Development of Low-Cost and Narrow-Border Automotive Panel by DeMUX of IGZO-TFT

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Abstract

We have developed a high-mobility, highly reliable IGZO-TFT, and have achieved higher definition and narrower border for medium-sized displays such as tablets and notebook PCs. This time, we have developed BCE IGZO-TFT that satisfies DeMUX in order to narrow the frame at the bottom of automotive displays, which has been difficult until now. High mobility is required to realize DeMUX. To achieve this, we added an extra metal layer to the conventional BCE structure TFT, creating a Double Gate structure. In addition, by using DeMUX, we were able to reduce the cost by reducing the source driver to a single chip.

Author keywords

IGZO; Oxide TFT; BCE; Double Gate; DeMUX; narrow border; in-vehicle; automotive; Incell-TP;

1. Introduction

Recently, the technology of self-driving cars has advanced, and cars are becoming more than just a means of transportation, but also a place for entertainment, such as enjoying watching movies inside the car. Since it has an entertainment aspect, it is natural that the display must also have touch panel performance. In addition, there is an increasing trend of replacing side mirrors with cameras and checking the information on the display inside the car, and the demand for car displays is increasing at an accelerating pace.

However, since there is only limited space inside a car, good design performance is required, such as making the hidden area as small as possible. Design performance is also extremely important in the sense that it must harmonize with the interior environment of the car. There is also a concern that the cost will increase as the number of displays increases.

In order to solve these problems, we proceeded with the development of an automotive panel equipped with DeMUX. By using DeMUX, the bottom border, which is the largest non-display area of the display, can be made narrower. Additionally, by adopting DeMUX, the number of source drivers can be reduced, resulting in cost savings.

In terms of cost, we used IGZO TFT this time. Compared to LTPS, IGZO can be manufactured in large areas such as G8 size, and has fewer layers. In this respect, it is possible to reduce costs.

We have developed a narrow bottom border display equipped with 4DeMUX using IGZO TFT, and have confirmed the effectiveness with an actual display.

2. DeMUX technology

Narrower borders on the left and right sides of the display have been achieved by downsizing the GIP (Gate driver In Panel). On the other hand, narrowing the border at the bottom of the display can be achieved by using DeMUX technology.

Fig.1 shows the circuit diagram of DeMUX.

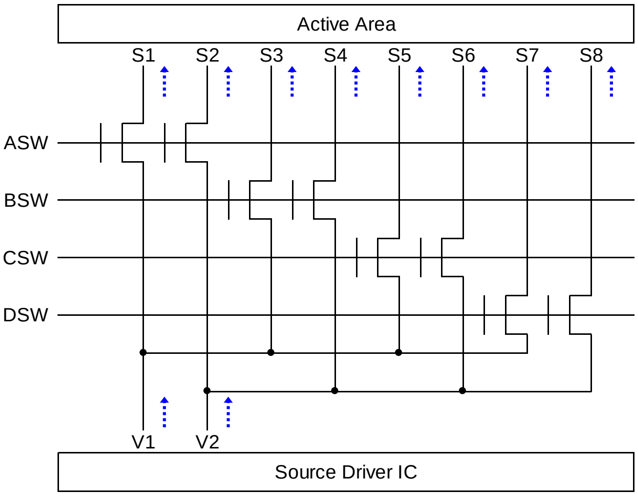

Figure 1. DeMUX schematic

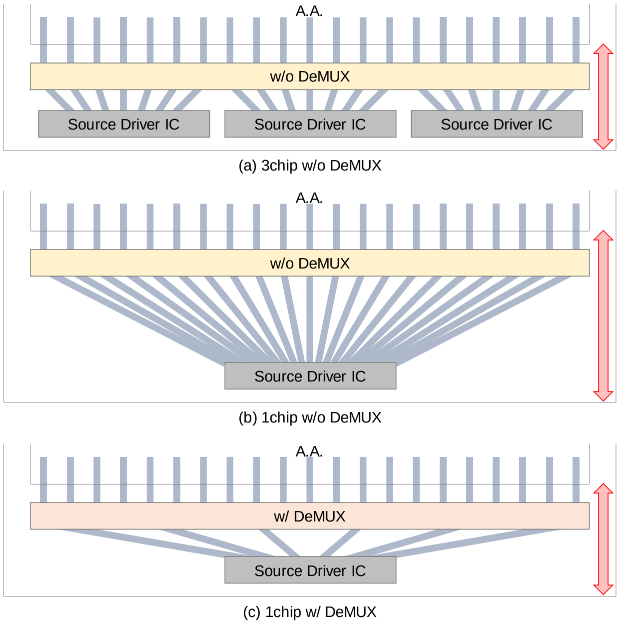

Figure 2. Narrowing the border with DeMUX (a)3chip w/o DeMUX (b)1chip w/o DeMUX (c)1chip w/ DeMUX

