Xing He[1]
Y. Yamaguchi[1], T. Kaneko[1], and T. Kato[1,2]
[1] Department of Electronic Engineering, Tohoku University, Sendai 980-8579, Japan, [2] JST-PRESTO

he.xing.q7@dc.tohoku.ac.jp

Scalable fabrication of TMD-based highly-transparent solar cells

Layered transition metal dichalcogenide (TMD) is known as a true 2D material with excellent semiconducting properties. TMD is one of the most attractive materials for future transparent and flexible optoelectrical devices due to their atomically thin structure, band gap in visible light range, and high optical transparency [1-3]. Although the solar cell of TMD has been widely investigated by many groups, those are based on the pn junction type solar cell. Since complicated structures are required to form pn junction structures in TMD such as dual gate electrodes or position selective doping, the device size of pn junction solar cell with TMD is limited within very small region (few μm). In spite of the outstanding advantages of TMD, those merits of TMD have not been applied in transparent and flexible solar cell, which is attracted intense attention as a next-generation energy harvesting technology.

Recently, we have developed a new fabrication process of TMD-based solar cell [4]. In our process, Schottky type device configuration is utilized, which can be simply formed by asymmetrically contacting electrodes and TMD. The power conversion efficiency clearly depended on the work function difference between two electrodes (ΔWF), and a higher efficiency could be obtained with higher ΔWF (Pd-Ni), which is consistent with our concept, where Ni and Pd can form large and small Schottky barriers to operate as power-generation and carrier-collect regions, respectively. Based on the optimizations of electrodes and distance, the power conversion efficiency can be reached up to 0.7 %, which is the highest value for solar cell with similar TMD thickness [4].

In our previous study, we used conventional metals such as Ni and Pd to tune the Schottky barrier height between electrode and TMD, which suppress the transparency of whole device. Furthermore, the device size was limited within μm scale because of the size of exfoliated TMD.

To improve the transparency of whole device, we use indium tin oxide (ITO) as electrodes. The directly grown large area WS_2 films are also used to overcome the limited device size. After controlling the ΔWF of ITO electrodes and optimizing the synthesis conditions of WS_2, clear power generation can be observed with ITO/WS_2 based transparent solar cell in large scale (Figure 1). Since our simple fabrication process includes high potential for large scale fabrication, this achievement is very important for realizing the industrial application of TMD as a transparent and flexible solar cell.

References

[1] T. Kato and T. Kaneko, ACS Nano, **8** (2014) 12777.
[2] T. Kato and T. Kaneko, ACS Nano, **10** (2016) 9687.
[3] C. Li, Y. Yamaguchi, T. Kaneko, and T. Kato, Appl. Phys. Express, **10** (2017) 075201.
[4] T. Akama, W. Okita, R. Nagai, C. Li, T. Kaneko, and T. Kato, Sci. Reports, **7** (2017) 11967.

Figures

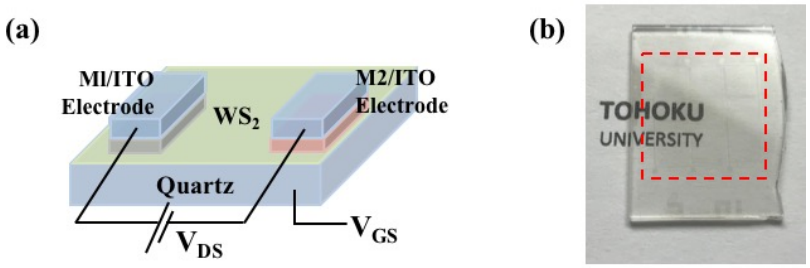

Figure 1: (a) Structure diagram and (b) typical optical image of transparent solar cell fabricated with directly grown WS_2 crystal. (Metal (M))