Extended Abstracts of the 2012 International Conference on Solid State Devices and Materials, Kyoto, 2012, pp374-375

Realization of drosophila gustatory receptor based ion-sensitive field-effect transistors

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1. Introduction

Alzheimer's disease (AD) is the most common neurodegenerative disease causing dementia, it was first reported by German physician Alois Alzheimer in 1907. The cause about pathogenesis of Alzheimer's disease is not known exactly. Recently, many reserchs have suggested the pathogenesis of AD came from role of Beta-amyloid (Aβ) protein or Tau-protein. [1], [2] One of the endeavours to screen AD patient is to apply AD-related olfactory sensory loss. Nevertheless, there have been various challenges in traditional sensing techniques to study on biomarker of AD.

In this study, we realized drosophila gustatory Gr5a receptor based ion-sensitive field-effect transistors (ISFETs) instead of olfactroty sensory loss. It might provide other possibility to find out biomarker of AD by using drosophila gustatory system. The specific and sensitive signal of ISFETs was observed from interaction between drosophila Gr5a receptor and specific materials, in particular, trehalose.

2. Experimental

A p-type (100) bulk-Si wafer with a 300-nm-thick oxidation SiO_2 was used as substrate. The phosphorus-doped poly-Si thickness of 100 nm was deposited by LPCVD for S/D junction. The SiO_2 layer with a thickness of 28 nm was grown by dry oxidation. Subsequently, rapid thermal annealing (RTA) as post deposition annealing was carried out at 850 °C for 30 s in N_2/O_2 gas ambient. Then, Al was deposited by e-beam evaporator for metal contact pad. After that, a forming gas annealing at 450 °C for 30 min in N_2:H_2 (98%:2%) ambient was conducted. The reservoir for pH buffer solution was formed at the exposed gate window region of ISFETs using polydimethylsiloxane (PDMS). Fig. 1 (a) shows practical device image and Fig. 2 (b) shows schematic of ISFETs with SiO_2 membrane.

Meanwhile, the S2 drosophila cells were transfected by gustatory Gr5a receptor, which are expected to carry receptors protein of interest (especially, trehalose). They are culture in suspension form at room temperature for three days to reach exponential phase. Then, various trehalose concentrations were added in a camber with transfected Gr5a cells line. Then, the current-voltage (I-V) characteristics for different trehalose concentrations were measured by Hewlett-Packard 4156B semiconductor parameter analyzer.

3. Results and discussions

Fig. 2 shows the drain current versus gate voltage (I_D-V_G) characteristics of the MOSFETs on bulk-Si substrate. The device shows excellent transfer characteristics such as low leakage current (<10^{-12} A), a good SS (85 mV/dec) and a high on/off current ratio (7.3 x 10^6).

Fig. 3 shows I_D-V_G curves of the ISFETs response to different pH buffer solutions. The reference voltage (V_R) for each pH buffer solution shown in insets of Fig. 3 was defined as the corresponding gate voltages to the drain current of 100 nA. The ISFETs with SiO_2 sensing membrane exhibits pH sensitivity of 34.9 mV/pH and linearity of 99.4%.

Fig. 4 shows the drift rate for SiO_2 membrane measured in the pH 7 buffer solution for 12 hours. It indicates durability against the electrolyte. The ISFETs with the SiO_2 membrane revealed the good long-term stability (1.17 mV/h).

Fig. 5 shows response voltages for various trehalose concentrations with a Gr5a receptor cells sample, a S2 cells sample and a sample without any cells. Obviously, voltage shift in a Gr5a receptor cell sample was enlarged more than those of control groups. Also, uniform signal tendency in a Gr5a receptor cell based FET was observed as mole concentrations of trehalose were increased.

4. Conclusion

We realized drosophila gustatory Gr5a receptor based ISFETs. The specific and sensitive signal of ISFETs was observed from interaction between drosophila Gr5a receptor and specific materials. The Gr5a receptor cell based FET showed a uniform response depending on the concentrations of trehalose. As a result, using drosophila gustatory system with specific signal of interest, it might provide other possibility to find out biomarker of AD.

Acknowledgements

This research was supported by the Converging Research Center funded by the Ministry of Education, Science and Technology (No. 2011K000694).