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Here, a 4DeMUX structure is used that divides the output signal of the source driver IC into four parts. Switching is performed using four transistors with the SW wiring (ASW/BSW/CSW/DSW) as the gate. In this time, we adopted 4DeMUX to achieve both single IC chip and narrower bottom border in the resolution of common automotive panels (1920*720). By using 4DeMUX, the number of source bus lines is reduced to 1/4, and by reducing the number of wires to the source driver IC, it is possible to achieve a narrower border at the bottom as shown in Fig.2.

Conventionally, multiple source drivers are arranged on a panel, as shown in Fig.2(a). If the number of source drivers are reduced, the bottom border will become larger as shown in Fig.2(b). Since different signals are input to the source signals, a space is required between adjacent wiring lines. If the space between the wires is prepared for the number of wires, the bottom border will become larger in the vertical direction, as shown in Fig.2(b). By adopting DeMUX, the number of wires from the source driver can be reduced as shown in Fig.2(c), so the number of spaces between wires can be reduced and the bottom border can be made smaller. By using DeMUX, it is possible to reduce the number of source drivers and narrow the border.

However, on the other hand, since the signal is divided into four parts and switched using four transistors with the SW wiring (ASW/BSW/CSW/DSW) as the gate, it is necessary to charge “the high-load wiring” in “a short time”, resulting in high Ion is required. The timing chart of 4DeMUX is shown in Fig.3. The source signal (A) 1H consists of (B) the charging time of the source bus line and picture element TFT, (C) the fall time of the DeMUX SW, and (D) the fall time of the gate signal. 4DeMUX divides the output signal of the source driver IC into four parts, so the time spent charging the source bus line is reduced to about 1/4 compared to when there is no DeMUX. Table.1 shows the 1H time (Fig.3(A)) and charging time (Fig.3(B)) for a 12.3-inch 1920*720 resolution panel, which is a common automotive panel.

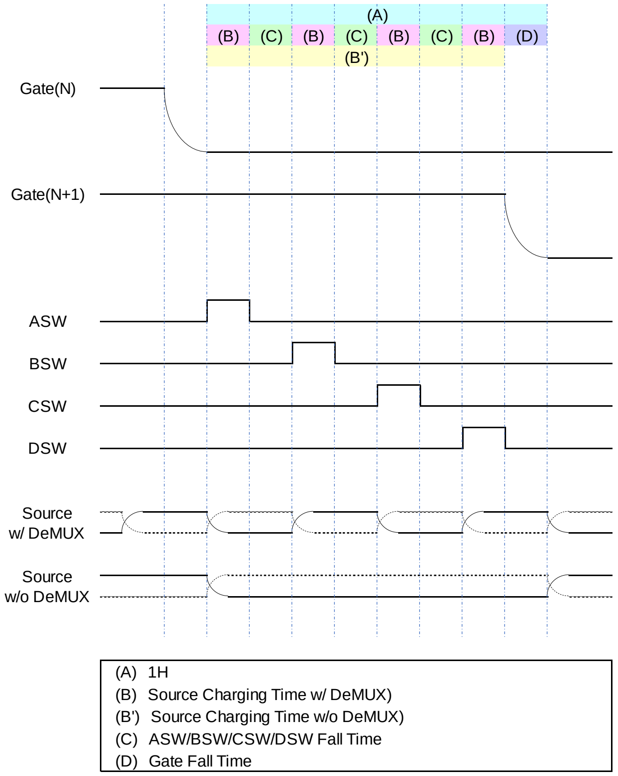

Figure 3. 4DeMUX timing chart

Table 1. 1H time and charging time

	w/o DeMUX	2DeMUX	3DeMUX	4DeMUX
Charging time (Fig.3(a))	16.7 μsec	7.5 μsec	4.7 μsec	3.2 μsec
1H time (Fig.3 (b))	17.8 μsec	17.8 μsec	17.8 μsec	17.8 μsec

The above calculation includes In-cell TP (Touch Panel). It is also necessary to take time to drive the touch panel, and this time we are expecting 5μsec. As a result, the 1H time is shorter. Among them, 2DeMUX, 3DeMUX, and 4DeMUX reduce the number of wires from the source driver and make a greater contribution to narrowing the frame, but the time available for charging decreases accordingly, and 4DeMUX has only 3.2μsec. It is necessary to charge the source bus line within this short period of time.

