

F-5-1 (Invited)

Recent progress of organic transistor integrated circuits for large-area sensor applications

T. Someya^{1*}, T. Sakurai², T. Sekitani¹, H. Kawaguchi²,
S. Iba¹, Y. Kato¹, and Y. Noguchi¹

¹ Quantum-Phase Electronics Center, School of Engineering, the University of Tokyo,
7-3-1 Hongo, Bukyo-ku, Tokyo 113-8656, Japan

*Phone: +81-3-5841-6820, e-mail: someya@ap.t.u-tokyo.ac.jp

² Center for Collaborative Research, the University of Tokyo, Tokyo 153-8505, Japan

1. Introduction

Organic field-effect transistor (FET) integrated circuits (ICs) are attracting considerable attention since their properties are complementary to silicon-based VLSIs, which are high-performance, but expensive. Organic ICs are mechanically flexible, shock-resistant, thin, and lightweight. Furthermore it is expected that organic transistor integrated circuits would be ultra-low in cost even for large area. Mobility of organic transistors is about two or three orders of magnitude lower than silicon and the resultant circuit is slow in speed. The slow speed may not fit for video and RF applications, but it is acceptable for most of area sensor applications (1-6).

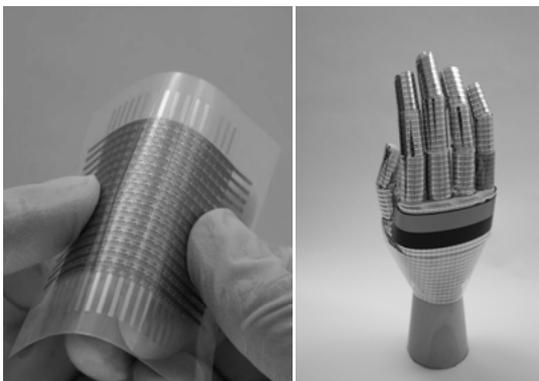


Figure 1: Images of flexible, large-area pressure sensors based on organic transistor active matrix. Those new devices are suitable for artificial skins for humanoid robots.

In this paper, we present recent advances of organic transistors and their applications to two kinds of large-area sensors; electronic artificial skins (E-skins) and sheet image scanners.

2. E-skins

It is believed that skin sensitivity will be important for future generation robots used by humans in daily activities for home-care and entertainment purposes. The fabrication of a sensitive skin consisting of thousands of pressure sensors would require a flexible electronic switching matrix that cannot be realized with present silicon-based conventional electronics.

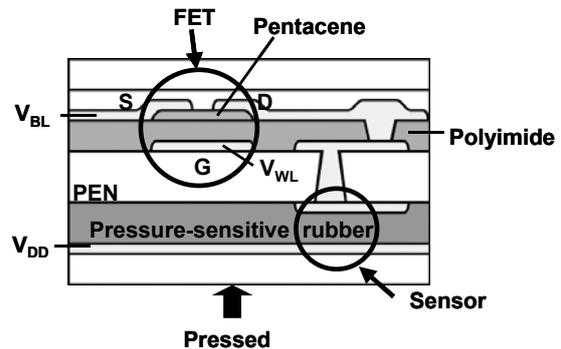


Figure 2: A cross-sectional structure of electronic artificial skins with an organic transistor active matrix for data readout. The transistors are connected to sensors using pressure-sensitive rubber sheets.

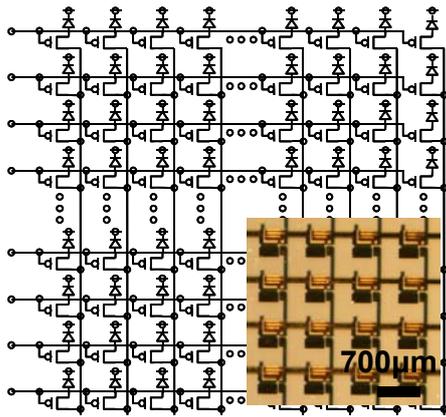


Figure 3: The circuit diagram of a sheet-image scanner. The microscopic image of sensor cells is also shown.



Figure 4: An image of a sheet image scanner, which is conformable to the bent page of a book.

electronics. Here we present that integration of organic transistors and rubber pressure sensors provides an ideal solution to realize a practical artificial skin. In particular, moving images of pressure have been taken by flexible active matrix drivers with organic transistors whose mobility reaches as high as $1.4 \text{ cm}^2/\text{Vs}$. The device is electrically functional even when it is wrapped around a cylindrical bar with a 2 mm radius.

3. Sheet image scanners

We report on a large-area, flexible, and lightweight *sheet image scanner* on a plastic film integrating high-quality organic field-effect transistors (FETs) and organic photodiodes. Organic photodetectors distinguish between black and white from the difference of reflectivity between black and white parts on paper. The sheet has no optical or mechanical parts, and therefore very thin, lightweight, and mechanically flexible.

Acknowledgements

The authors acknowledge MEXT IT program, JSPS and NEDO for financial supports.

References

- [1] Takao Someya, Tsuyoshi Sekitani, Shingo Iba, Yusaku Kato, Hiroshi Kawaguchi, and Takayasu Sakurai, "A large-area, flexible pressure sensor matrix with organic field-effect transistors for artificial skin applications", *Proceedings of the National Academy of Sciences of the United States of America*, Volume 101, 9966 (2004).
- [2] T. Someya and T. Sakurai, "Integration of Organic Field-Effect Transistors and Rubbery Pressure Sensors for Artificial Skin Applications", *IEDM*, 8.4, 203 (2003).
- [3] T. Someya, H. Kawaguchi, and T. Sakurai, "Cut-and-Paste Organic FET Customized ICs for Application to Artificial Skin", *ISSCC*, 16.2, 288 (2004).
- [4] Hiroshi Kawaguchi, Takao Someya, Tsuyoshi Sekitani, and Takayasu Sakurai, "Cut-and-Paste Customization of Organic FET Integrated Circuit and Its Application to Electronic Artificial Skin", *IEEE Journal of Solid-State Circuits*, Vol. 40, 177 (2005).
- [5] H. Kawaguchi, S. Iba Y. Kato, T. Sekitani, T. Someya, and T. Sakurai, "A Sheet-Type Scanner Based on a 3D-Stacked Organic-Transistor Circuit Using Double Word-Line and Bit-Line Structure", #32.3, *ISSCC* (2005).
- [6] T. Someya, S. Iba, Y. Kato, T. Sekitani, Y. Noguchi, Y. Murase, H. Kawaguchi, and T. Sakurai, "A Large-Area, Flexible, and Lightweight Sheet Image Scanner", *IEDM*, 15.1 (2004).