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Carbon nanowalls for sustainable future

Masaru HORI[1]*, Hiroki KONDO[2], Kenji ISHIKAWA[2], Keigo TAKEDA[2], Makoto SEKINE[2] and Mineo HIRAMATSU[3]

[1] *Institute of Innovation for Future Society, Nagoya University, Japan*
[2] *Plasma Nanotechnology Research Center, Nagoya University, Japan*
[3] *Electrical and Electronic Engineering, Meijo University, Japan*

hori@nuee.nagoya-u.ac.jp

Carbon nanowalls (CNWs), that is, two-dimensional carbon nanostructures composed of the stacks of plane graphene layers standing on the substrate have been synthesized by the plasma chemical vapor deposition (CVD) without any catalysts. The large surface area and sharp edges of CNWs will provide us with opportunities towards environmental devices with green and life innovations. We have fabricated CNWs successfully using the unique plasma equipment of capacitively coupled plasma enhanced CVD assisted by the radical injection. The densities of radicals of carbon precursors and H atom in the plasma processing were measured by the appearance spectroscopy and the vacuum ultraviolet absorption spectroscopy, respectively. The structure and morphology of CNW were precisely controlled by the ratio of the amount of carbon based radicals against H, O, and N radicals injected. In order to clarify the growth mechanism, the initial growth stage was investigated by the spectroscopic ellipsometer. By controlling CFx based species, H, N and O radicals in the plasma, electronical properties of CNWs were successfully controlled We have found out semiconductor properties in CNWs and synthesized of n and p types semiconductor of CNWs. CNWs are therefore considered to be one of the most promising carbon materials for nanometer-scale electronic devices. Furthermore, Pt nanoparticles with a high density on the order of 10^{13} cm^{-2}, and with diameters ranging from 2 to 3 nm, were uniformly deposited over the entire surface of CNWs by using a supercritical fluid metal organic fluid deposition (SCF-MOCFD) system. The CNWs with Pt nanoparticles showed excellent properties of fuel cell devices. Especially, this Pt nanoparticles-supported CNWs exhibited much higher durability than those of conventional carbon black, in which the electrochemical surface area of Pt catalyst was hardly changed even after 20,000 cycles in high potential cycle testing. This result indicate the CNWs have a great potential to realize the tough fuel cell devices. Recently, CNWs were applied to the environmental sensing devices, where the organic vapors, iso-pentane, diethyl ether, acetone and methanol, of different polarity and vapor pressure were selected and the highest sensitivity was exhibited to acetone compared with the other vapors. CNWs indicated an ultrahigh water-repelling, but this property was drastically changed to be hydrophilic by the oxygen plasma treatment, which is used for the bio-nano device of cell cultivation and the bio sensor for the detection of Bovine serum albumin (BSA) employing an cyclic voltammetry. On the basis of these results, the new avenue for the sustainable future opened by the CNWs will be introduced.