3. BCE IGZO-TFT and Double Gate structure

In order to realize 4DeMUX, that is, to charge the source bus line in a very short time of 3.2μsec, it is essential to increase the current of the DeMUX-TFT. This was achieved by adding M3 metal to the conventional BCE type TFT (IGZO5) and using it in the Double Gate structure. Its structure is shown in Fig.4 and Fig.5.

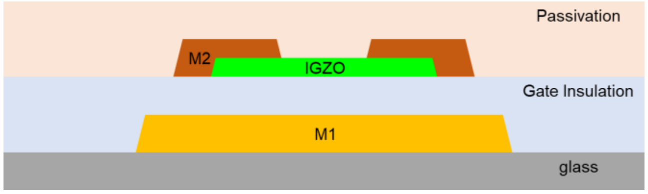

Figure 4. conventional BCE type TFT

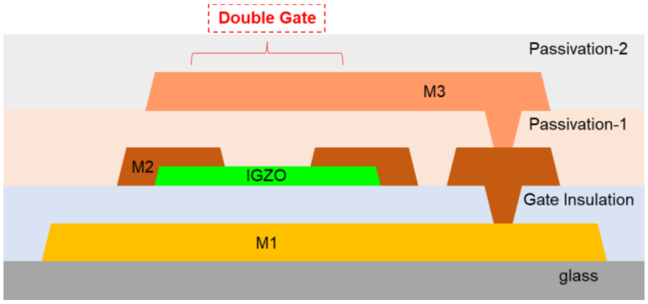

Figure 5. Double Gate structure using M3 metal

By using M3 metal as the top gate and making the transistor a double gate, we were able to increase the current. The TFT characteristics are shown in Fig.6.

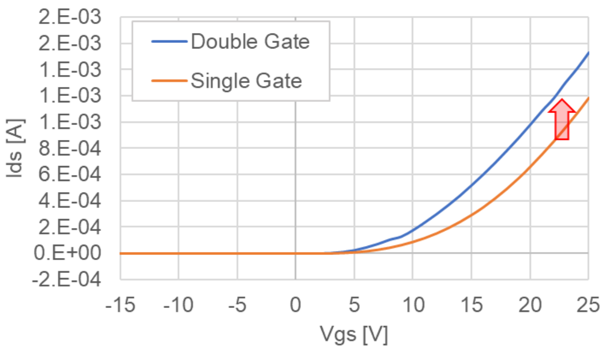

Figure 6. Characteristics (Single Gate vs Double Gate)

By changing the conventional structure of Single Gate to Double Gate, the mobility increased by about 25%.

4. Simulation

As mentioned above, using DeMUX makes charging difficult. However, by converting the DeMUX transistor into a Double Gate, the mobility is improved and the charging rate is also improved.
Fig.7 shows the results of a source bus line charging simulation when using Double Gate transistors in DeMUX.

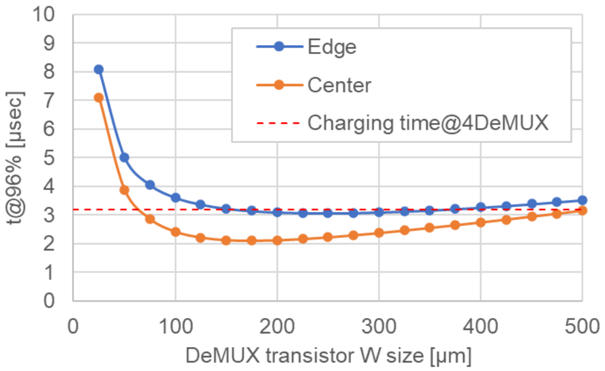

Figure 7. Simulation of source bus line charging

The simulation confirmed the operation after 1000 hours at 85℃. We are assuming a 12.3-inch/1920*720/In-cell TP panel, and have confirmed the time it takes for the charging rate on the opposite side of the source bus line to reach 96%. In this case, as shown in Table.1, it is said that it will operate normally if it can be charged within 3.2μsec. According to the results in Fig.7, the operation of DeMUX is valid if W=200μm.
Note that the difference between the center part and the edge part of the panel is because of the difference in the load outside the A.A., not within the A.A. of the panel. As shown in Fig.8, this is due to the difference in the length of the A.A. external wiring between the center and edge of the panel. As the load becomes larger, charging at the edge becomes more difficult.

