

Surface Functionalization of Fluoropolymers with Amino and Carboxyl Groups by Atmospheric Pressure Plasma Jets with Substrate Biasing

M. Nagatsu^{1,2}, and M. Kimpara²

¹ Shizuoka University, Research Institute of Electronics, Hamamatsu 432-8561, Japan

² Shizuoka University, Graduate School of Integrated Science and Technology, Hamamatsu 432-8561, Japan

Fluoropolymers are difficult materials to modify their surfaces because of the presence of strong C-F and C-C bonds. Surface modifications by low pressure plasma surface treatment have proven to be efficient, but it needs costly high-vacuum systems. In this study, the surface modification of fluoropolymer films with amino- and carboxyl-groups was performed by using atmospheric pressure plasma jet under negatively-biased substrate condition. Ion bombardment effect onto the polymer surface due to negative substrate bias will make dangling bonds and eventually improve the chemical modification on the surface. Functionalized surfaces were analyzed by XPS to confirm the breaking C-F bond and creating C-C or C=O bond. Fluorescence patterns where the fluorescent dyes connect specifically with the amino or carboxyl group, respectively, were clearly observed by fluorescence microscope.

1. Introduction

Fluoropolymers, such as polytetrafluoroethylene (PTFE), perfluoroalkoxy polymer (PFA), fluorinated ethylene-propylene(FEP), etc., have been widely used in various industrial fields, because of their excellent chemical, mechanical and electrical properties. In this study, amino- and carboxyl-group modification of fluoropolymer sheets was performed by using an atmospheric pressure plasma jet (APPJ) under a negatively-biased substrate condition.^{1,2} With negative biasing, ion bombardment effect on the polymer surface will serve to modify the surface with functional groups more efficiently.

2. Experimental setup and results

In this experiment, PTFE films with a thickness of 50 μm or 1 mm were used. The PTFE film was fixed on the stage by a carbon tape and was masked by a Cu grid, as illustrated in Fig. 1(a). The APPJ plasma was generated by applying a high voltage of ± 8 kV with a frequency of 5 kHz and duty ratio of 50% to the electrodes. Fluoropolymer films were modified by two types of functional groups by changing gas species. While He/NH₃ gas mixture was used for amino group modification, He/O₂ gas mixture was used for carboxyl group modification. Figs. 1(b) and (c) show fluorescent microscope images of PTFE surface after amino- and carboxyl-group modification, respectively. Fluorescence pattern shows clear modification in the maskless area. Figure 2 shows the XPS spectra of C 1s and N 1s of amino group modified PTFE surface. It is clearly seen that the CF₂ peak intensity dropped to generate C-C or C=O bonds after plasma treatment, and NH₂ at ~ 400 eV peak was appeared. The details

of other experimental results will be presented at the conference.

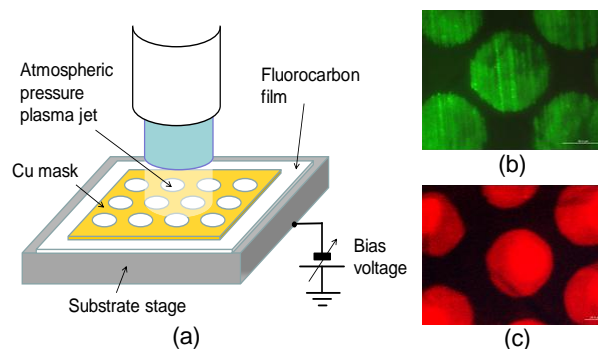


Fig. 1 (a) Experimental setup of APPJ, and fluorescence images of (b) amino group and (c) carboxyl group modification, respectively.

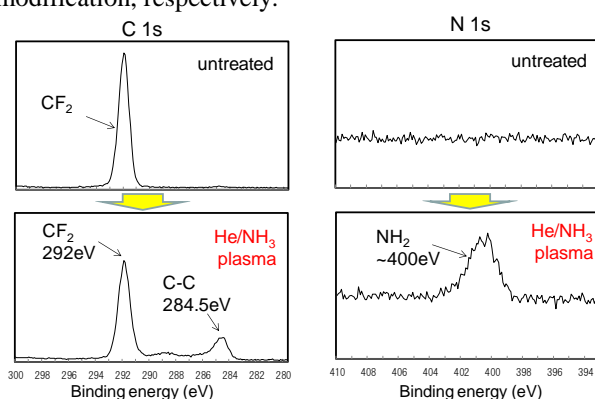


Fig. 2 XPS spectra of C 1s and N 1s for untreated and H/NH₃ plasma treated PTFE films.

References

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- [2] T. Abuzairi, M. Okada, S. Bhattacharjee, M. Nagatsu, Appl. Surf. Sci. 390 (2016) 489-496.