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Carbon nanotubes on electrodes in short-time heteroelectrode arc

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Abstract

Short-time arc discharges with a short gap were generated between heteroelectrodes in stationary and running arc mode, under 25 kP of He. The electrodes used were pure graphite (C), nickel and yttrium mixed graphite (C–Ni/Y), and molybdenum (Mo). After the arc discharge, the surfaces of the anode and cathode were microscopically observed. On Mo electrode surface, no nanotubes were observed. With regard to C electrode, the multiwall nanotubes were observed only at the cathode spot where the arc was forcibly extinguished, and no nanotubes were observed at the anode spot. On the other hand, when the C–Ni/Y was used for the electrode, the nanotubes were observed both at the cathode spot where the arc was forcibly extinguished, and at the anode spot. These nanotubes on C–Ni/Y electrode were of multiwall, not of single wall.

Keywords: Multiwall carbon nanotube; Heteroelectrode; Stationary arc; Running arc; Graphite electrode; Catalyst mixed electrode

1. Introduction

Carbon nanotubes are considered to be potential materials for various applications, such as reinforcement in composites, electronic applications (battery electrodes, field emitters, scanning probe tip), etc., as summarized recently in several scientific literatures [1–3]. A variety of methods for producing the nanotubes have been developed [1–3], including the classical, but simple, and original method of electric carbon-arc discharge. It is important that the growth phenomenon of the nanotubes in the arc is clarified, not only from the scientific viewpoint of revealing nanotube formation mechanisms, but also from the engineering viewpoint of understanding the arc physics with graphite electrode.

To date, in order to understand the carbon nanotube growth in the carbon arc, the authors have carried out various experiments such as heteroelectrode arc discharging between graphite (C) and molybdenum (Mo) electrodes in low pressure [4], C cathodic vacuum discharge [5], and running and jumping arcs driven by magnetic field under low pressure and vacuum [6,7]. The results have revealed that the multiwall carbon nanotubes are produced by the cathode spot, without being dependent on atmospheric pressure, ambient gas species (helium (He) and hydrogen (H_2)), and the existence of a magnetic field. The nanotubes are also found to be destroyed by the cathode spot, so they can be observed at the crater where the arc is forcibly extinguished by switching the power off, but not at the crater where the arc is self-extinguished. In these experiments, the investigation has concentrated on the phenomena on a pure graphite electrode.

In the present study, in order to investigate the effect of C electrode with catalytic metals on nanotube growth on the electrode, a short-time arc was generated between nickel and yttrium mixed graphite (C–Ni/Y) electrode and Mo electrode, as well as C and Mo electrode. The arc was operated in both stationary mode (no magnetic field) and running mode (under magnetic field). The products on the electrodes were microscopically observed.

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