Compact Color Hard Copy System Using Vacuum Fluorescent Print Head and Instant Color Film

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Abstract

A compact full color hard copy system using vacuum fluorescent tube and instant color film has been developed. In this system, Polaroid AUTO FILM is used as recording material, and the color vacuum fluorescent print head (C-VFPH) with Red, Green , and Blue filters is used as light sources.

In this paper, first, printer construction and print head are described, and then the color reproduction characteristics of the system is measured and compared with the other printing systems.

Introduction

Various kinds of printers have been developed and widely used in many fields. Qualities of hard copy have been improved greatly. However, almost printer is not compact and it takes much time and cost to get hard copy, particularly in sublimation printer, laser printer and ink jet printer.

Therefore compact printing system was developed to fulfill a need for television picture and computer users. This was made possible by a new vacuum fluorescent print head and instant color film.

In a previous paper, a structure and drive system of the print head have already been reported, in this paper color reproduction characteristics of this printer is mainly introduced and described.

Color Vacuum Fluorescent Print Head

Developed color print head is compact size, it has a width of 40mm, height of 8mm, and length of 150mm. The head is consisted of a vacuum fluorescent tube, Red Green and Blue filters for color separation, and a selfoc lens array (SLA) for imaging as 1:1 ratio from printer head to film as shown in Figure 1. The vacuum fluorescent tube is a front luminous type with flat emission surface. This specific character is significant to eliminate the distortion of image and to provide the space for color filters.

Figure 2 shows the emission pattern layout. An array of square pixels (159µm × 159µm) is formed in the anode electrode. The precisely spaced pixels were created in an aluminum film using a photolithography and the emission pixels are spaced equally in the printing direction. Each RGB component group contains four lines of pixels, and the spacing between each color group is set appropriately to ensure exact overlay of the separate color and is determined by the emission timing.

An image is printed on the film with 160 dpi resolution by transmitting data from the control circuit in coordination with the moving C-VFPH.

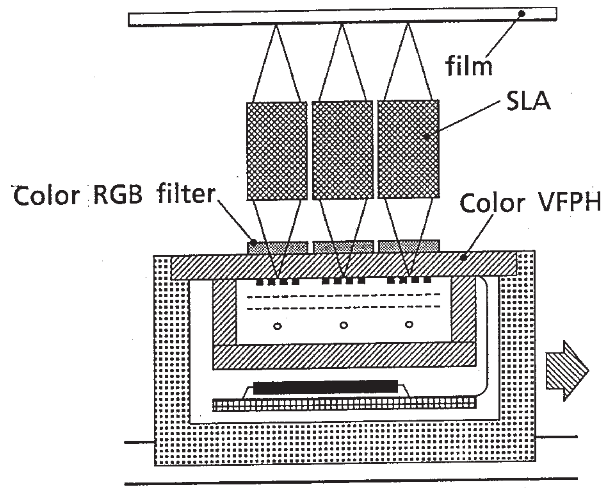
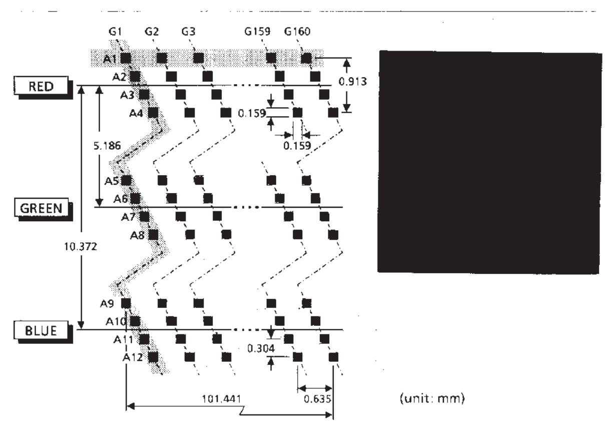


