Hironaga Noguchi
Takakazu Seki , Kazuki Yatsu , Yuhei Hayamizu
School of Materials and Chemical Technology Department of Materials Science and Engineering Tokyo Institue of Technology, 2-12-1 Ookayama, meguroku, Tokyo, Japan

noguchi.h.ae@m.titech.ac.jp

Self-Assembled Peptides as a Molecular Scaffold on CVD Grown Monolayer MoS_2 Transistor

2D materials such as graphene have been investigated to be applied for biosensors due to their excellent electrical properties and high specific surface area. More recently, MoS_2 field-effect transistor (FET) has exhibited higher sensitivity than graphene FET due to its semiconducting nature [1]. There are two reported methods of probe immobilization on MoS_2 FET [1,2]. One is using oxide layer. This method has problem that thickness of oxide layer decrease sensitivity. The other is immobilization via direct covalent bond. In this case, it is possible to achieve high sensitivity because of direct transmission of binding events. However direct covalent bond to MoS_2 disturbs intrinsic electrical property. So we focus self-assembled peptides to overcome these problems. Designed peptides on the surface of 2D materials form uniform and ordered structures arise from self-assembly with non-covalent integrations. These self-assembled peptides are expected as a molecular scaffold for immobilizing probe molecules without degrading the electrical properties. It has been reported that under dry condition self-assembled peptides on the surface of the graphene and MoS_2 change the electrical properties [3]. Since the operation of the biosensor is carried out under wet condition, behavior of MoS_2 FET in solution is important. However, the response of MoS_2 FET to the absorbed peptides has not been reported yet.

In this work, we observed the influence of the self-assembled peptides in buffer solution on the electrical characteristics of MoS_2 FET. We demonstrate biomolecule detection using immobilization of peptides with bio-probe through co-assembly process.

Y5Y (YGAGAGAGAGAY) peptide inspired by fibloin form unform and oriented structure and can maintain ordered nanostructures even after rinsing with DI water. [4] In this work , we designed RY5, EY5, and QY5, in which positively charged arginine, negatively charged glutamaic acid, and neutral glutamine were introduced at both ends of Y5Y. MoS_2FET were fabricated by transferring a CVD grown monolayer MoS_2 to an electrode prepared by a lithography technique. For the measurement, the source-drain current with respect to the gate voltage was measured with a platinum reference electrode in 10 mM phosphate buffer. After the formation of the peptide self-assembled structures, measurements were carried out in the same manner. The morphology of the self-assembled peptides on MoS_2 surface was also measured by Atomic force microscopy (AFM). We chosed streptavidin (SA) as a detection molecule becasuse specific interaction between avidin and SA is widely used to demonstrate biomolecule detection.

We found that three peptides form uniform and ordered structures on MoS_2 surface. In the conductivity measurements, MoS_2-FET shows no shift of threshold voltage after forming peptide self-assembled structure on the surface and also no change in the transistor mobility. This results suggests that our peptides may be useful as a molecular scaffold for MoS_2 biosensor.

References

[1] Sarkar, D., Liu, W., Xie, X., Anselmo, A. C., Mitragotri, S., & Banerjee, K. *ACS nano*, *8*(4), 3992-4003. (2014).

[2] Naylor, C. H., Kybert, N. J., Schneier, C., Xi, J., Romero, G., Saven, J. G., ... & Johnson, A. C. *ACS nano*, *10*(6), 6173-6179. (2016).

[3] Hayamizu, Y., So, C. R., Dag, S., Page, T. S., Starkebaum, D., & Sarikaya, M. *Scientific reports*, *6*, 33778. (2016).

[4] Peiying Li, Kouhei Sakuma, Shohei Tsuchiya, Linhao Sun, and Yuhei Hayamizu , *ACS Appl. Mater. Interfaces*, Just Accepted Manuscript,(2019)

Figures

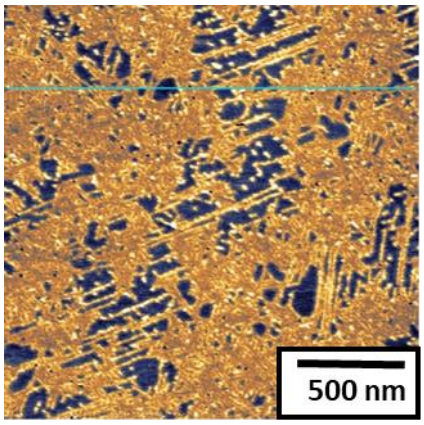

Figure 1: AFM image of self-assembled peptide structure on the MoS_2 surface.

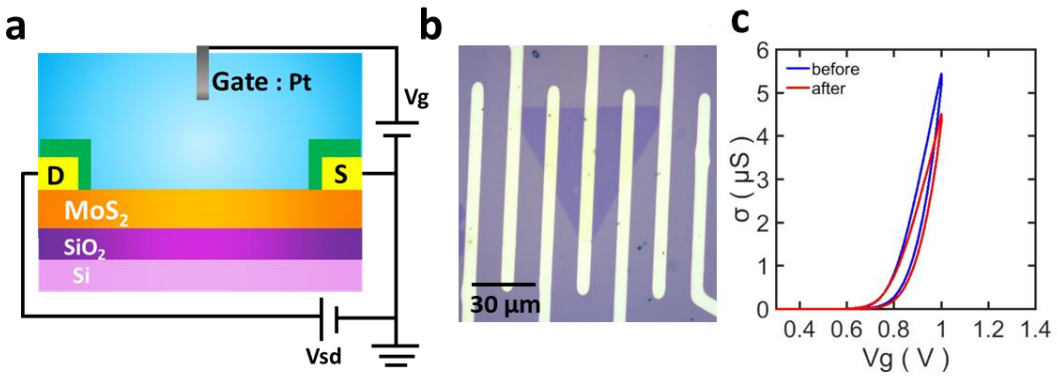

Figure 2: (a) Schematic of the MoS_2 transistor (b) Optical Image of MoS_2 transistor (c) Source-Drain conductivity *vs* applied Gate voltage of MoS_2-FET before and after the incubation of peptides.