Electrical Conductivity of Single Particle Junctions Using Cobalt- and Cobalt-Carbide-Encapsulated Carbon Nanocapsules

D. Matsuura, T. Kizuka

Division of Materials Science, Faculty of Pure and Applied Sciences, University of Tsukuba, Tsukuba, Ibaraki 305-8573, Japan

e-mail: kizlab@ims.tsukuba.ac.jp

By assembling carbon nanocapsules (CNCs) in single particle junctions (SPJs), the properties of graphene shells can be applied to nanodevices [1]. In this study, we investigated the effect of the encapsulation of cobalt (Co) and Co carbide (Co3C) in CNCs on the electrical properties of SPJs. CNCs encapsulating Co and Co3C were synthesized via a gas-evaporation method and were dispersed on the tip of a gold (Au) plate. The Au plate was manipulated to sandwich CNC with an opposing another Au plate. A bias voltage was then applied between both the plates. A series of these manipulations was performed inside a transmission electron microscope at room temperature at a vacuum of 1 × 10−5 Pa.

Figure 1 shows a high-resolution image of a SPJ assembled from a Co3C-encapsulating CNC and the two Au plates. The diameter of the CNC was 34 nm. We defined a current density as the current through the SPJ divided by the perimeter of the contact interface. Irrespective of the perimeter values, the current density was almost constant. This feature was also observed for SPJs constructed of Co-encapsulating CNCs. The electrical conductivity of graphite along the in-plane direction is 2.6 × 106 S/m, which is 10⁴ times greater than that along the c-axis direction. Therefore, we found that the current through the SPJs flowed along the outermost graphene layers of the CNC; the conductivity of encapsulating particles minimally affected the electron transport.