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Effect of Disorder on AC Response of Metallic Carbon Nanotubes

DAISUKE HIRAI, The University of Tokyo, TAKAHIRO YAMAMOTO, Tokyo University of Science, SATOSHI WATANABE, The University of Tokyo — Metallic carbon nanotubes (M-CNTs) have long coherent lengths. In fact, the Anderson localization has been observed in M-CNTs with defects at room temperature [1]. In considering the AC response, not only the understanding of DC conductance behavior but also that of phase-difference between electric current and bias voltage are important. At present, however, the influence of disorder on the AC response remains unclear. In this study, we calculated the AC response of M-CNTs with disorder based on the nonequilibrium Green's function method combined with nearest-neighbor π-orbital tight-binding approximation and wide-band-limit approximation. In our simulation, disorder potential is described as $V = \Sigma_i V_i$, $|V_i| \leq W$, where V_i and W are localized potential at ith carbon atom and strength of disorder, respectively. We found that the DC conductance decreases with the CNT length, while the behaviors of phase-difference are drastically different by the disorder strength: for a small disorder the phase-difference always behaves inductive, while for a large disorder the phase-difference transits from inductive response to capacitive one with increase of the CNT length. Moreover, we clarified that inductive-capacitive transition universally occurs at the same value of DC conductance. [1] C. Gomez-Navarro et al., Nature 4, 534 (2005).

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