

Postcard-Size 3D and Moving Image Printing Employing Thermal Dye Transfer Technology

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Abstract

In this paper we describe the development of new 3D and moving image printing technology that employs a specially prepared printer engine, newly developed dye transfer materials and a postcard-size lenticular lens sheet.

This printer engine consists of a flat platen on which the lens face of the lens sheet is fixed, a moving uniaxis stage with high feed precision that holds the flat platen, a printing device with an edge-type line thermal print head and an ink sheet roll, and a laser device for detecting the lens position. The engine is set up so that it is possible to print images onto the lens sheet and detect the lens position by operations carried out on the reverse side of the lens sheet. The line of the print head is parallel to the longitudinal direction of the lens.

The printing process on the lens sheet can be conducted at an actual lens pitch of 503 µm in spite of using a print head with a resolution of 300 dpi. This system allows six different image-signals to be printed within the width of one lens after detecting the lens position.

Postcard-size high-quality 3D images with a high degree of stereoscopic effect and moving images with six different picture frames can be achieved by employing simple printer construction and print processes.

Introduction

The digital imaging world continues to evolve rapidly, with mega-pixel digital cameras (DSCs), becoming increasingly common. A range of printing systems, including conventional photographic systems, are thus required for business and other use.

Conventional mini-Lab-shops in the photofinishing market have been changing into digital mini-Lab-shops. Meanwhile, the image quality level of thermal dye transfer printing and ink-jet printers are about to overtake that of the conventional photography, with the result that business competition between these printing methods is intensifying.

Against this backdrop of accelerating change in the 2D digital imaging business, the demand for 3D images based on simple and instant method is also increasing.

Conventional photographic 3D printing technologies employing lenticular lens with an emulsion layer on the reverse side have a long history of development. The three dimensional print technology combining a lenticular lens with photo-thermographic color images has been also developed. These conventional 3D printings have drawbacks such as the need to use a wet-process in the former and painstaking matching between lens position and 3D signals in the latter.

An instant holographic portrait printing system has also been presented.[1] But this system has a bulky and complex construction, and can not deliver full-color images.

We originally developed a card-size motion image printer (MIP) combining thermal dye transfer printing and lenticular lens[2] and have marketed it, although patent applications of similar concepts concerning this technology have already been made by several companies.[3,4,5] However, we have newly developed a postcard-size 3D and moving image printing employing dye transfer technology with high registration accuracy and incorporating a parallax correction method.

We report here the development of a newer postcard-size 3D and moving image technology (new MIP).

Principle and Constitution of 3D and Motion Image Printing

Fig. 1(a) shows a schematic cross section of the postcard-size MIP printing system for direct printing on the back surface of a lenticular lens sheet by means of thermal dye transfer. Fig. 1(b) shows a schematic cross section of the acrylate resin lens sheet. A dye acceptor layer is coated at a thickness of 7-8µm on the back surface of the lens sheet. The printing system chiefly consists of a printing device with an edge-type thermal print head and ink-roll incorporating a feed and take-up reel, a lens clamping device to fix the lens sheet so that the lens surface faces towards the flat-platen, a moving uniaxis stage with high feed precision holding the flat platen, and a laser device for detecting the lens position. The printing system is set up so that it is possible to print images on the reverse side of the lens sheet after detecting the lens position by operations from the reverse side.

