Electrical stimulator based on high power transistor array for tactile sensation *

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I. Introduction

The use of electrical stimulation is an attractive approach for generating haptic sensations due to its potential for diverse sensations, compact size, and low power consumption. However, current electrical stimulators face limitations in spatial resolution due to electrode and contact line density. In this study, we introduce a new type of stimulator structure with active matrix design employing transistor to achieve higher electrode density [1][2][3].

II. Results

To generate artificial tactile sensations using electrical stimulation the operating voltage is not low, ~ 50V. Although the driving voltage depends on the impedance of electrode or design of stimulator structure such as shape of ground electrode, it is not easy to decrease under 50V due to high impedance of finger skin. The other issue of stimulator is electrode density. The easiest and the common design of stimulation electrodes is dot matrix array (Fig.1.a). However, it is hard to achieve high electrode density using dot matrix because of high number of contact electrode lines. One of ideal solutions is active matrix (AM) design with transistor array. Unfortunately, the electrical stimulation conditions, nearly 1mA with 50V, are so severe for a general transistor system. To overcome this obstacle, we studied thin film transistor (TFT) system employing Indium Gallium Zinc Oxide (IGZO). By employing an AM structure (Fig. 1. (b, c)), we were able to reduce the number of contact lines from 64 to 16 compared to a dot array. This stimulator is expected to enhance spatial resolution in electrical stimulation based on the basic principle of transcutaneous electric nerve stimulation (TENS).

The electrical stimulator was designed with 64 stimulation sites in a compact area of 1.1 x 1.1 cm by utilizing 8 gate lines and 8 drain lines (Fig. 2). To achieve the 1mA and 50V, we investigate the voltage endure property by channel length from 5μm to 100μm. All of length can endure the stress, and then we chose it as 5μm for high current flow. We increase the W/L from 20 to 4200 with comb like shape for the compact size. The full structure of the stimulator and individual TFT structure are shown in Fig. 2. The electrical characteristics of the individual TFT with 30kΩ are presented in Fig. 3. The current level can be effectively modulated by varying the gate voltage(V_g) level. Moreover, the output current over 1mA indicates that the current level is enough for stimulating fingertips which is confirmed by perception test. The changes of resistance are shown in Fig. 3 (c) for various situations. The TFT performs well as switch. However, it shows negative shift characteristics with negative voltage of drain(V_d), and therefore, it should be considered when V_{off} is chosen.

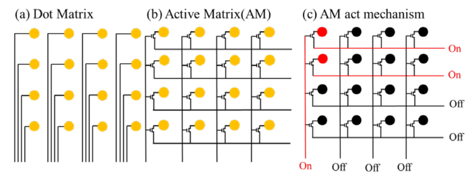

Figure 1. Structure of (a) dot matrix (b) active matrix and (c) acting mechanism of AM structure.

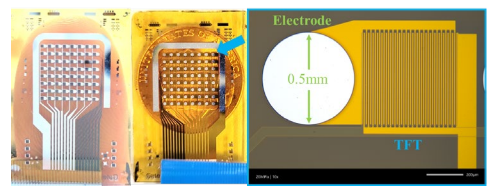

Figure 2. (left) full structure of stimulator (right) enlarged TFT picture.

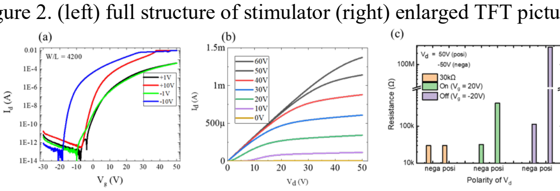

Figure 3. (a) Transfer curve (b) Output curve (c) Resistance with 30kΩ

III. Conclusion and Future plan

In this paper, we presented a new electrical stimulator design with an AM structure, which has the potential to provide higher spatial resolution tactile sensation to subjects. We found that when the stimulation location is changed, the stimulation voltage and sensation get different. To solve this problem, we plan to fabricate more transparent stimulator to align the location by fingerprint. These next steps will help us gain a better understanding of the capabilities of this stimulator and its potential for use in future applications.

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