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Deposition of high-purity Cu films on polyimide by RF atmospheric pressure plasma spraying in N_2 atmosphere

窒素雰囲気下でのRF駆動大気圧プラズマ溶射による 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 driven by a 13.56 MHz RF power is developed for high-purity Cu films coating on polyimide. Pure Cu micro-powder was injected into the quartz tube by a powder feeder with plasma gas, and sprayed by plasma jet on polyimide substrate in a chamber full of nitrogen. Optical emission spectra obtained during coating by different plasma gas reflected the different chemical reaction. Cu film coating was characterized with XPS, SEM, stylus profile and four-probe meter. 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

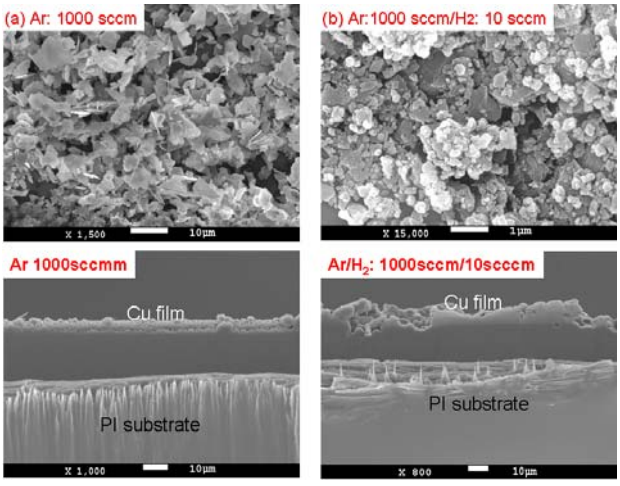
For fabrication of future flexible electronic devices, an atmospheric pressure plasma jet (APPJ) driven by RF power is developed for high-purity Cu films coating on polyimide. In previous studies, we found that by adding H_2 gas into Ar APPJ and working in N_2 atmosphere, quality of Cu film was significantly improved. Furthermore, in order to improve Cu film depositing rate, we developed a no-electrode plasma-spray technology for pure metal coating on polyimide at low temperature. [1]

2. Experimental setup

A plasma jet was set up in a chamber and working in nitrogen atmosphere in order to avoid oxidization. The plasma jet was jetted out from a quartz nozzle. Micro Cu powder was employed as Cu source and was injected into the quartz tube by a powder feeder with plasma gas. A 4-turns solenoid coil made of Cu tube was wound around the quartz tube. The plasma was ignited by applying RF power of 200 W to the Cu coil after plasma-gas introduction (Ar: 1000 sccm, or Ar/H_2: 1000 sccm/10 sccm). The inserted Cu powder was sprayed by plasma, and then Cu film was coated on polyimide substrate from the nozzle tip.

3. Results and discussion

To discuss the effect of Cu power, H_2 addition and Nitrogen background gas on plasma characteristics, the OES measurement was performed. The effects on Cu film quality were studied by means of XPS and SEM. After H_2 addition, it was found that the Cu granular grew more densely and the number of voids decreased, as shown in Fig. 1. It was also confirmed by XPS that a high purity Cu film was synthesized without the oxidization. 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.



(a) (b)

Fig.1. SEM of surface and profile of Cu film coated on polyimide by (a) Ar and (b) Ar/H2 plasmas for 30 s.

References

[1] P. Zhao, W. Zheng, Y. Meng, and M. Nagatsu, J. Appl. Phys. 113, (2013) 123301.