

Compact Color Hard Copy System Using Vacuum Fluorescent Print Head

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Abstract

This paper reports a battery-driven compact and light-weight full color hard copy system, which enables high speed printing using an instant color film and a vacuum fluorescent print heed (VFPH). The resolution of the VFPH is 217 dpi with gray scales using pulse-width modulation and images are printed through Selfoc(R) lens arrays (SLA(TM)).

1. Introduction

In recent years, the integration of PDA and communica-tion has made it possible to get an easy access to image data from any place. On the other hand, portable image input devices such as electronic still cameras and digital video cameras are prevailing at the steady pace. Under such circumstances, the demand for portable color printers is expected to increase. In reality, there is still no portable color printer to output images for practical use. This paper reports a recently developed compact color printer using VFPH, SLA, instant films, which features com-pactness, light weight and low power consumption.

2. Configuration of the Color Printer

Figure 1 shows the cross section of the color printer, consisting of the moving unit, the developing unit and optical unit which carries out processes from exposure to developments. The optical unit is a head module con-sisting of the VFPH, a mirror to bend a light path, SLA or unity magnification lens, and filters to shift colors. The moving unit moves the head module at a uniform speed, and the developing unit stores film and develops images taken. In principle, an image is printed on a film through the following process; data entering into an IC cause phosphor to emit light, and the pattern generated by such light emission produces an equivalent image on a film which is printed on a film by the moving head module. Selecting colors by shifting filters and exposing red, green and blue images one at a time, a full color image is transferred on a film. The outer dimension of the optical unit is 9515545(mm), which is compact enough to carry even after being packaged in a case with the circuit board.

The VFPH with 480 dots is capable of producing an image of 480640 pixels (VGA) in coordination with line scanning. The resolution of 217dpi was decided in consideration of the effective area for memory storage (7556mm) of a film. Luminous elements are arranged in zigzag to the direction of lines, and driver ICs are mounted on the both sides of dot arrays, enabling static drive.

The optical unit is thin and compact with SLA and a mirror. Between the luminous layer and SLA, R,G and B filters are mounted to allow the formation of full color images by exposing each color frame of R,G and B in series after color selection.

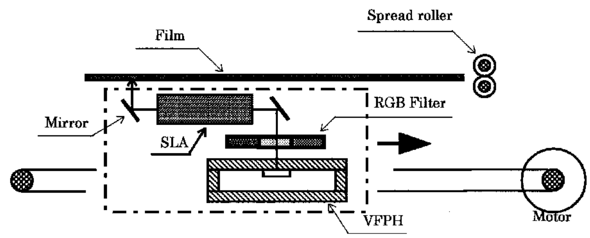

Figure 1 Structure of Printer

3. Structure of Electrodes

Figure 2 shows the cross section of electrodes of the VFPH. Within a vacuum package of 85mm (l)20mm (W)6mm (H), two cathode electrodes are arranged at the center and the anode electrodes consist of shield electrodes surrounding the cathode electrodes and grid electrodes formed on the glass base plate. Figure 3 shows the emission pattern layout. The principle of light emission is basically the same as that of a VFD. Electrons emitted from the heated cathode electrode hit and excite phosphor coated on the anode electrode to emit light. The VFPH is a front luminous type with a flat emission surface.

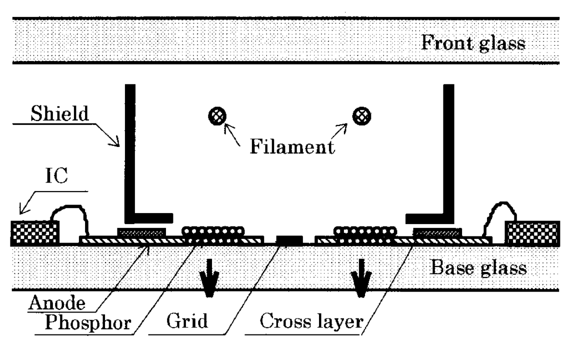

Figure 2 Electrode Structure of VFPH

The anode electrode is formed with aluminum thin film, on which the ZnO:Zn phosphor is coated by photolithography. The anode electrode directly below phosphor has a square opening in which luminous patterns of 117m^2. The grid electrode is formed around the anode electrode on the same plane, and controls the variation of radiant intensity by reducing the effect of field of the neighboring luminous elements. The shield electrode prevents electrons from flowing into the IC and the wiring is effective for decreasing the reactive power of the shield electrode. By providing the shield electrode, the power consumption of the VFPH was reduced down to 1W or less, which is less than a half of the VFPH without the shield electrode.

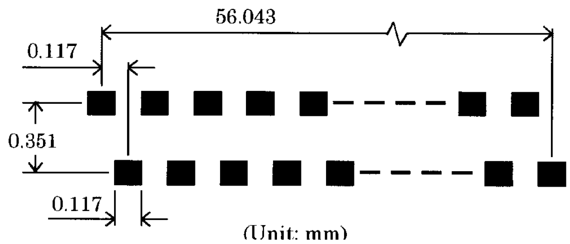

Figure 3 Emission Pattern Layout

4. Luminous Characteristics

Figure 4 indicates the dependence of the luminance of the VFPH on the anode voltage, where the ZnO:Zn phosphor is used and the withstanding voltage of the driver is set at 40V, the maximum voltage. The current of 10 uA/dot was obtained at the anode voltage of 40V. Since the anode current becomes lower, it is possible to use low cost driver ICs. Figure 5 shows the luminous pattern, whose shape is trapezoidal having relatively flat peak luminous distribution, indicating uniform luminance.

