10-Physical and Chemical Properties of Materials in Relation to Structure (Superconductors, Fullerenes, etc)

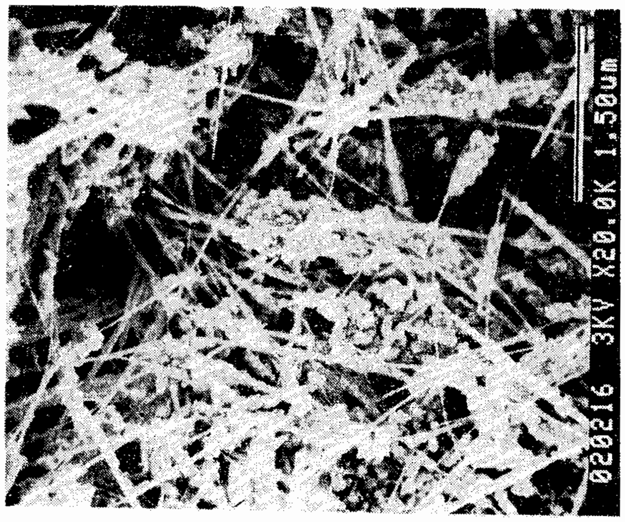

Fig. 1. SEM image of carbon deposit in 50 Torr CH4.

PS-10.02.08 STRUCTURAL STUDY OF ORTHORHOMBIC C_{60} CRYSTAL UNDER HIGH PRESSURE.

By S. Shimomura, H.Kawada*1), S.Nozawa1), Y. Fujii2), K.Kikuchi3), Y.Achiba3), and I.Ikemoto3).
Institute of Physical & Chemical Research (RIKEN), Wako 351-01; Univ. Tsukuba, Tsukuba 3051); ISSP, Univ. Tokyo, Tokyo 1062); Tokyo Metropo. Univ., Hachioji 192-03, Japan3).

In contrast to a well-known fcc C_{60} crystal, a relatively large single crystal (0.1 x 0.5 x 5mm^3) with an orthorhombic lattice was successfully grown from CS_2 solution(Kikuchi et al.,1991). Its structure was tentatively assigned to the space group Pbnm with its lattice constants a=24.99, b=25.60, c=10.00 A (Z=8) under an ambient condition. In order to study its structural aspects under hydrostatic pressure, we have carried out x-ray diffraction experiments by using a diamond-anvil cell on both conventional laboratory source and synchrotron radiation source of the Photon Factory. With increasing pressure, we have discovered a phase transition from orthorhombic to monoclinic lattices between 1.1 and 2.2GPa at room temperature. Upon the transition, the orthorhombic c-axis inclines in the ac plane by an angle of 0.55deg. while other principal axes are retained. The pressure dependence of its unit cell volume (bulk compression) does not show appreciable discontinuity across the transition pressure and it is fitted by the Birch-Murnaghan equation of state resulting in its bulk modulus $K_0=10.5+1.9$GPa. This is contrast to the value of the fcc crystal ($K_0=18.1$ GPa) (Duclos et al., 1991), showing that the orthorhombic crystal is much more compressible than the fcc one. However, we have not succeeded in obtaining information of molecular displacements associated with the transition.

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Duclos, S.J., Brister, K., Haddon, R.C., Kortan, A.R., & Thiel, F.A. (1991), Nature **351**, 380.
Kikuchi, K., Suzuki, S., Saito, K., Shiromaru, H., Ikemoto, I. & Achiba, Y. (1991), Physica C **415**,185-189.

PS-10.02.09 FORMATION OF CARBON NANOTUBES BY THE EVAPORATION OF CARBON ROD CONTAINING Sc_2O_3

By Masato OHKOHCHI*, Yoshinori ANDO, Department of Physics, Meijo University, Tenpaku-ku, Nagoya 468, Japan, Shunji BANDOW, Inst. Molec. Sci., Myodaiji, Okazaki 444, Japan and Yahachi SAITO, Mie University, Uehama, Tu 514, Japan

Gas evaporation method using dc arc-discharge has been applied to form fullerenes, i.e. carbon 60 and relatives. When the fullerenes are formed by this method, carbonacious deposits are formed onto the tip of negative electrode. It is well known that there exist carbon nanotubes and nanoparticles in the deposits (Iijima, Nature 1991, 354, 56, Ando and Iijima, Jpn. J. Appl. Phys., 1993, 32, L107). Recently, the experiment of metal encapsulated fullerenes has become interested from the viewpoint of physical properties. When the positive carbon electrode is replaced to carbon rods containing metal, metal encapsulated fullerenes are formed (Shinohara et al., Nature, 1992, 357, 52.). Here, we carried out arc-discharge by the use of carbon rods containing Sc_2O_3 on the positive electrode, and observed by high resolution SEM carbon nanotubes and nanoparticles growing in the carbonacious deposits. From the result, we discuss Sc effect on the growth of the tube.

On the negative electrode side, the high purity graphite rod of 10mmϕ was used. On the other hand, three kinds of carbon rods (containing Sc_2O_3 and pitch, containing pitch only and pure graphite containing nothing) were used on the positive electrode to compare difference of the nanotube growth brought about by composition of original carbon rod. The atmospheric gas used in the experiment was helium gas of 50 Torr. Dc arc electric current was varied in the range from 180A to 260A. The deposits formed by this evaporation were cut by diamond saw, and the cross section was observed by SEM.

The feature of nanotubes in the deposit formed by evaporation of a rod containing Sc_2O_3 and pitch is shown in Fig. 1. The amount of nanotubes is tremendous. Many nanotubes with same diameter are bundled together to form long wavy fibres. On the other hand, in the case of rods without Sc_2O_3 , the nanotubes are straight and not so bundled. Also, many more nanoparticles than bundles are observed in this case. From these observations, it became clear that Sc had a great effect on the growth of nanotubes.