Flexible, Large-Area Sensor Matrix with Organic Transistor-Based Circuits

Takao Someya[1)] and Takayasu Sakurai[2)]

1) Quantum Phase Electronics Center, School of Engineering, University of Tokyo
7-3-1 Hongo, Bunkyo-ku, Tokyo 113-8656, Japan
Phone: +81-3-5841-6820, Fax: +81-3-5841-6834, Email: someya@ap.t.u-tokyo.ac.jp

2) Center of Collaborative Research, University of Tokyo
4-6-1 Komaba, Meguro-ku, Tokyo, Japan
Phone: +81-3-5452-6251, Fax: +81-3-5452-6252, Email: tsakurai@iis.u-tokyo.ac.jp

Flexible, large-area pressure-sensors have been fabricated with integrating rubber pressure sensors and pentacene field-effect transistors (FETs) on plastic films with mobility of 1.4 cm^2/Vs. The sensor matrix consists of 32×32 or 16×16 sensor cells, SENSELs, each of which has one transistor and one pressure sensor. The periodicity of SENSELs is 2.54 mm, which corresponds to 10 dots per inch (dpi). The total area is 8×8 cm^2 or 4×4 cm^2. Furthermore, the sensor matrix has been integrated driver circuits such as row decoders and column selectors to read out pressure images. The present area pressure sensors are suitable for artificial skin applications and make full use of advantages of organic FETs, namely, mechanical flexibility and low-cost feature for large area electronics.

Device structure is shown in Fig. 1. First, gate electrodes are deposited through a shadow mask technique on a 75-μm thick polyethylene naphthalate (PEN) film. Then, polyimide insulator is spin-coated and cured at 180 ºC for 1hr in an oven under the nitrogen environment. Then, via holes are made through polyimide films using a CO_2 laser drill machine. Next, pentacene is deposited through a shadow mask on the film by vacuum sublimation at the pressure of 3×10^{-5}Pa at ambient substrate temperature. The nominal thickness of the pentacene layer is 50nm. Gold is evaporated on the film to form source/drain electrodes (top contact geometry).

To complete the integration, organic FETs are stacked with pressure sensors. The pressure sensors are made out of pressure-sensitive conductive rubber sheets sandwiched between a copper-coated polyimide film and another polyimide film with two-dimensional via-hole matrix with round diameter of 100μm and spatial periodicity of 2.54mm (0.1inch). Via-holes are fabricated on the polyimide films by the conventional method similar to flexible circuit boards: combination of chemical etching, drilling and plating. The pressure-sensitive sheet is 0.5-mm thick silicone rubber containing graphite particles as conductors. Resistance changes from 10MΩ to 1kΩ, depending on the pressure applied to the sheet. When the SENSEL matrix is pressed by an object, the sensor of the pressed area turns on, and the corresponding sencels pull the bit lines up to V_{DD}.