Figure 1. Structure of Color VFPH

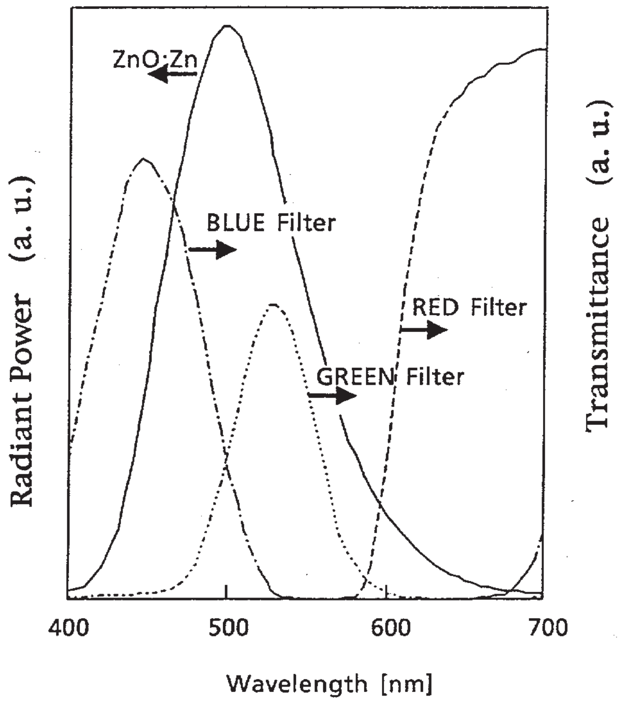


Figures 2. Emission Pattern Layout

Spectral Characteristics of Print Head

Figure 3 shows the radiant power emission curve of phosphor ZnO:Zn and spectral transmittance of Red, Green and Blue filters used in the print head. Since the ZnO:Zn has broad wavelength emission from 400nm to 700nm, therefore it can encompass the spectral sensitivity of photographic film with the combinations of appropriate red, green and blue filters. On the other hand, relationship between radiant excitance (mW/cm^2) from phosphor and anode voltage Eb is approximately linear from 50 V to 300 V as shown in Figure 4. According to this characteristics, it became possible to compensate the intensity distributions of RGB component by adjusting the anode voltage. Figure 5 shows the spectral sensitivity distribution of

Polaroid AUTO FILM and the spectral characteristics of phosphor with r, g, b filters after compensations. The chromaticities of this print head and NTSC receiver primaries are shown in Figure 6 by the points marked (Δ) and (●) respectively. This figure also shows the chromaticities of 6 primary colors of the Polaroid AUTO FILM. It is seen that the chromaticities of printer head and NTSC are approximately same. This means that a similar color correction method from NTSC television picture to film may be applicable in this printing system.



Figures 3. Radiant Power Curve of ZnO:Zn Phosphor and Transmittance of Filters

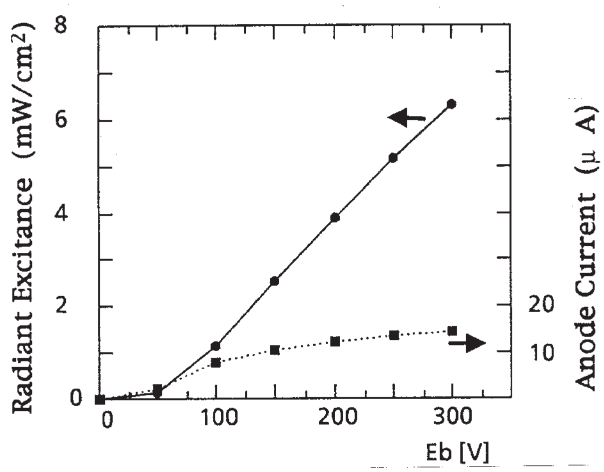


Figure 4. Relationship Between Radiant Excitance and Anode Voltage

Color Reproduction Characteristics

In this printing system, the YIQ signal of NTSC is converted to RGB signal by an NTSC/RGB decoder and then printed to 640 × 400 pixels with 256 levels on the Polaroid film. Color gamut of reproduced image is therefore principally dependent on the recording film.

Figure 7 shows the chromaticity values of 6 test stimuli (cyan, magenta, yellow, red, green and blue) of the image obtained by this printing system. The chromaticity values of offset print image is also shown for comparison. It is clear that the chromaticities of reproduced red, green and blue in this system are approximately same with those obtained images in offset print. However, cyan is more green and of lower purity, magenta is more blue and yel-low is more red and of lower purity. We consider that these are influenced by imperfect adjustment of anode voltage in each RGB component and the difference of RGB spectral response of printer head and spectral sensitivity of instant film.

The problem will be solved with careful adjustment of anode voltage, however, it is necessary to facilitate the operation for color correction.

