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Proposal of Integrated Light Emitting Device Array with Shift Register

N.Komaba, S.Ohno, Y.Kusuda, Y.Kuroda, K.Yamashita and S.Tanaka

Tsukuba Research Laboratory, Nippon Sheet Glass Co.,Ltd.,
5-4 Tokodai Tsukuba-city Ibaraki 300-26, Japan

We propose two types of new integrated light emitting device array with shift register for photo-printer head. The proposed arrays consist of "SLED" shift register and the light emitting thyristors for printing. In this paper, the type 2 device, which is one of the proposed types and has 12 bits and 62.5 μm-pitch thyristor array, was fabricated and demonstrated. It has wide operating margin, about 2V, and also has 10MHz as the maximum transfer frequency.

1. Introduction

Recently the research of LED photo-printer head has been actively undertaken. The LEDs are driven with the external circuits, so several thousands of bonding wires are needed to connect between LED array and driving IC. Therefore, to reduce the cost and the size of LED photo-printer head, it is very important to integrate the driving circuits and LEDs on the same chip.

In this paper, we propose two types of new integrated light emitting device array without the external driving circuits, which consists of "SLED" shift register and light emitting thyristors. The SLED, self-scanning light emitting device, consists of the pnpn thyristors whose gates are connected one another through the resistor network or the coupling diodes, and it is known to act as an optical shift register.[1)-3)]

The newly proposed device array has some merits as compared with the conventional LED array. It does not need the external driving circuits, so the numbers of bonding wires are remarkably decreased. Therefore, we can reduce the cost and the size of LED photo-printer head, and also the fine one can be realized.

2. Operation principle of the SLED

Fig.1 shows the equivalent circuit diagram of SLED, which consists of the light emitting thyristors with pnpn structure (T(1)-T(5)), the two transfer clock lines ϕ_1 and ϕ_2, the coupling diodes D_C and the

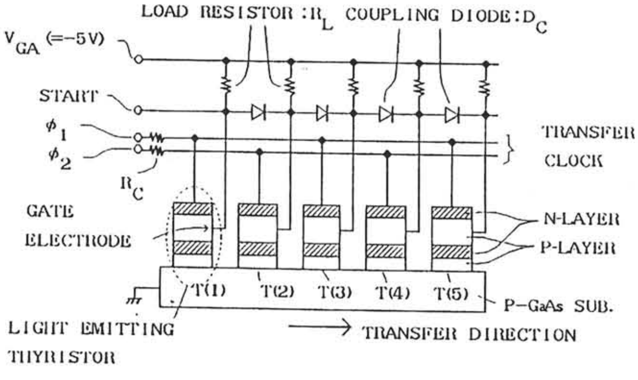

Fig.1 Equivalent circuit diagram of SLED

gate resistors R_G. V_{GA}(=-5V) is the bias voltage.

The cathode turn-on voltage is nearly equal to V_G-V_{dif}, where V_G is the gate potential and V_{dif} is the diffusion potential. When the thyristor T(2) is at ON-state with the low-level of clock ϕ_2, the gate potential is nearly equal to the anode potential. By the current flowing through the coupling diodes, the gate potentials of right-hand side thyristors are raised up. The next low-level clock pulse ϕ_1 after ϕ_2 is applied to cathodes of T(1), T(3) and T(5), simultaneously. The appropriate low voltage of ϕ_1 can be turned-on only T(3), utilizing the differences of the gate potential among T(1), T(3) and T(5). Therefore, the ON-state can be transferred to right-hand side by the two-phase transfer clock pulse.

3. Proposal of new integrated light emitting device array

We propose two types of new integrated light emitting device array for LED photo-printer head, which are named here as type 1 and type 2. The features of each device array are summarized in Table 1.

3-1 Type 1 device

Fig. 2 shows the equivalent circuit diagram of type 1 device array. A bit of this device array consists of two thyristor elements of SLED shift register and a light emitting thyristor for printing which corresponds to a pixel of LED array.

The printing data, synchronized with transfer clock pulse ϕ_1, are transferred and kept on the SLED shift register as the pattern of ON-states. By the next pulse ϕ_I, these data are transferred to light emitting thyristor array and can be written into the photoconductor drum.

