24P017-O

Fabrication of Graphene Film on Cu Substrate using Microwave Plasma Enhanced Chemical Vapor Deposition

マイクロ波プラズマCVD法を用いた銅基板へのグラフェン膜の作製

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Graphene is a material of growing technological importance owing to their outstanding properties and numerous actual and potential applications. Extensive efforts have been done in the preparation of graphene by a variety of methods including thermal chemical vapor deposition (CVD) on Cu substrate. In this study, we attempted to fabricate graphene films on Cu substrate using microwave plasma enhanced CVD. The graphene film fabricated on Cu substrate was evaluated by scanning electron microscope and Raman spectroscopy.

1. Introduction

Graphene is the hexagonal arrangement of carbon atoms forming a one-atom thick planar sheet. An ideal graphene will spread flat, and this can be classified as two-dimensional carbon. Graphene is a promising material for future electronic applications due to its unique electronic properties [1]. Graphene has shown promising applications as ultra-sensitive gas sensors [2], transparent electrodes in liquid crystal display devices [3], and large-capacity electrodes in Li ion batteries [4]. Various methods have been reported for the synthesis of graphene, including (i) mechanical exfoliation from highly oriented pyrolytic graphite (HOPG) [5], (ii) chemical exfoliation from bulk graphite [6], (iii) thermal decomposition of carbon-terminated SiC [7]. Recently, fabrication of graphene films has been reported on Cu substrate using chemical vapor deposition (CVD). For example, graphene was fabricated on copper foils at high substrate temperatures up to 1000 ºC using CVD [8]. On the other hand, microwave plasma-enhanced chemical vapor deposition (MWPCVD) has been demonstrated for the synthesis of carbon nanotubes, carbon nanowalls, carbon nanosheets and diamond films.

In this work, we attempted to fabricate graphene films on Cu substrate at lower temperature of 750 ℃ using MWPCVD.

2. Experimental

Figure 1 shows the MWPCVD system used in this study. Home-made ASTeX-type MWPCVD reactor consists of a cylindrical stainless steel chamber. The microwave (2.45 GHz) is coupled from the rectangular waveguide into the cavity via an axial antenna. A discharge called a “plasma ball” is generated above the substrate [9].

A mixture of CH_4 and H_2 was used as the source gas. The flow rates of CH_4 and H_2 were 20 and 180 sccm, respectively. The growth experiments were carried out for 30 min at microwave power of 1100 W, total pressure of 70 Torr, and substrate temperature of 750 °C. The deposits on the Cu substrate were evaluated by scanning electron microscope (SEM) and Raman spectroscopy.

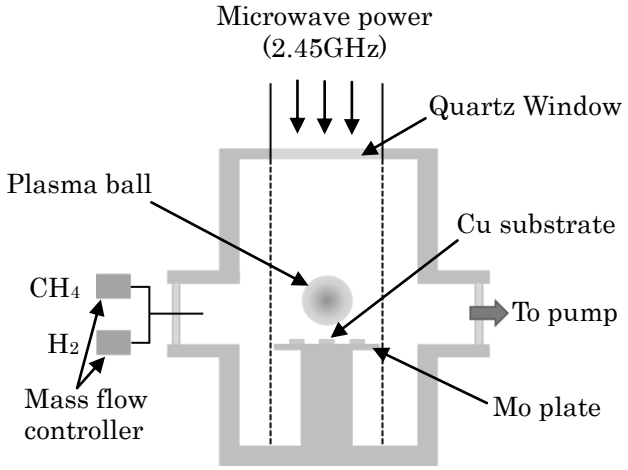

Fig.1 Schematic of MWPCVD system.

3. Results and discussion

Figure 2 shows the top view SEM image of

carbon film on Cu substrate. It was confirmed that the thin films such as carbon films were deposited on the Cu substrate.

Figure 3 shows the Raman spectrum of deposits grown on Cu substrate. The main features in the Raman spectra of carbon films are, so-called, G band and D band peaks, which lie at around 1580-1590 cm^{-1} and 1350-1360 cm^{-1}, respectively, for visible light excitation [10]. The most prominent feature in the Raman spectrum of graphene is reported to be the 2D peak at around 2700 cm^{-1}, and its position and shape can be used to clearly distinguish between single-layer, bilayer, and few-layer graphenes [11]. Although Raman spectra were taken at several positions on the deposits, distinct 2D peak could not be confirmed in this case, as shown in the Raman spectrum of Fig. 2.

At present, we are carrying out growth experiments by changing the substrate bias, position on the Mo plate, gas mixing ratio, as well as the substrate temperature.

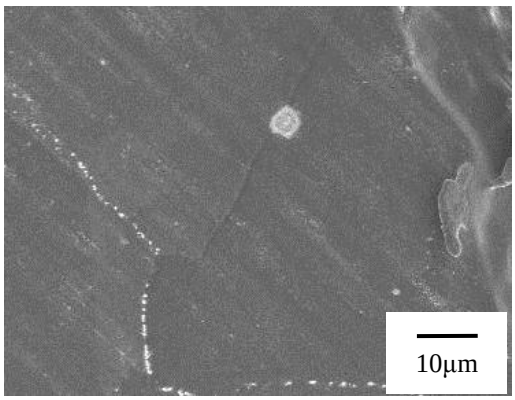

Fig. 2 The top view SEM image of carbon film grown on Cu substrate

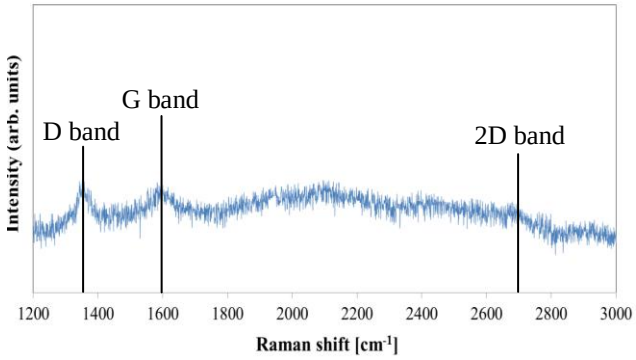

Fig. 3 Raman spectrum of carbon film grown on Cu substrate.

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