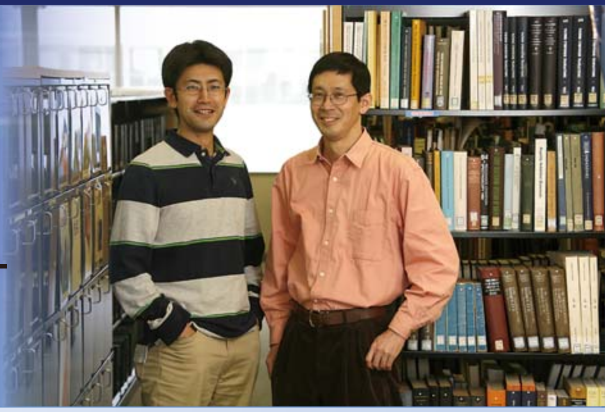
Development of Carbon Nanotubes with High Electrical Conductivity

- Application to Nanowiring and Transparent Electrodes -

Nano Frontier Materials Group, Nano System Functionality Center



Group Leader
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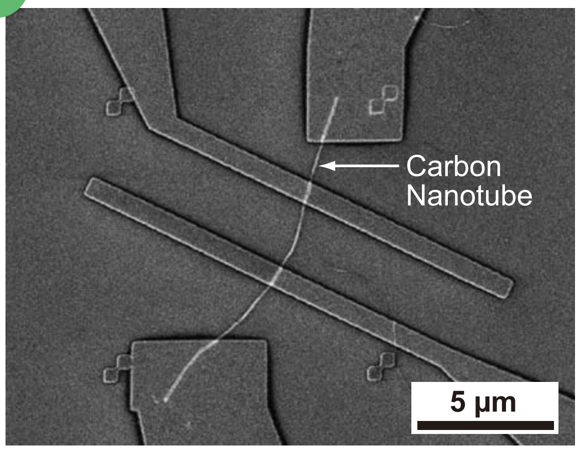
Beautiful diamond jewels, graphite used in pencil leads, soccer ball-shaped C_{60}, fullerenes, and carbon nanotubes (CNTs); they all consist of single element, carbon. Because CNTs have a fine straw shape with a diameter of less than one ten-thousandth of a millimeter and is light and strong, these novel properties make them potentially useful for a variety of applications in fields, such as nanowiring for future LSIs, and transparent electrodes. However, depending on the "handedness," or chirality, of CNTs, its properties differ greatly, for example, showing metal-like conductivity or the properties of a semiconductor. To date, attempts to control the chirality have not been successful.

In order to use CNTs for nanowiring and similar applications, high electrical conductivity independent of chirality is necessary. We have successfully fabricated boron-doped CNTs by a simple chemical vapor deposition method employing an electric furnace. Using electron beam lithography, four terminals were fabricated on a CNT and its electrical conductivity was measured (see **Fig. 1**). The results showed that the electrical conductivity of the CNTs at room temperature is one to two orders of magnitude higher than that of conventional multi-walled CNTs. Furthermore, it was also found that the CNTs retain its high electrical conductivity at down to extremely low temperatures (see **Fig. 2**).

Our group is conducting research on high electric conductivity and superconductivity that are found to occur when boron is added to diamond. Similarly, in CNTs, we assume that hole carriers are introduced into carbon when doped with boron, making it possible to obtain high electrical conductivity independent of the chirality of CNTs. In the future, superconductivity could also be found in boron-doped CNTs.

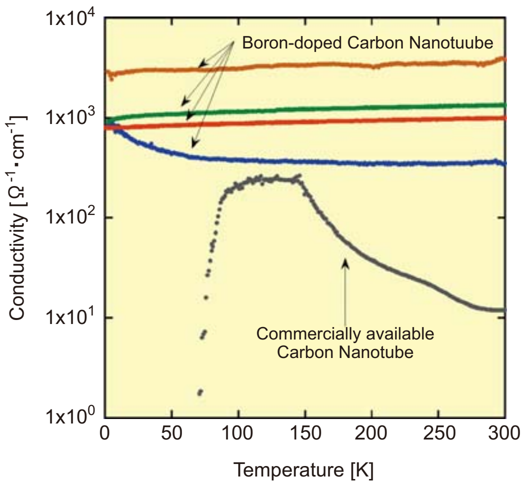
This new method has applications in a wide range of fields, including transparent electrodes and conductive films produced by adding CNTs to resins, nanowiring for future LSIs, CNT field effect transistors (FET), probes for scanning probe microscopes, electron emission devices, and fuel cells.

Fig.1



Scanning electron microscope image of a boron-doped CNT with a nanofabricated four terminals.

Fig.2



Temperature dependency of electrical conductivity.