# 2

# Syntheses and Electronic Applications of Helical Carbon Nanofibres

Yoshiyuki Suda, Hirofumi Takikawa and Hideto Tanoue
*Toyohashi University of Technology*
*Japan*

## 1. Introduction

Helical carbon nanofibre (HCNF) is spiral-shaped carbon nanofibre (CNF) with coil and fibre diameters in the range of 20—1000 nm and 5—400 nm, respectively. The unique three-dimensional structure of HCNFs induces a lot of researches to apply HNCFs to electrical and electronic engineering as well as mechanical engineering. Carbon nanotubes (CNTs) were first discovered in the soot produced by an arc discharge and laser ablation has been one of the most reliable methods to prepare high-quality CNTs. On the other hand, HCNFs has been almost entirely grown by chemical vapour deposition (CVD) using hydrocarbon feedstock gases. In this chapter, we describe the history, classification, synthesis, and application of HCNFs. We mainly introduce our research results including the latest topics, comparing with the other group's work. The problems that still remain in the CVD growth and the future researches of HCNFs we intend are also discussed.

## 2. History of HCNFs

In 1953, Davis et al. have found minute vermicular growths of carbon through the experimental work on the deposition of carbon in the brickwork of blast furnaces (Davis et al., 1953). In 1955, Hofer et al. reported the growth of carbon filaments with fibre diameters of 10 to 200 nm. They used the catalytic deposition technique of carbon from carbon monoxide by the following disproportionation reaction.

$$2CO \rightarrow C + CO_2 \quad (1)$$

At atmosphere pressure, the reaction takes place between 300 and 800°C. They used Ni, Co, and Fe as a catalyst and a combustion tube with an electric furnace for the carbon growth. Carbon filaments grew on all of the catalysts at 390°C, and the deposits on Fe were single solid strands. They also found that the filaments were extended in two directions from central catalyst particles (Hofer et al., 1955).

Boehm intended to find a continuous process of carbon filaments by feeding metal carbonyl into a CO stream before it passed a heated tube. He introduced $Ni(CO)_4$- or $Fe(CO)_5$-containing CO (80%)/$H_2$ (20%) gas mixture into the heated zone of a heat-resistant glass tube with an electric furnace at temperatures of 550—770°C. When $Fe(CO)_5$ was used, the