探針増強ラマン散乱による炭素ナノ材料計測研究

Nanoscale characterisation of carbon nanomaterials using tip-enhanced Raman spectroscopy

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Carbon nanotube (CNT) shielded MoTe nanowire (MoTe@CNT) is regarded as a promising candidate for ultrasmall electronic components. [1] However, the physicochemical properties and structural heterogeneity of MoTe@CNT are still not fully understood; therefore, development of nanoscopic spectroscopy is required to unveil its properties. Tip enhanced Raman scattering (TERS) enables to analyze chemical structures with high spatial resolution. In this work, we improved the fabrication method of TERS probe to investigate the heterogeneity of MoTe@CNT.

AFM cantilevers were dipped into the solution of silver nanowires (AgNWs) fabricated by polyol method [2]. The attached AgNW was cut by applying voltage under an optimized condition. The spatial resolution of TERS spectrum of CNT was estimated to be 3 nm. The enhancement factor (EF) was investigated by HS-C_6H_{12}O-Azobenzene functionalized Au (111): EF=2.57×10^5.

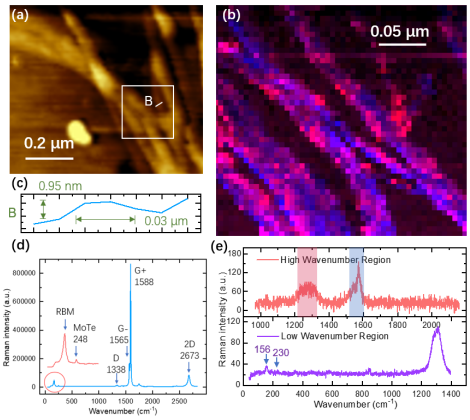

Fig. 1. (a) AFM image of MoTe@CNT; (b) TERS mapping of squared region in (a); (c) Height profile of cross section B; (d) Raman spectrum of MoTe@CNT; (e) One spectrum in (b) (upper), spectrum from low wavenumber region (lower)

MoTe@CNT was synthesized by template-based method [1]. Fig. 1a and 1c show the AFM image and the height profile of cross section B. Fig. 1b shows the TERS mapping of squared area in fig. 1a. The D and G bands are marked by red and blue, respectively. The peak of MoTe was observed at 248 cm^{-1} by Raman spectrum of bulk MoTe@CNT but not observed by TERS (Fig. 1d and 1e), probably because the distance between TERS probe and MoTe inside the CNT exceeded the detection capability. The splitting of G-band in MoTe@CNT in TERS spectrum would be attributed to the interaction between MoTe and CNT. This result suggests that TERS unveils the heterogeneity of MoTe@CNT.

[1] M. Nagata, S. Shukla, and Y, Nakanishi, et al., Nano Lett. 19, 4845−4851 (2019).

[2] P. Walke, Y. Fujita, and W. Peeters, et al., Nanoscale. 10, 7556-7565 (2018).