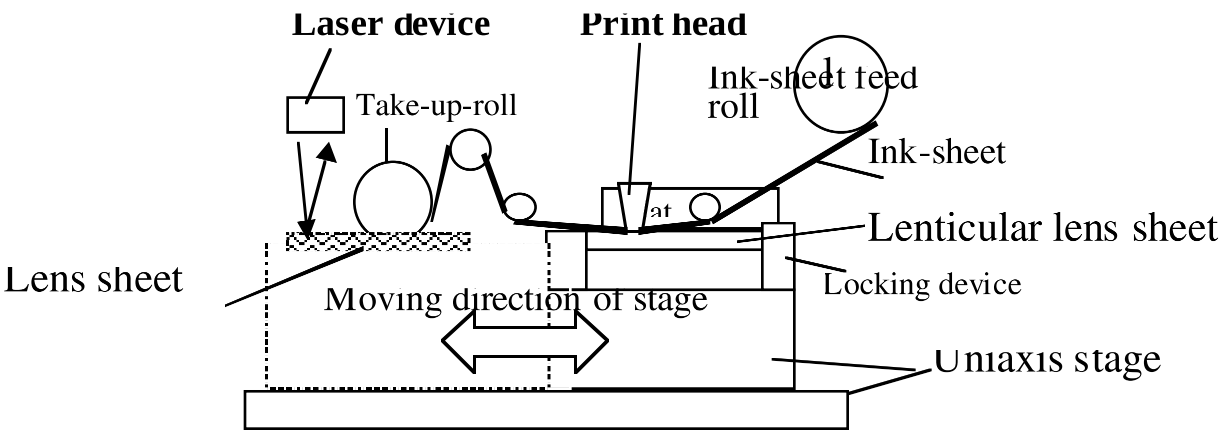

Figure 1(a). Schematic cross section of post-card-size MIP printing system

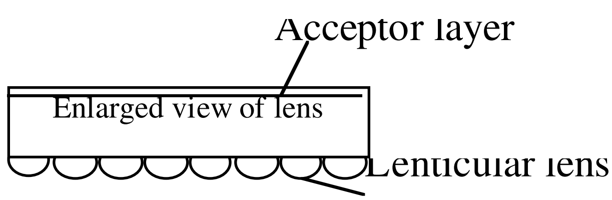

Figure 1(b). Enlarged view of cross section of lenticular lens sheet

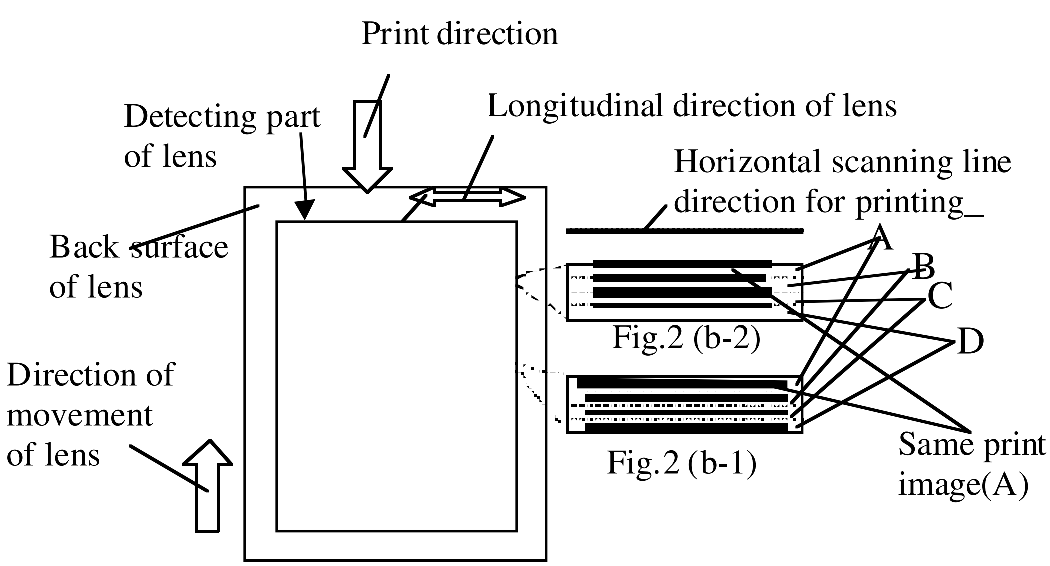

Figure 2. (a) Top view of lens sheet; (b) Relationship between lens position and printed line of dots; (b1) Center part of lens sheet; (b2) Left or right side of lens

Fig. 2(a) shows a top view of the lens sheet, and Fig. 2(b-1) and Fig. 2(b-2) show enlarged views illustrating the relationship between the lens position and the printed dots and lines. The line of the print head is parallel to the longitudinal direction of the lens. The printing process on the lens sheet can be conducted at a lens pitch of 508 µm as a design value, while using a print head with a resolution of 300dpi. This basically allows six different image signals to be printed within the width of single lens.

A semiconductor laser device with a repetition accuracy of 5µm is used to detect the lens position. After analyzing the waveform of first lens of the sheet and determining its position, the lens sheet is moved to the print position.

The uniaxis stage, moving with an accuracy of 0.5µm per pulse, has a positioning accuracy of 10µm within the whole postcard-size lens sheet. A parallax correction method was studied by employing the laser device and uniaxis stage.

Specifications of the print engine are shown in Table 1.

