs substrate is used for the heterostructure wafer. The new LED is able to attain high-power emitted light 10 or more times more powerful than the conventional LED by using selective masked Zn diffusion in the heterostructure wafer. Consequently, the new LED makes the new print head applicable to 45 pages per minute high-speed print head. Moreover, since the power consumption of this LED is small, the quantity of heat per head is small and expansion and contraction of each head due to heat does not become a problem.

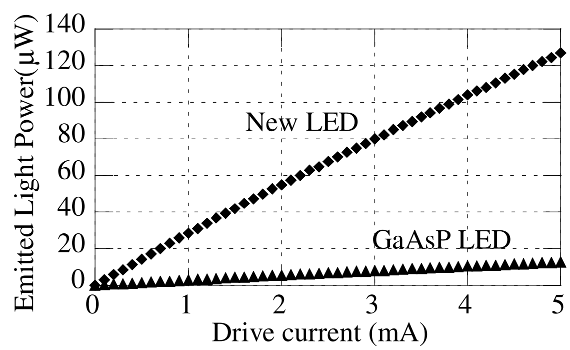

Figure 11. Emitted light power in relation to drive current for the new LED and the conventional LED.

Conclusion

We have developed the optimum LED print head for high-speed high-quality color printing. The new color LED print head is superior to the laser scanner print head with the high performances of 45 pages per minute and 1200dpi. Since the LED print head has excellent high-speed, high-density, and miniaturization features, these applications not only apply to high-speed high-quality color electro photographic printers, but can also be applied to copying machines, printing press, etc. in the future.

Table 1 Main Specifications of the New LED Print Head

ITEM	CONTENT
Print speed	45 pages per minute
Print resolution	1200 dots per inch
Print size	216 mm (A4 size)
Wave length	760 nm
Average light power	Min.1μW/dot
Light power uniformity	<±1%
Image formation element	Rod lens array 20 degrees
Total number of LEDs	9984 dots

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Biography

Masumi Taninaka received a B.E. and M.E. degree in electrical engineering from Nihon University, Japan, in 1991 and 1993, respectively. In 1993, he joined Oki Electric Industry, Co., Ltd., and engaged in the development of double-function LED array chips and very high-density LED array chips for electro photographic print heads. He moved to Oki Digital Imaging Corporation in 1999, and has been engaged in the development of the high-speed high-resolution LED print head. He is a member of the Japan Society of Applied Physics. E-mail: taninaka@mo.okidata.co.jp