Characterization of carbon films by microwave-plasma assisted chemical vapour deposition in open-air system

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Reactive plasma has been generated under the open air condition by microwave excitation of a downstream flowing mixture of hydrogen and methane. The plasma torch having the shielding gas flow was employed to eliminate the effect from the atmospheric gas such as nitrogen and oxygen. The carbon films were deposited in the methane concentration about 10% (CH_4/H_2). The films have DLC properties from the Raman spectra. The intensity ratio of bonding energy $sp^2/(sp^2+sp^3)$ was 0.7. The films were smooth, flat and hard.

1. Introduction

In recent days, plasma phenomena and its process under atmospheric pressure have been widely researched. The plasma process under atmospheric pressure will be high in deposition/etching rate in spite of its controllability of plasma. If the process under atmospheric pressure realizes in "the open-air", the processing system becomes simple and the controllability of substrates such as the processing area and the handling of substrates, and also the processing rate becomes high in proportion to the pressure. But there are not enough data about the films deposited in the open-air condition. We researched about the influences of the atmospheric gas and the atmospheric pressure as the high pressure CVD process to the deposited films.

2. Instructions

2.1. Design of Torch

Experimental setup employed in this study is schematically shown in fig.1. Microwave power is supplied by a semiconductor generator at 2.45 GHz. The microwave is guided to the co-axial waveguide by a rectangular-to-coaxial line transition. The process gase mixed with hydrogen and methane were supplied through the gap between outer electrode and inner electrode to the end of nozzle. The plasma is torched between the end of inner electrode and the substrate caused by the high electric field between them. The shield gas of helium was supplied to separate between the plasma and the atmosphere.

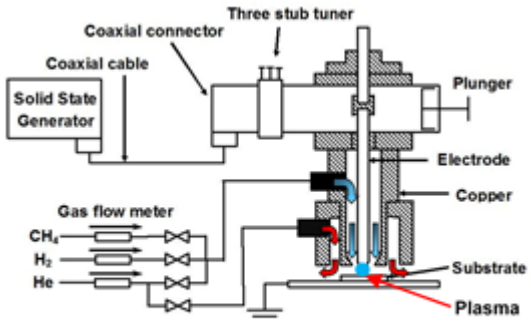

Fig.1 Apparatus of the plasma torch with the flow of shield gas.

2.2 Experimental conditions

Experimental conditions employed in the present study were as follows. The flow rate of CH_4, H_2 and He were 15 sccm, 150 sccm and 165 sccm, respectively. The incident power is 50 W, and the processing time was 10 min. The silicon and stainless steel substrates were used for the deposition, and the gap between the nozzle and the substrate was 1.0 mm.

3. Results

Fig.2 shows the Cls X-ray Photoelectron Spectrum of the film deposited on the stainless steel (JIS:SUS304). The intensity ratio of bonding energy $sp^2/(sp^2+sp^3)$ is about 0.7. The profile corresponding to C=O bond is found in the figure.

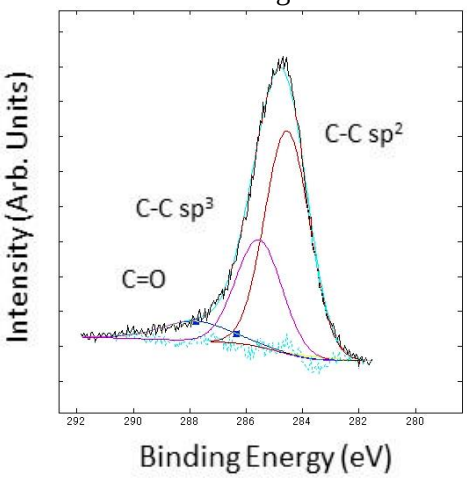

Fig.2 The Cls XPS of the film deposited on the stainless steel.