Naoyuki Kanda Yusuke Nakanishi, Dan Liu, Zheng Liu, Kazu Suenaga, David Tomanek, and Hisanori Shinohara Department of Chemistry, Nagoya University, Nagoya 464-8602, Japan

Contact : kanda.naoyuki@j.mbox.nagoya-u.ac.jp

Growth and Characterization of One-Dimensional Transition Metal Monochalcogenides Inside Carbon Nanotubes

The idea that single units of van der Waals (vdW)-bonded materials might show exotic properties distinct from their bulk counterparts has been verified by the successful isolation of two-dimensional (2D) vdW-layered materials such as graphene and transition metal dichalcogenides (TMDs). Similarly, isolated 1D vdW-wired materials like transition metal monochalcogenides (TMMs) could exhibit superlative properties being significantly absent in their bundles [1, 2]. Recently, our group has succeeded at the synthesis of MoTe nanowires (NWs) isolated within carbon nanotubes (CNTs), and observed their unusual torsional dynamics [3]. On the encapsulation of TMM-NWs, transport characteristics of CNTs are also expected to vary drastically due to their interaction. However, the transformation from TMDs produces the NWs in low yield, which makes it difficult to perform detailed studies of their properties.

Here we report high-yield synthesis of MoTeNWs inside CNTs from molybdenum oxides and tellurium. Atomic-resolution STEM observation reveals that the nanowires can be efficiently self-assembled from these precursors (Fig. 1a, b). Their effective growth was further confirmed by Raman spectroscopy (Fig. 1c). Furthermore, this method is applicable to a new member of TMM-NWs (Fig. 2). Their efficient and general growth allows for studies of the properties of TMM-NWs as well as transport characteristics of the hybrid CNT materials. Detailed discussion will be presented in the conference.

References

- [1] H. Zhu, Q et al., Adv. Mater. 29, 1606264 (2017).
- [2] I. Popov, S et al., Nano Lett. 8, 12 (2008).
- [3] M. Nagata et al., Nano Lett., in press.

Figures



Figure 1: (a) Low- and (b) high-magnification HAADF-STEM images and the corresponding model of MoTeNWs@CNTs. (c) Raman spectrum of MoTeNWs@CNTs. The peak located at 250 cm⁻¹ derives from A_g mode of MoTeNWs.



Figure 2: (a) Low-, (b) high-magnification HAADF-STEM images, and (c) EDX spectrum of WTeNWs@CNTs.