References

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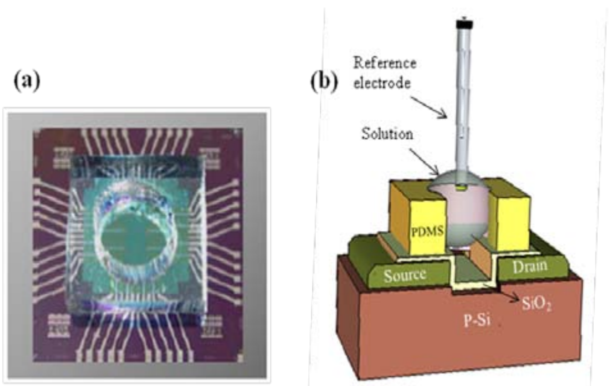

Fig. 1. (a) practical device image and (b) schematic of ISFETs with SiO_2 membrane.

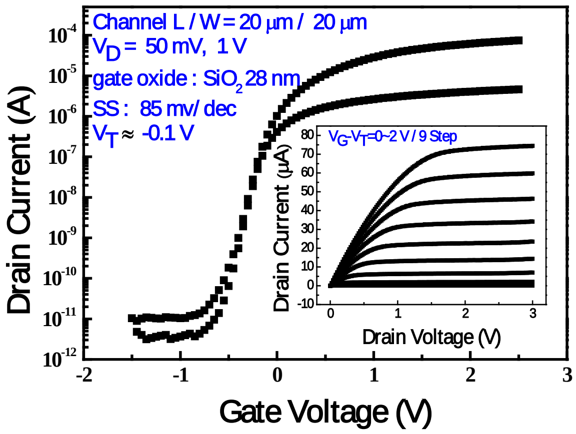

Fig. 2. Drain current versus gate voltage (I_D-V_G) characteristic. The inset drain current versus drain voltage (I_D-V_D) characteristic.

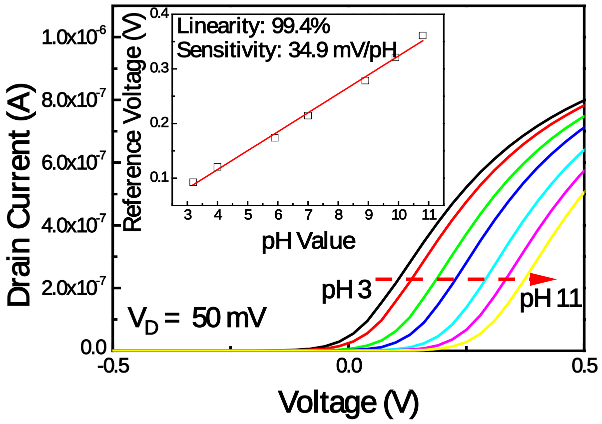

Fig. 3. I_D-V_G characteristics of the ISFETs with SiO_2 membrane in different pH buffer solutions. The insets show the sensitivity of the SiO_2 membrane at room temperature.

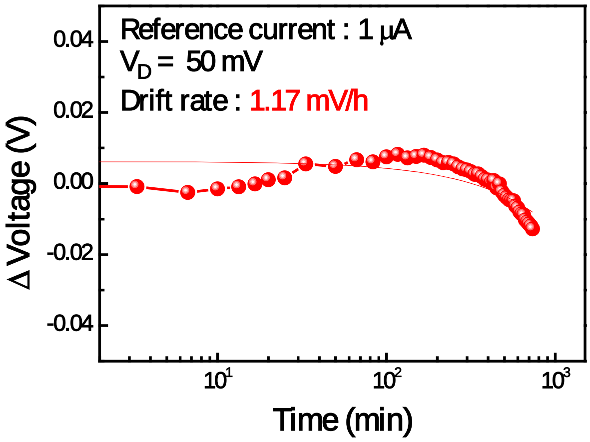

Fig. 4. The drift characteristic of the SiO_2 membrane in pH 7 buffer solution for 12 hours.

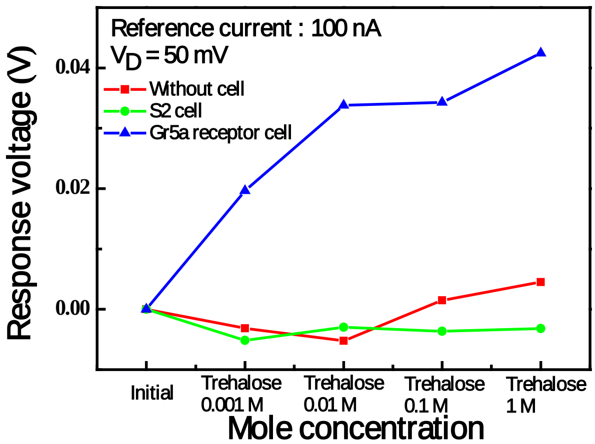

Fig. 5. Response voltage for various trehalose concentrations with a Gr5a receptor cells sample, a S2 cells sample and a sample without any cells.