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Deposition of highly conducting Cu thin film on polyimide substrate using RF-driven atmospheric pressure plasma jet in nitrogen atmosphere
窒素雰囲気下でのRF 駆動大気圧プラズマジェットによる ポリイミド基板への高導電性銅薄膜堆積

Peng Zhao[1], Wei Zheng[2], and Masaaki Nagatsu[1]
趙 鵬[1], 鄭 偉[2], 永津 雅章[1]

[1] *Graduate School of Science and Technology, Shizuoka University, 3-5-1, Johoku, Nakaku, Hamamatsu 432-8561, Japan*
静岡大学創造科学技術大学院, 〒432-8011 浜松市中区城北3-5-1
[2] *Research and Technology Center, Yazaki Corp.,*
矢崎総業株式会社, 〒410-1194 静岡県裾野市御宿1500

For fabrication of future flexible electronic devices, an Ar/H_2 atmospheric pressure plasma jet (APPJ) driven by a 13.56MHz RF power is developed for depositing highly-conducting Cu thin films on polyimide substrate. Under air atmosphere, the oxidization of deposited film is inevitable. However, by adding a fractional amount of H_2 gas into Ar APPJ, quality of Cu film was significantly improved. This might be due to the fact that the hydrogen atoms play an important role of reduction reaction to avoid the Cu film oxidization. The effects of background gas species on Cu film quality were studied by means of XPS and SEM. By replacing air to nitrogen, it was confirmed by XPS that a high purity Cu film was synthesized, without the oxidization of Cu film. All the plasma properties and the results of Cu film would give us an insight on the mechanism and the possibility of improving the process.

1. Introduction

For fabrication of future flexible electronic devices, an Ar/H_2 atmospheric pressure plasma jet (APPJ) driven by a 13.56 MHz RF power is developed for depositing highly conducting Cu thin films on polyimide substrate. In previous studies, we found that by adding a fractional amount of H_2 gas into Ar APPJ, quality of Cu film was significantly improved. But under air atmosphere, the oxidization of deposited film is inevitable because of existence of oxygen. So we developed the technology in nitrogen atmosphere. [1, 2]

2. Experimental setup

A plasma jet was set up in a chamber and working in nitrogen atmosphere in order to avoid oxidization, as shown in Fig.1. The plasma jet was jetted out from a quartz nozzle. A Cu wire 1 mm in diameter was employed as a source for the deposition and inserted into the quartz nozzle. A 4-turns solenoid coil made of Cu tube was wound around the quartz tube. The plasma was ignited by applying RF power of 300 W to the coil after plasma-gas introduction. The inserted Cu wire was heated and evaporated by plasma, and then Cu film was deposited on polyimide substrate from the nozzle tip of 1 mm.

3. Results and discussion

To dicuss the effect of nitrogen backgroud gas on plasma characteristics, the optical emission spectroscopy (OES) measurement was performed. The effects on Cu film quality were studied by means of X-ray photoelectron spectrometry (XPS) , stylus profiler and scanning electron microscope (SEM). By replacing air to nitrogen, it was confirmed by XPS that a high purity Cu film was synthesized, without the oxidization of Cu film. The thickness of Cu film was also verified to be increased by stylus profiler. All the plasma properties and the results of Cu film would give us an insight on the mechanism and the possibility of improving the process.

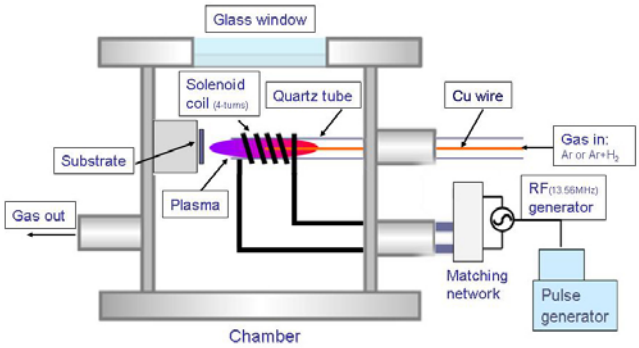

Fig. 1 The schematic of the RF-driven APPJ in chamber

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