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Effects of Chirality and Defect Introduction on the Intermediate Frequency Mode

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An intermediate frequency mode (IFM) of single-walled carbon nanotubes (SWCNTs) has intriguing properties. The IFM originates from a phonon branch that has acoustic nature in graphene, and has non-zero momentum. Phonons with these properties are usually not analyzable with photons. However, the IFM of SWCNTs was successfully observed in prior reports [1, 2]. Remarkable features of the IFM may provide new insights into Raman spectroscopy of SWCNTs. Although the effects of chirality and defect density on the peak position was well explained in these reports, what determines the IFM intensity is not clear. We will show our recent analysis of the IFM intensity with focusing on the effects of chirality and defect density.
Intensities of the IFM, the D-mode, and the G-mode are shown in Figure 1a as functions of a duration time of defects introduction into an air-suspended SWCNT. Defects were introduced by using photoinduced bleaching in air [3]. The G-mode intensity decreased as results of the defect introduction. On the other hand, the IFM intensity increased along with the D-mode intensity. Furthermore, fluctuations of the IFM intensity was clearly following that of the D-mode intensity, which implies that the IFM originates from K-momentum phonons similar to the D-mode. From the results shown in Figure 1a, we suggest the intensity ratio IIFM/ID as a good representation to understand the physics underlying K-momentum phonons. Figure 1b shows effects of chirality on the IIFM/ID, as well as IRBM/IG, obtained from 5 kinds of SWCNTs; (12,1), (11,3), (10,5), (9,7), and (9,8). Although the chiral angle dependence of the IIFM/ID is less significant than the IRBM/IG, the ratios decrease with an increase of the chiral angle.

[1] T. Inaba, et al., J. Phys. Chem. C submitted
[2] A. Vierck, et al., Carbon 117, 360 (2017)
[3] T. Inaba, and Y. Homma, Appl. Phys. Let. 107, 071907 (2015)

Summary

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