3-2 Type 2 device

Fig. 3 indicates the equivalent circuit diagram of type 2 device. Transferring "ON-state" of SLED shift register addresses the light emitting thyristors, which are turned-on by applying the pulse ϕ_I synchronized transfer clock. The emitting light intensity can be modulated by the current control of the pulse ϕ_I.

In this type, only one light emitting thyristor can be turned-on at the same time. Therefore, the light emitting duty is 1/128, in case the device array has 128 light emitting thyristors for printing.

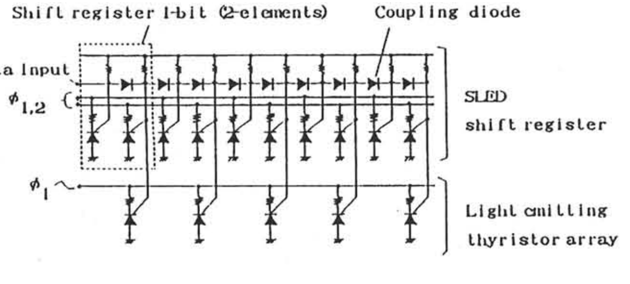

Fig.2 Equivalent circuit diagram of type 1 device

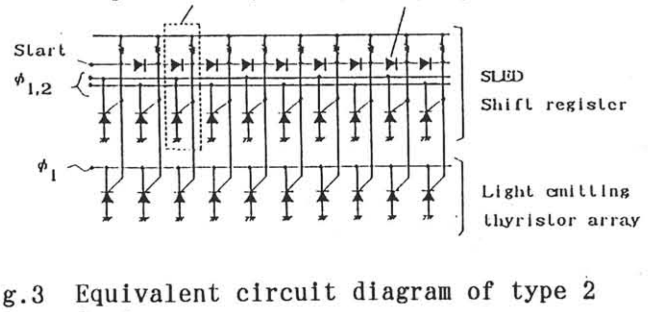

Fig.3 Equivalent circuit diagram of type 2 device

Table 1 Features of new device array

	Type 1	Type 2
Number of emitting bits at the same time*1	128	1
Function*2	S,L,E	S,E
Duty*3	1/2	1/128
Intensity control	digital	analog
Thyristor numbers of 1 bit	3	2

*1)This comparison is based on the assumption that 1 array has 128 bits.
*2)S:shift register, L:latch and E:light emitting.
*3)The duty:1/2 depends on the share between the data transferring time on the SLED and the light emitting time for printing.

4. Fabrication and demonstration

We fabricated 12 bits and 62.5 µm-pitch type 2 device array and demonstrated the fundamental operation.

4-1 Fabrication

The process flow of type 2 device is shown in Fig. 4. The fabrication process consists of 8 photolithographic steps. The pnpn-GaAs epitaxial film is grown by the MOVPE method and has double hetero-structure listed in Table 2.

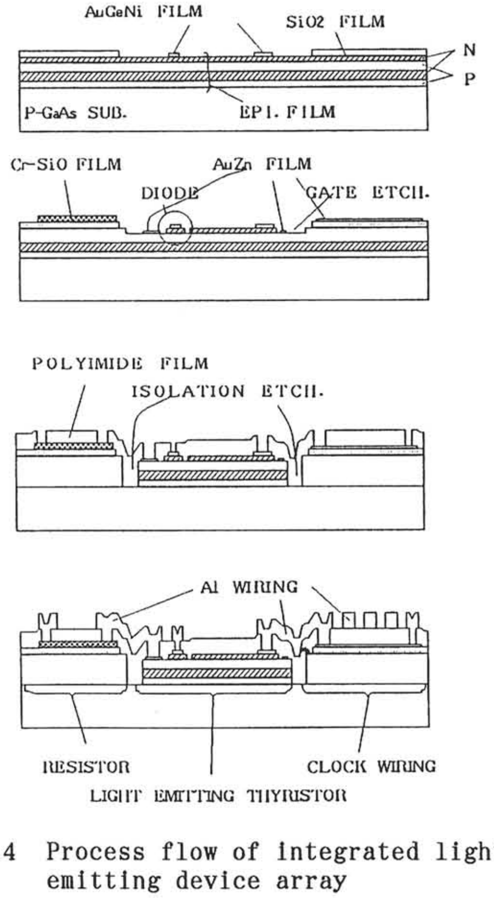

Fig.4 Process flow of integrated light emitting device array

Table 2 Structure of the epitaxial film

Layer	Type (μm)	Thickness (cm^{-3})
6th n-GaAs	0.15	$2x10^{18}$
5th n-$Al_{0.3}Ga_{0.7}As$	0.40	$3x10^{18}$
4th p-GaAs	1.0	$1x10^{17}$
3th n-GaAs	0.30	$1x10^{18}$
2nd p-$Al_{0.3}Ga_{0.7}As$	0.42	$1x10^{18}$
1st p-GaAs	0.50	$2x10^{18}$
sub.p-GaAs	450	$1x10^{18}$

