Deposition of Organic Monolayer Film on TMDC-FET for Doping and Atomic Layer Deposition

K. Matsuda[1], D. Horiba[1], T. Kojima[1], K. Sakanashi[1], M. Ke[1], S. Kumagai[2], T. Okamoto[2], N. Aoki[1]

[1]*Department of Materials Science, Chiba University, Chiba 263-8522 Japan*

[2]*Department of Chemical Science and Engineering, School of Materials and Chemical Technology, Tokyo Institute of Technology, 4259-G1-7 Nagatsuta, Midori-ku, Yokohama, 226-8502 Japan*

n-aoki@faculty.chiba-u.jp

The doping effect is one of the most critical considerations in the practical utilization of 2-dimensional (2D) materials, such as transition metal dichalcogenides (TMDCs), as channel materials for 2D field-effect transistors (FETs) in future logic circuits. In this study, we demonstrate p-type doping for a few-layer crystal of WSe_2 through charge transfer doping using an organic monolayer formed on the WSe_2. Hexafluoro-tetracyano-naphthoquinodimethane (F6-TCNNQ) is one of the promising molecules for acceptor doping due to its electron affinity level, which is deeper than the valence band edge of monolayer WSe_2. Additionally, it possesses a flat molecular structure and highly electron-attracting characteristics due to the presence of halogen atoms. Such an organic monolayer could prove useful as a seed layer for the atomic layer deposition (ALD) of high-*k* metal oxides in 2D-FETs composed of TMDCs for future VLSI applications [1]. Using a vacuum-tube furnace, we have achieved selective growth of the F6-TCNNQ monolayer on a WSe_2-FET at an appropriate temperature without deposition occurring on other regions such as metal electrodes and SiO_2 on the substrate. Following the deposition process, a clear positive shift in the threshold voltage was observed without any degradation in mobility or the on/off ratio, as depicted in Fig. 1. Furthermore, we have confirmed that the contact resistance between the metal (Pd or Pt) and the WSe_2 has been significantly improved by more than one order of magnitude after the deposition of F6-TCNNQ on top of the FET channel, showcasing its secondary effects. Utilizing the organic monolayer as a seed layer, our ongoing efforts involve depositing high-*k* metal oxide on the WSe_2 by ALD. This research is supported by Tokyo Electron Limited.

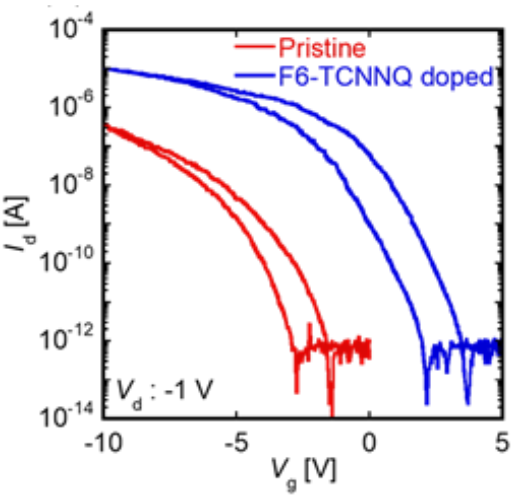

Fig.1. Transfer curves before and after F6-TCNNQ deposition.

References

[1] W. Li et al., Nature Electronics, **2**, 563 (2019).