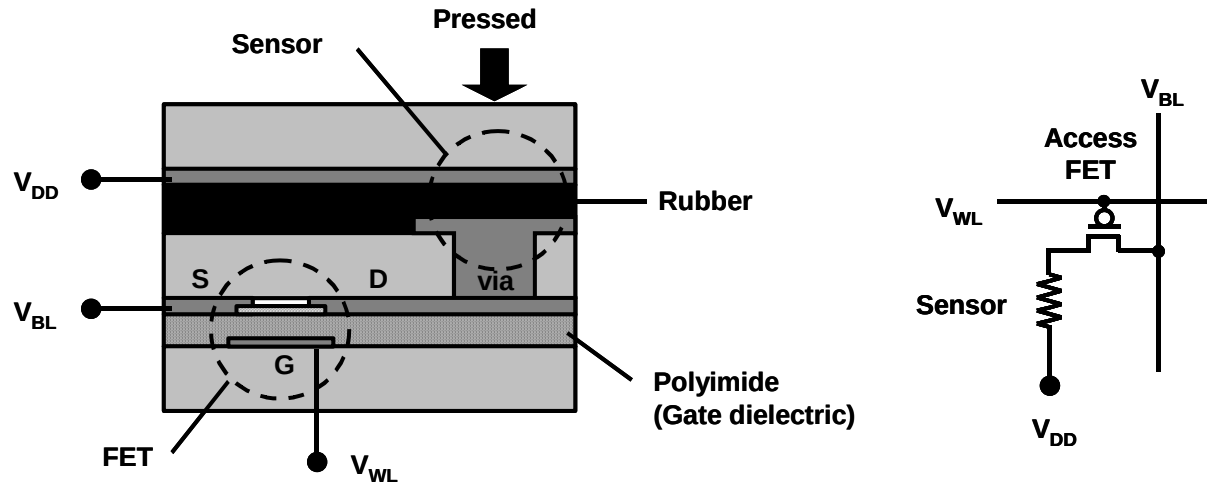

Figure 1: The cross-sectional illustration and the corresponding circuit diagram of one sensor sell, SENSEL, consisting of one access transistor and one pressure sensor are shown. V_{BL} and V_{WL} represent a bit line and word line, respectively.

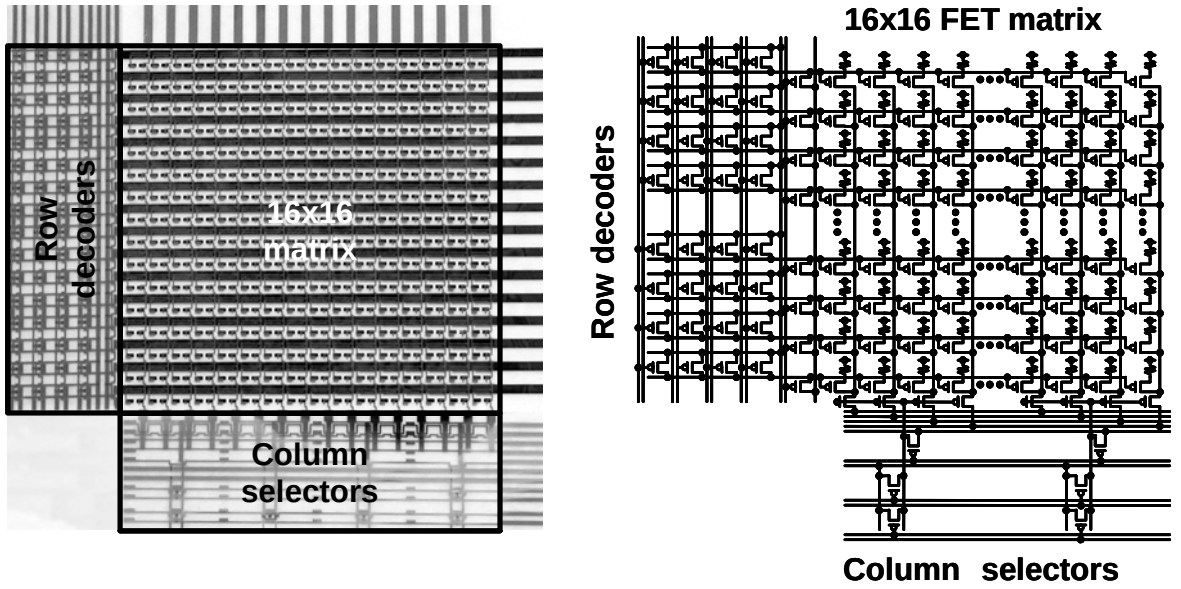

Figure 2: A photograph and a circuit diagram of the artificial skin system consisting of the sensor matrix, the decoder part, and the output part. The matrix has 16 x 16 sensor cells, SENSELs. An insulator film with via holes, a pressure-sensitive rubber sheet and a metal sheet for supplying V_{DD} are stacked and attached under the sensor matrix area.

References

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