

Effect of ambient gas and pressure on fullerene synthesis in induction thermal plasma

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Abstract

Fabrication of fullerenes (C_{60} , C_{70} , etc.) by direct evaporation of C–Si mixed powder using radio frequency inductively coupled thermal plasma were made to find a suitable gas kind and pressure for fullerene synthesis. The results showed that: (1) 150 Torr lower pressure and He/Ar mixed gas are more suitable for fullerene synthesis than higher pressure and pure Ar gas, and (2) it is important for fullerenes synthesis that the radiation intensity of C_2 and C spectra is stronger at 10 mm below coil end, i.e. high-temperature plasma torch region, and it becomes very weak at 150 mm below coil end, i.e. inside the reactor chamber. Furthermore, numerical simulation was carried out to derive the temperature and gas flow fields in the plasma torch and reactor chamber. The calculation results indicate that He mixing into Ar gas can increase the temperature-gradient at the center axis of the plasma torch, and that pressure has a distinct effect on plasma axial velocity distribution.

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1. Introduction

Since Kratschmer et al. reported evidence for the presence of C_{60} in a sample of carbon dust prepared from vaporized graphite and were able to isolate macroscopic quantities of C_{60} and C_{70} in 1990 [1,2], there is increasing interest in the synthesis of fullerenes C_{60} , C_{70} as well as higher-order fullerenes [3–8]. The main methods for fullerenes synthesis are: resistive heating [2], inductive heating [9], arc discharge [10] and combustion [11]. We have been synthesizing fullerenes using radio frequency inductively coupled thermal plasma (RF-ICTP), and found that: (1) the productivity of fullerene has a relation with the radiation intensity of C_2 molecular and C atomic spectra from the induction plasma, (2) C–Si mixed material powder is more favorable to fullerene formation than pure C material powder [12,13].

In this paper, spectroscopic observation and production analysis were carried out to investigate the influence of plasma gas composition and pressure on fullerene synthesis. The pressure was set to 150, 380 and 500 Torr, and pure Ar and He/Ar mixed gas were chosen as gas kinds. At the same time, the influences of ambient gas and pressure on fullerene formation were discussed according to the numerical simulation results of a two-dimensional local thermodynamic equilibrium (LTE) model.

2. Experiment

2.1. Experimental setup

The induction plasma torch used in the experiment is the same as that presented in our previous publication [13], which is composed of two coaxial quartz tubes, and a three turns coil. The coil is connected with a 1.67 MHz oscillator with a maximal power up to 200 kW. Two types of gases such as sheath and carrier gases are

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