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Plasma Irradiation Technology for Direct Bonding of Plastic Films – Contact Angle and Bonding Strength

°Miyoshi Yokura[1,2], Toshiki Mori[1], Kenichi Uehara[1], Yukiko Izumi[3], Kumiko Takahashi[3], Shigehisa Tomita[3], Hiroaki Nishikawa[4], Satoru Kaneko[5], Yoshinobu Nakamura[6], and Tamio Endo[1]
Mie University[1], APC Co., Ltd.[2], Toray Research Center[3], Kinki University[4], Kanagawa Ind. Tech. Center[5], University of Tokyo[6],
E-mail: miyokura@tree.odn.ne.jp

1. Introduction

Polymer films such as PP and PET are widely used. PET films are used for electrical insulating sheets in motors and flexible electronics. There are many demands to use plastic films in laminations. Usually they use adhesives for the laminations. We have developed a technique of direct homo- and hetero-bondings of various plastic films by the plasma irradiations as demonstrated in Fig.1. PET films can be bonded eight years after the plasma irradiation, indicating the plasma-irradiated activated surface has long lifetime. It is inevitable to clarify the origin of long lifetime as well as the bonding mechanism, then we investigated effects of soaking of the irradiated PET films in liquid reagents before the heat-press bonding.

2. Experimental Processes

PET film was attached on the rotating drum electrode in the plasma irradiation chamber shown in Fig.2. CO_2 gas was introduced into the chamber and discharged. The plasma irradiated films were soaked in various liquid reagents; pure water, acid, alkali, organic solvent, and ionic solutions. After that the samples were heat-pressed to make the bonding. We measured the bonding strength by 180° peel strength *S*p. The surface activation was estimated by pure water contact angle θ. The chemical bonding state was characterized by XPS and FTIR.

3. Results and Discussion

The contact angles after soaking the samples in the reagents are shown in Fig.3. The peel strengths after heat-press are also shown in Fig.3. The non-irradiated sample shows a large angle, low-activated surface, then no bonding. The plasma irradiated sample shows a small angle, high-activated surface, then strong bonding. The angle becomes larger for water-soaked sample, but still it has strong bonding. When the sample is soaked in $AlCl_3$ and $FeCl_3$, the angle becomes more large (inactive), then it has no bonding. It should be expected that the plasma-created OH and COOH are reacted with Al and Fe ions, then they are removed away from the surface. The XPS shows the Al and Fe peaks on the surface, supporting these reactions. Thus the bonding mechanism is related to OH and COOH. The water has less effect on the surface activity and bonding.

Fig 1.

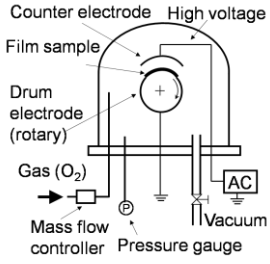

Fig 2.

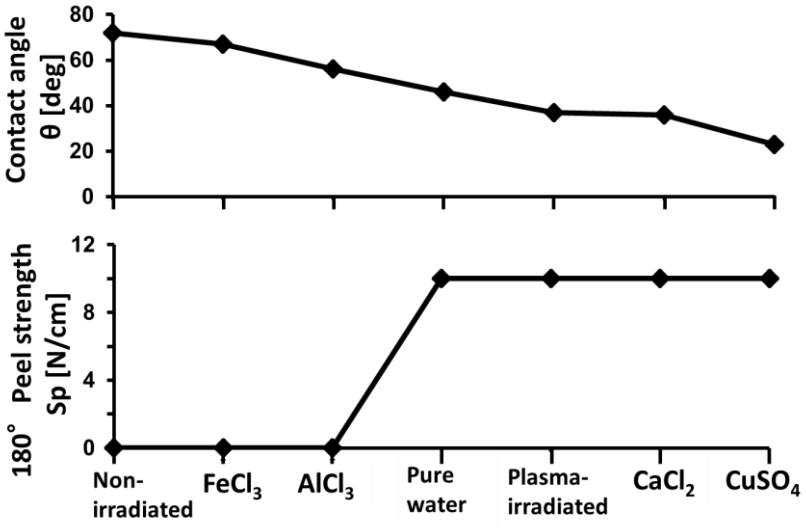

Fig 3.