Extended Abstracts of the 2015 International Conference on Solid State Devices and Materials, Sapporo, 2015, pp814-815

Electronic Device from TFT Display for Applications on Biological Cells.

Agnès Tixier-Mita [1,3], Satoshi Ihida [2], Bertrand-David Ségard [4], Grant A. Cathcart [1],
Takuya Takahashi [1], Hiroyuki Fujita [3], and Hiroshi Toshiyoshi [1,3]

The University of Tokyo,
[1] Research Center of Advanced Science Technology;
[2] Institute of Industrial Sciences
[3] Center for International Research on Micronano Mechatronics / Institute of Industrial Sciences;
[4] Laboratory for Integrated Micro-Mechatronics Systems / CNRS-IIS (UMI 2028);
4-6-1, Komaba, Meguro-ku, Tokyo 153-8505, Japan.
Phone: +81-3-5452-5131 E-mail: agnes@iis.u-tokyo.ac.jp

Abstract

This paper presents results on the investigation of Thin Film Transistors (TFT) substrates, coming from Liquid Cristal Display panels, for biological cells electrical manipulation, sensing and studies. TFT technology allows to fabricate very large and dense arrays of independent and transparent micro-electrodes on glass substrates. This dense array of micro-electrodes has been used for dielectrophoresis experiments, pH sensing and impedance measurements on yeast cells.

1. Introduction

Thin Film Transistors technology has long been the technology used for Liquid Cristal Displays panels. This technology knew a great improvement at the beginning of the 80's thanks to the development of hydrogenated amorphous silicon (a-Si: H), which improved drastically its stability and characteristics, letting Active Matrix (AM) LCDs production becoming possible [1]. In AM LCD technology, or TFT LCD technology, each pixel is attached to one transistor which actively controls the pixel state, independently from the others. This technology allows fabrication on any kind of substrate, in particular on glass, which is a key substrate for display application.

Beyond LCD development other applications have been investigated since 20 years, in areas as different as: microelectronic devices (memory [2]), chemical sensing (pH [3], gas [4]) or bio-chemical sensing [5]. For this last field, Organic Thin Film Transistors, OTFT, have played an important role [6]. However, their fabrication, stability in air and large driving voltage make their use quite challenging.

Each pixel in TFT LCD devices can be considered as one electrode controlled by one transistor. If the electrodes are made in Indium Tin Oxide (ITO), the system is almost completely transparent. Such structure is of great interest for biological research on cells, because of the transparency of the device (for observation with inverted microscope), the dimensions of the micro-electrodes, close to the one of cells, the possibility to activate individual electrodes anywhere on the device to electrically interact with cells anywhere wanted. Finally, the stability of the fabrication technology is no more to be demonstrated.

TFT substrates can then be considered as advanced Multi-Electrode-Arrays with an additional advantage that sensors can also be integrated on the substrate.

This article presents results from our group on the usage of TFT substrates for biological cells applications.

2. TFT substrates.

The TFT substrates used in this research are obtained by separating the upper glass of a TFT LCD panel for smart phone from the lower glass. This is the lower glass which is used here as a substrate, as it contains the array of micro-electrodes. The details of the structure has already been presented in [7]. To summarize, the TFT substrate consists in a dense array of transparent micro-electrodes, few 10 μm in width per more than 100 μm in height, each of them being controlled individually by one transistor. Figure 1 shows a close view of the micro-electrodes array.

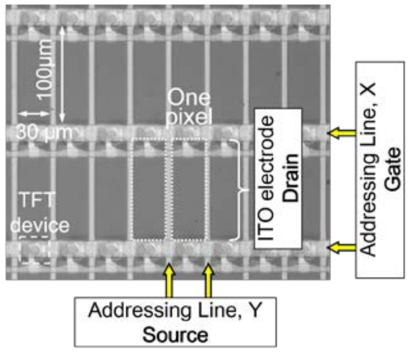


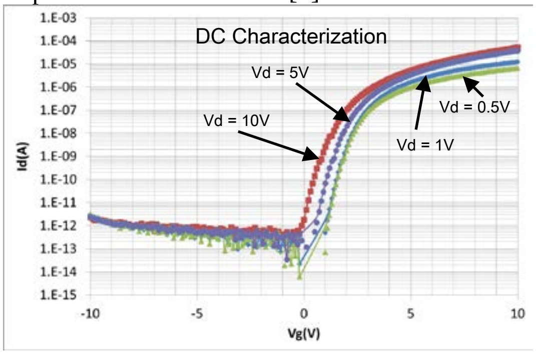
Fig. 1: Close view of a TFT substrate.

3. Electrical characterization of one TFT.

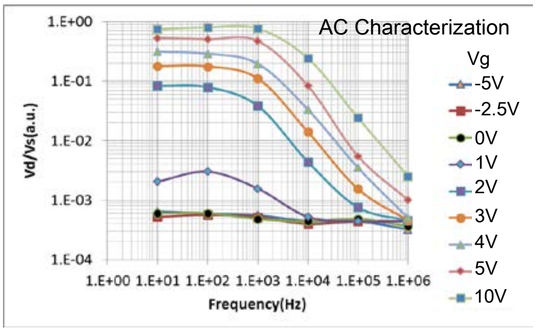
Figure 2 presents the DC and AC electrical characterization of one TFT. For AC characterization, the graph shows that from 1 kHz, there is a clear attenuation of the signal amplitude with increasing frequency.