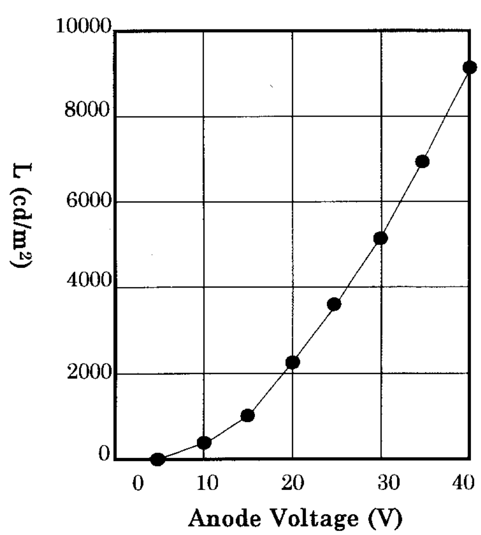

Figure 4 Relationship Between Luminance and Anode Voltage

5. Spectral Characteristics of Print Head

The spectral characteristic of ZnO:Zn coated on the light emission element (anode) is distributed in a wide range from 400nm to 700nm with the peak at 505nm. The spectral distribution covers the film's sensitive range of R,G and B. Accordingly, it is possible to expose each color of R,G and B by selecting bands of the desired wavelength from the light emitted from ZnO:Zn using color filters. As shown by the spectral characteristic of phosphor, in the green region spectral distribution was observed most, followed by those in the blue and the red regions. The optimum color balance is obtained by changing the anode voltage for each color to adjust the luminous intensity. Figure 6 shows the film spectral sensitivity and the spectral distribution of ZnO:Zn. Gelatin filters were used for RGB and the optimum selection of filters reduced crosstalks below 1%.

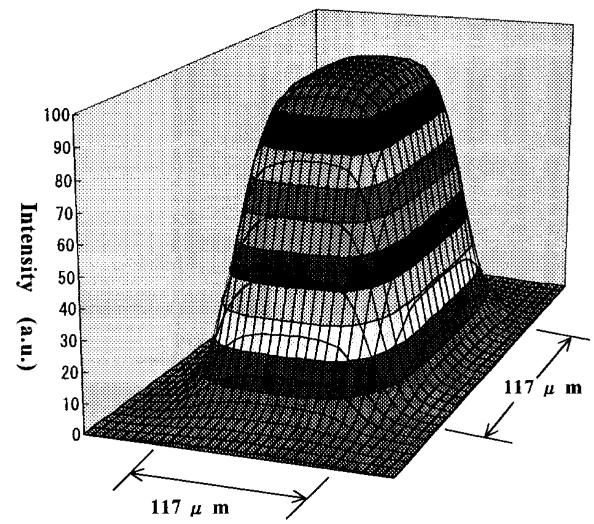

Figure 5 Exposure Beam Profile

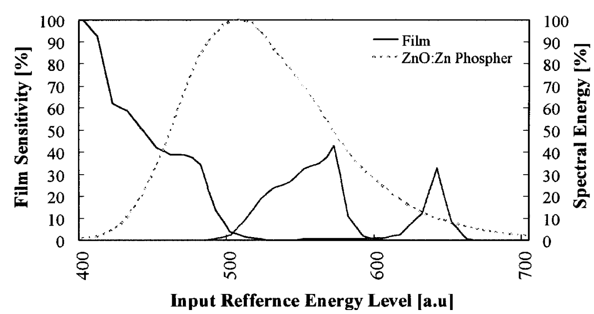

Figure 6 Film Sensitivity and ZnO:Zn Spectral Energy

6. Circuit Configuration

The circuit of the printer is shown in Figure 8. The circuit for storing image data consists of 2 line buffers to store 480-dot data for a display line, a controller circuit for the line buffer, an address generator, a control circuit for 256 gray scale level, a ROM for compensation data, a circuit to calculate compensation amount, and a circuit to generate data according to gray scale control. Besides these, a motor driver, a control circuit for camera back and a power source are provided. The operation of the memory circuit of image data is (1) to intensify the color of the image data stored into memory, (2) to compensate film density, (3) to compensate temperature, and (4) to store compensated data into the buffer for display lines. While the one line buffer is reading out the data for storage, the other line writes in data for the next display line. Read-out and write-in operations shift everytime the control of 256 gray scale completes. To the print head, data for one emission line, 480 dots, are transmitted every control of gray scales.

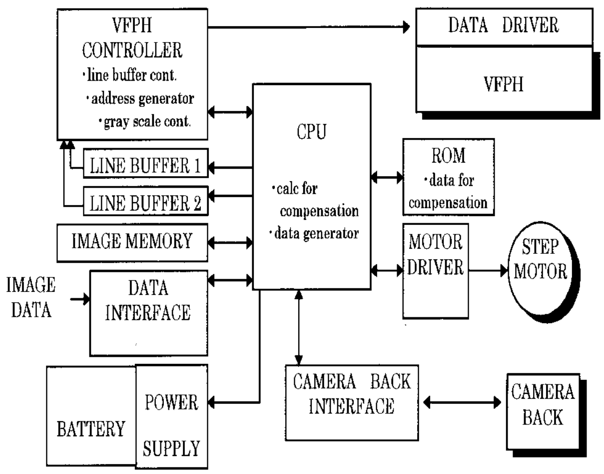

Figure 7 Block Diagram of Printer System

7. Conclusion

Since the power consumption of the VFPH is below 1W, it is possible to use a smaller size of power source which generates less heat, requiring no cooling device. The optical unit was reduced in thickness by the use of SLA and a mirror. The instant film simplified the developing unit, and reduced the total size. The combination of the ZnO:Zn phosphor and color filters produced a print head excellent for the hard copy system using silver halide film.

Acknowledgment

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