4-2 Demonstration of fundamental operation

Fig. 5 shows the photomicrograph of the fabricated type 2 device array, which consists of 12 bits light emitting thyristor array for printing, SLED shift register, and transfer clock lines. The gates of SLED shift register are connected by the resister network. Fig. 6 indicates the CCD image of operating type 2 device, whose light emitting thyristors emit alternately.

We can demonstrate that the fabricated type 2 device has two functions of shift register and light emission for printing. Its operating margin is about 2V and its maximum transfer frequency is 10MHz.

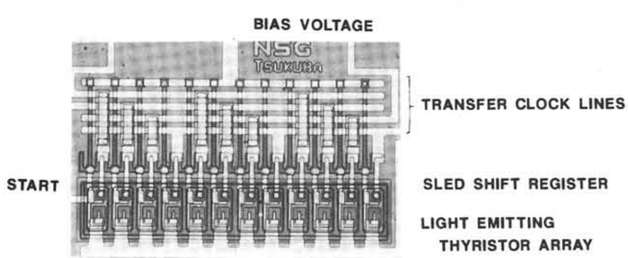

Fig.5 Photomicrograph of type 2 device. The gates are connected one another through the resistor network.

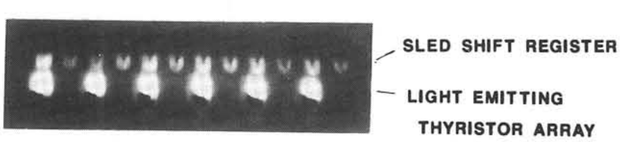

Fig.6 Photograph of CCD image of transferring type 2 device. Light emitting thyristors emit alternately.

5. 64 bits SLED shift register

We fabricated 64 bits SLED shift register for the first step to the realistic integrated light emitting device array and demonstrated its transfer action. Fig. 7 and 8 show the photomicrographs of 64 bits SLED shift register and its CCD image of the operation, respectively.

Also, the 800DPI and 32 bits fine pitched SLED shift register was fabricated and demonstrated.

6. Conclusion

In order to realize the compact and fine LED photo-printer head, two types of new integrated light emitting device array was proposed. Type 2 device, which has 12 bits and 62.5 μm-pitch, was fabricated and its operation was successively demonstrated. Also, the 64 bits SLED shift register was fabricated. The light emitting device array integrated with the SLED shift register does not need the external driving circuits. Therefore we can realize the compact and fine LED photo-printer head.

Reference

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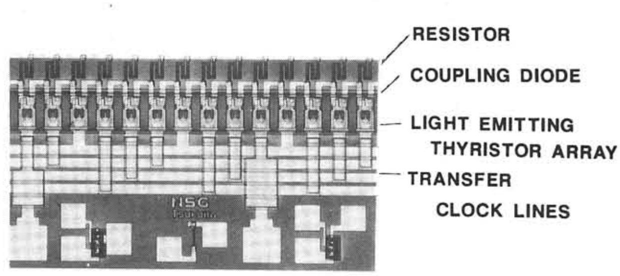

Fig.7 Photomicrograph of 64 bits and 240DPI SLED

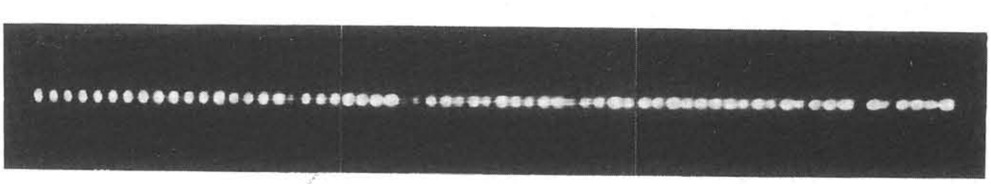

Fig.8 Photograph of CCD image of transferring 64 bits SLED