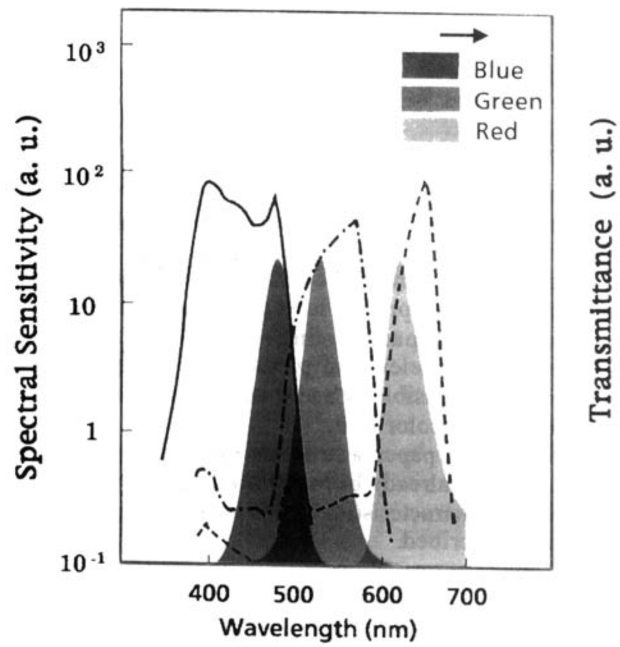


Figure 5. Spectral Sensitivity Distribution of Polaroid AUTOFILM and Spectral Characteristics of C-VFPH

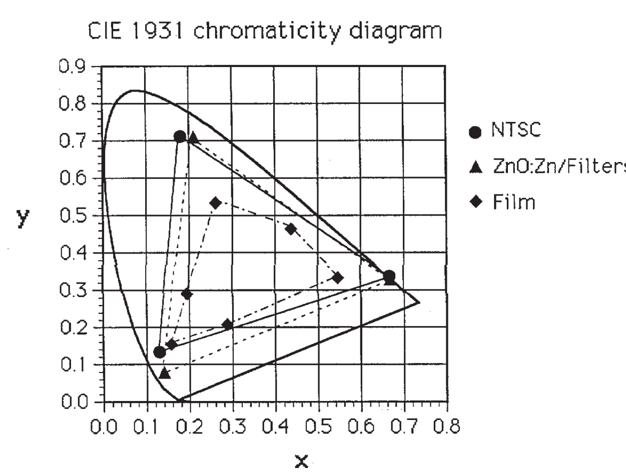


Figure 6. Chromaticities of C-VFPH and NTSC

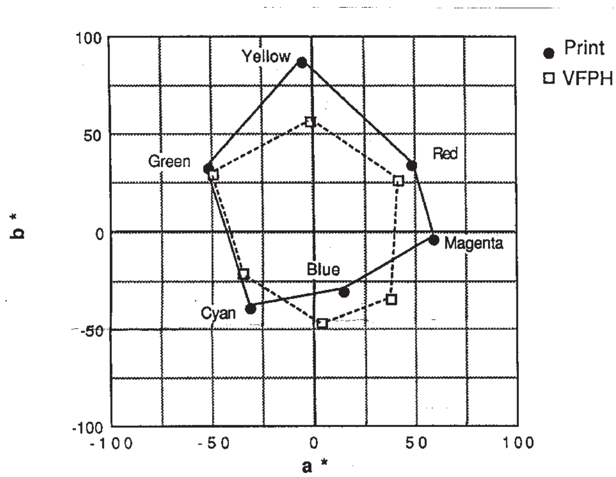


Figure 7. Chromaticity Values of 6 Test Stimuli

Figure 8. Print Sample (Original to be posted.)

Figures 8 and 9 show the printing results on the Polaroid AUTO FILM of 4×2.5 inches (101.6×63 mm). Original picture of Figure 8 is recorded on the Ektachrome 100 sheet film, then the image is digitized to 640×400 pixels at 8bits levels by mechanical scanner. On the other hand, the image shown in Figure 9 is gastric mucous image taken by NTSC video endoscope. Printing speed of this printer is 20 mm/sec, then it takes only 3 seconds for exposure on the film and after the processing of instant color film, we can get full color print.

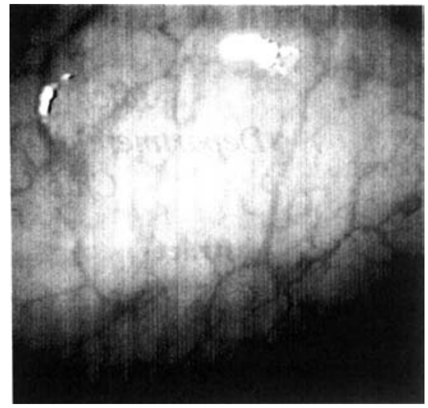


Figure 9. Print Sample (Original to be posted.)

Conclusion

A compact printer using Polaroid instant color film and ZnO:Zn phosphor has been developed. The printer is superior to the other printing systems in cost and speed though there still remains some problems in color reproduction.

As the result, we consider that the developed printer is very useful to get color hardcopy from television pictures, particularly in medical images and other scientific applications for high speed and low cost.

Acknowledgments

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