4. TFT substrates used for cells biology culture and analyses.

Experiments of bio-compatibility of the substrates was conducted, demonstrating the good bio-compatibility with fibroblast cells, primary brain neurons from chick, as well as liver cells. Adhesion of these cells on the substrate has to be improved however. These results have been partially published in [7]. The possibility to attach a micro-fluidic device in PDMS on top of the surface as well as observation through the substrate with a fluorescent inverted microscope were also confirmed [7].



a)



b)

Fig. 2: DC and AC characterization of one TFT.

5. TFT substrates used for electrical manipulation of micro-beads and yeast cells.

TFT substrates have been used for electrical manipulation of micro-beads and yeast cells, using dielectrophoresis (DEP) technique. These experiments have been published in [7]. The experiments showed that micro-beads presented negative DEP, while yeast cells presented positive DEP, at 100 kHz. Vg = 1 to 3V, Vs = 3 to 4V. Electroporation and electrofusion are under investigation.

6. TFT substrates used as sensors.

Investigation on the possibility to use TFT substrates as sensing areas have been conducted.

pH sensing

pH sensing has been performed by measuring the Id(Vg) curve at pH 7 and pH 9, with Vg = 5V and Vd = 0.5V. A clear shift in the measured current can be observed on Fig. 3, demonstrating that the substrate could be used for pH sensing.

Impedance Sensing

Impedance measurement is an important parameter when working with biological cells, as the impedance of the cells depend on: their number, their size, their morphology, their type, the condition of their membrane, etc.

On Fig. 4, impedance in between two electrodes has been measured with only DIW and with a solution of 1% of yeast cells. Impedance clearly increases with the presence of yeast cells.

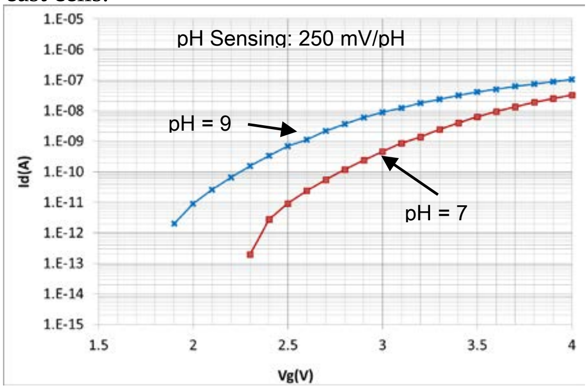


Fig. 3: Id(Vg) graph of a transistor for pH 7 and pH 9 showing that the characteristics is changing with the pH.

The measurement is performed in AC. One electrode is put on ON state, with Vg = 10V and Vd = 1V. Impedance is measured between the electrode on ON state and the neighbor one with an LCR meter, Agilent E4980A.

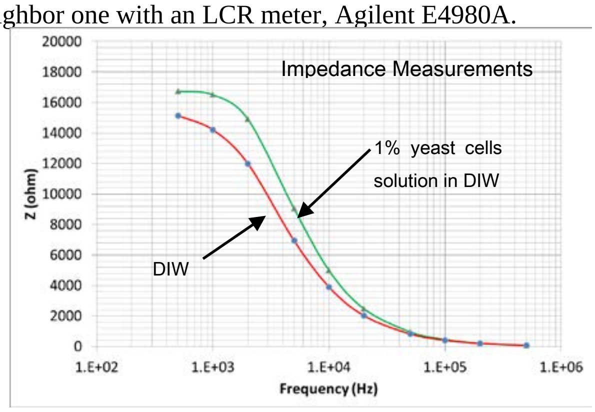


Fig. 4: Impedance measurement in between 2 electrodes

6. Conclusions

This article presents the overall results which has been obtained until now with the investigation of TFT substrates coming from LCD panels, for biological cells electrical manipulation, study and analyses. Characterization of some transistors as well as first results of pH sensing and impedance sensing on yeast cells are presented showing interesting data to be further studied.

Acknowledgements

UTokyo Nanofabrication site of VDEC is acknowledge for micro-processing.

References

[1] Y. Kuo, The Electroch. Society ***Interface,*** Spring 2013, 75.
[2] Y. Kuo *et al.*, Appl. Phys. Lett., **89**, (2006) 173503.
[3] C-M. Yang *et al.*, INEC'2013, 2-4 Jan. 2013, 480.
[4] F. Liao *et al.*, Sens. Act. B, 107-2, (2005), 849.
[5] P. Estrela *et al.*, J. Mater. Chem., 17, (2007) 219.
[6] D. Elkington *et al.*, Electronics 2014, 3(2), 234.
[7] A. Tixier-Mita *et al.*, MEMS'2015, 18-22 Jan. 2015, 354.