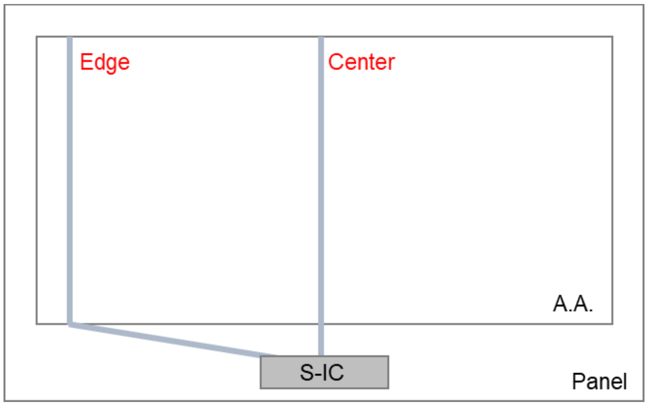

Figure 8. Load inside the panel (center vs edge)

Also, as shown in Fig.7, the W size of the optimal DeMUX transistor has a minimum value. This is due to the load on the transistor itself. As the W size becomes smaller, Ion becomes smaller and charging of the source bus line becomes more difficult, but the load on the DeMUX transistor itself hanging from the SW wiring becomes smaller. As the W size increases, Ion increases, making it easier to charge the source bus line, but conversely, the load on the DeMUX transistor itself that hangs from the SW wiring increases, which is a disadvantage. Due to the influence of ion and load, the W size has a minimum value. Of course, in terms of layout, the smaller transistor size is better for the width of the border. If the DeMUX transistor size is small, the load on the SW wiring will be small, which will also reduce power consumption.
The mobility dependence of the W size required for a DeMUX transistor is shown in Fig.9.

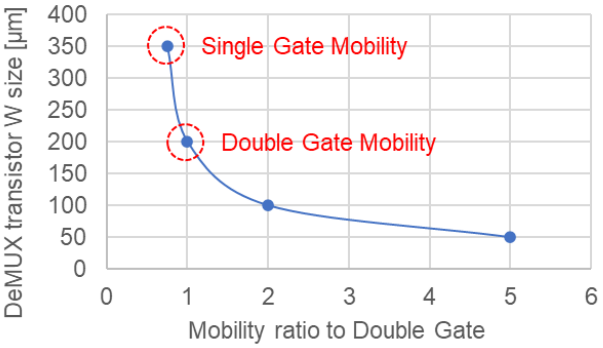

Figure 9. Mobility dependence of DeMUX transistor size

In Fig.9, the DeMUX transistor size required for DeMUX operation is calculated based on the Double Gate mobility and multiplying it by 2 or 5 times. The effect of increasing mobility is large up to about twice that, but beyond that the effect on transistor size becomes limited. On the other hand, the mobility of Single Gate is about 0.75 times that of Double Gate, but in that case W=350μm, which has a large effect on the transistor size and makes it impossible to fill the desired lower border. The effect of changing from Single Gate to Double Gate is very large.
The load capacity dependence of the source bus line is as shown in Fig.10.

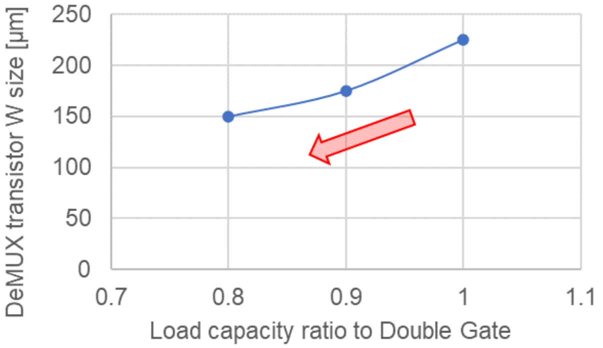

Figure 10. Load dependence of DeMUX transistor size

The source bus line running to A.A. has wiring such as a gate bus line and a load capacitance Cs. These are the results of the DeMUX transistor size when the source bus line load capacitance is reduced to 0.9 and 0.8 times compared to the reference. As shown in Fig.10, the transistor size can be reduced by reducing the load capacity. In the future, it will be important to reduce this load capacity in order to further narrow the frame.

5. Actual display evaluation

Based on the above results, we prototyped a narrow border automotive panel equipped with 1chip 4DeMUX. Fig.11 shows the specifications and the actual panel when lit.