Table 1. Specifications of print engine

Items	Contents
Print head	Edge-type line thermal head. Resolution: 300dpi Heater configuration: 70µm(width) x 140µm(length) Maximum print width: 106mm Printing pitch: 503µm/6 steps (6 horizontal print lines)
Lens sheet	Size: 120mm × 155mm Part forming lens: 94mm × 117mm Lens pitch(designed):508µm Lens direction: perpendicular to longitudinal direction of lens sheet Thickness: 1.44mm Index of refraction: 1.494 Number of lenticular lens: 230 Material: acrylate resin Acceptor Layer on back surface: specially prepared layer, 7-8 µm thick
Print size	104mm × 140mm
Accuracy	Feed revolution: 0.5µm/step Positioning accuracy: ±10 µm within whole lens sheet Registration between lens and printed dot line: ±10 µm Registration between 3 colors: ±10 µm
Laser device	Repetition accuracy: 5µm Minimum spot diameter: 50µm λ max: 670 nm
Ink sheet	Sequential print by primary colors Dye layer: specially prepared Back coat layer: specially prepared
Printing conditions	Printing of only 3 colors of Y, M, and C. Period of print: 20-30ms/ line Gradation: Y, M, C 256 steps

Printing can be carried out using an ink-sheet coated on only primary colors on the dye layer and the heat resistant sliding layer on the other side. A 3D image or a moving image can be observed from the lenticular lens side after being placed on a white plate.

Experimental

The experiments concentrated on the following issues: (1) registration between the lens and printed line of dots, and between the 3 colors, (2) parallax compensation concerning the relative positioning of the lens and printed dots, (3) improvement on the print density.

More specifically in the above-described experiments, improvement of (1) was carried out by focusing on the following details; (a) testing of actual lens pitch, (b) testing of the registration. As for improvement of (2), an optimum correction value for the parallax in terms of the printing pitch over the center position and to left and right of the lens was examined. The improvement of (3) was carried out on the following to obtain a high print density without wrinkles on the printed images caused by dye-transfer-printing on a hard surface such as an acrylate lens-plate ; (a) development of materials most suited for the acceptor layer coated on the back surface of the lens, (b) newly developed heat resistant sliding layer coated on the back surface of the ink sheet, and (c) print conditions such as the print-dividing method of a horizontal and vertical scanning lines.

Results and Discussion

Testing of Actual Lens Pitch

It was found by investigating the relationship between the printed line of dots and the width of the lens that the actual lens pitch was precisely 503µm. Because the lens sheet is fed with high accuracy, accurate positioning of the line of printed dots can be ensured. This allows the actual lens pitch ,which differs from the designed valued, to be interpreted as previously described.

Testing of Registration

Registration between the lens and printed lines of dots, and that between the primary colors within ±10 µm over the whole lens sheet, can be obtained. This can be attributed to the high accuracy of feed and positioning of the uniaxis stage.

Optimum Correction Value For Parallax

It was observed that printing while increasing the feed revolution by 2µm per single lens to match the movement of the lens sheet from the center to the left or right side was important. Using this form of parallax compensation, a highly stereoscopic image and high resolution of different motion images can be accomplished.

Print Density

In general, it is extremely difficult to carry out high density print on a hard surface such as an acrylate plate over a large size using thermal dye transfer. In our experiments, a high reflection density of 2.0 can be obtained without creating wrinkles of the printed images by using the newly developed acceptor layer, which is coated on the back surface of the lens sheet, and a newer back-coated layer of the ink-sheet. The acceptor layer, with a thickness of 7-8µm, consists of compounds containing cross-linked resins possessing an unusual combination of heat resistance and flexibility. The back coat layer provided on the reverse side of the ink-sheet also consists of compounds containing a large number of cross-linked resins.

Moreover, the dividing print of the horizontal and vertical scanning line contributes to maintain the high printing density and decrease the degree of wrinkles of the images. Nevertheless, this type of print dividing method causes a decrease of stereoscopic effect and the resolution of motion images. It is therefore advisable to select a lower division number of divided-printing.

Conclusions

We have developed a new dye transfer printing engine, which we have called the New MIP(Motion Image Printer), that enables the reproduction of postcard-size high-quality 3D images with a high stereoscopic effect as well as moving images with six different picture flames. Printing can be accomplished by using a new printing method with an edge-type thermal print head, a newly developed dye-transfer ink-sheet, a new lenticular lens with its back surface coated with a new type of dye receiving layer, a device detecting the lens position, and high precision feed technology for the uniaxis stage.

References

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