Chemically tuned p- and n-type WSe_2 monolayers with higher carrier mobility for advanced electronics

°Hyun Goo Ji,[1] Pablo Solís-Fernández,[2] Daisuke Yoshimura,[3] Mina Maruyama,[4] Takahiko Endo,[5] Yasumitsu Miyata,[5] Susumu Okada,[4] Hiroki Ago*,[1,2]

[1] Interdisciplinary Graduate School of Engineering Sciences, Kyushu University
[2] Global Innovation Center (GIC), Kyushu University
[3] Kyushu Synchrotron Light Research Center
[4] Graduate School of Pure and Applied Sciences, University of Tsukuba
[5] Department of Physics, Tokyo Metropolitan University
E-mail : h-ago@gic.kyushu-u.ac.jp

Semiconducting transition metal dichalcogenides (TMDCs), such as WSe_2 and MoS_2, have been attracting great interest due to their superior and unique properties [1]. Although both p- and n-type materials are required for their application in advanced electronics, most of semiconducting TMDCs exhibit n-type or ambipolar behavior. Therefore, several approaches have been reported to control the electrical polarity of semiconducting TMDCs, such as substitutional doping of transition metals and metal nanoparticle deposition [2,3]. However, these methods have critical disadvantages, such as carrier scattering and photoluminescence quenching. As an alternative, chemical doping can be a promising method. Although the usefulness of chemical doping has been demonstrated, the controlled p- and n-type doping with a single TMDC material has not been reported so far [4].

In this work, we demonstrate the doping of CVD grown-WSe_2 for selective conversion from ambipolar to p- or n-type semiconductors [5]. This was done by using 4-nitrobenzenediazonium tetrafluoroborate (4-NBD) and diethylene triamine (DETA) molecules as p- or n-type dopants, respectively. After the doping process, WSe_2 showed clear p- or n-type transport properties and the effective carrier mobility showed significant increase up to 10^3~10^4 times (Fig. 1). To demonstrate utilization of our chemically doped p- and n-type WSe_2, a complementary metal-oxide-semiconductor inverter was fabricated which showed extremely low power consumption and high voltage gain (~10) (Fig. 2). Moreover, a p-n junction was fabricated within single WSe_2 grain by spatially controlled doping technique, and it showed clear rectification behavior as well as optical response under laser illumination (Fig. 3).

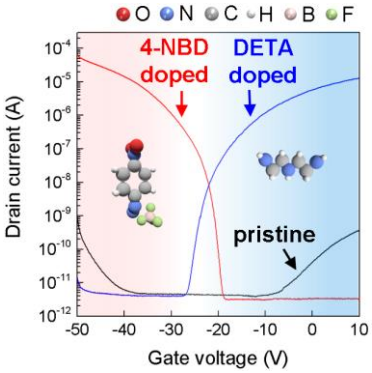

Fig. 1. Transfer curves of pristine and doped WSe_2

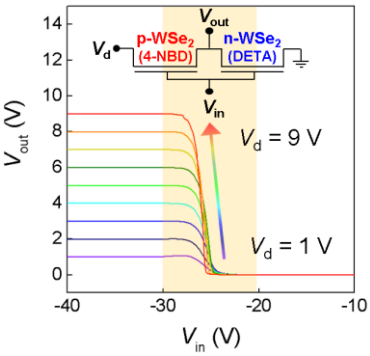

Fig. 2. V_{in}-V_{out} relationship measured from a CMOS inverter

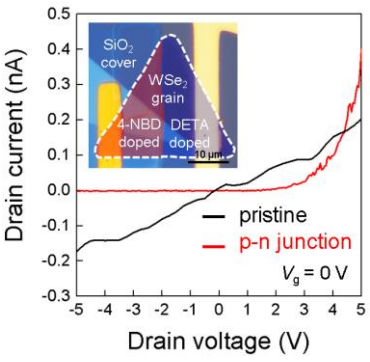

Fig. 3. Output curves of WSe_2 before and after forming a p-n junction

References

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