Display Size		12.3inch 1920(RGB)*720
TFT		IGZO
Gate		GIP
Source		4DeMUX 1chip
Border	L/R	2mm
	Bottom	6.8mm
Frequency		60Hz
Touch Panel		Incell-TP
Vgp-p		28V

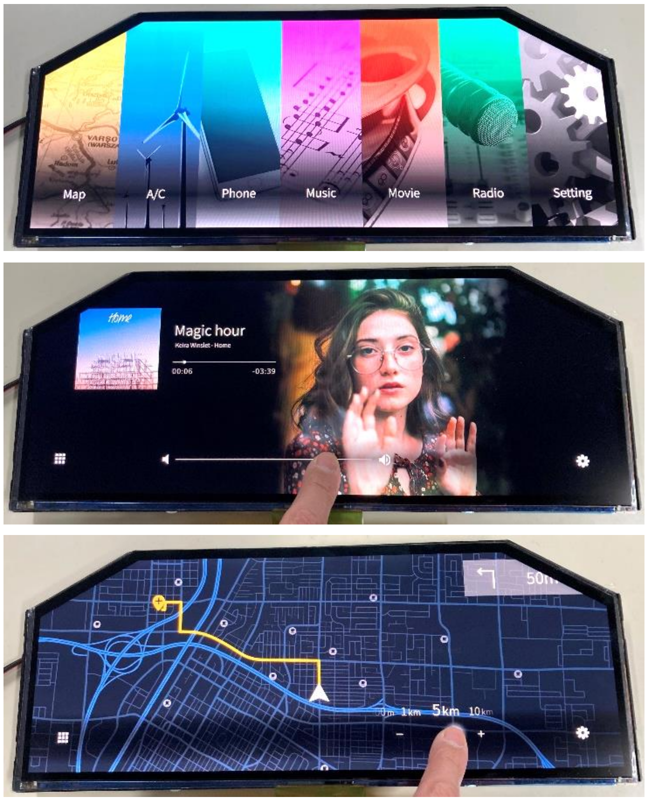

Figure 11. Narrow border panel with 1chip 4DeMUX

Various display patterns such as a white screen and a monochrome screen are lighting up normally, and the touch panel is also operating normally. Fig.12 shows the brightness evaluation results.

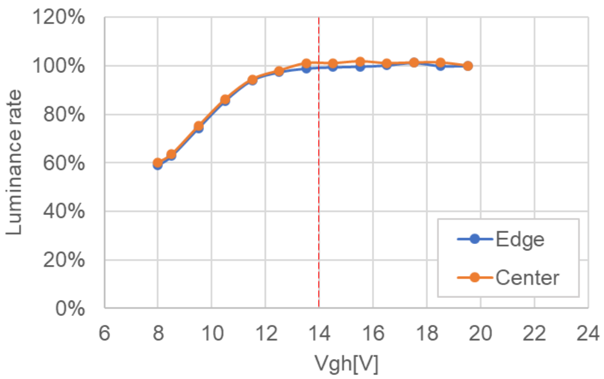

Figure 12. Brightness evaluation results of actual panel

There is almost no difference in brightness between the center and edge of the panel, and there is no haze. If Vgh is 14V or higher, it can be seen that the source bus line can be charged without any problems.

Fig.13 shows the results of module aging.

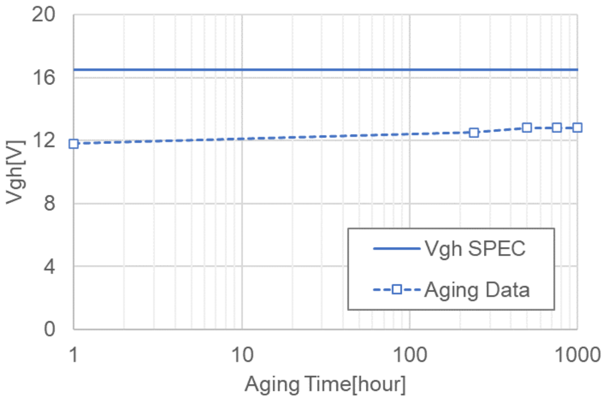

Figure 13. Module aging results

The aging condition is 70 degrees DRY. The panel surface temperature is set to 85 degrees. It cleared 1000 hours, and it was confirmed that there were no problems with the module reliability.

6. Conclusion

This time, we have developed BCE type Double Gate IGZO-TFT, which has significantly increased TFT current compared to the conventional BCE type Single Gate IGZO-TFT, and have successfully produced a prototype of a narrow border automotive panel equipped with 1chip 4DeMUX. Both the display and touch panel have been confirmed to work properly. Using a new M3 metal compared to the conventional process, we achieved 4DeMUX by improving mobility with the Double Gate structure, and succeeded in producing an automotive panel with a single chip and a narrower border.

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