TIGHT BONDING BETWEEN GLASS AND OXYGEN-PLASMA TREATED POLYESTER FILM

Miyoshi Yokura[1,2], Takuro Hayashi[2], Hisashi Katsumata[2], Guo Xiang[1], Tatsuya Yoshii[1], Masahito Matsui[1] and Tamio Endo[1]

1) Graduate School of Engineering, Mie University, Tsu, Mie 514-8507, Japan
2) Kawamura Sangyo CO., LTD., Yokkaichi, Mie 512-8052, Japan.

Introduction

Glass materials are very important in our usual lives, however they have inferiorities such as heavy and fragile. One simple solution is to develop new glass materials with light and nonfragile natures, the other is to obtain new composites made of glass and flexible plastic materials.
Biaxially oriented polyethylene terephthalate (PET) films have strong merits such as high mechanical strength, high electrical insulation and high heat resistance [1,2]. They have low cost productions.
A high transparency is an essential condition when they are used as the composite materials with the transparent glass. The glass plate and PET film composite can be used for building and automobile windows. A technology of bonding between the glass and PET films has a key factor. We hope to avoid using any glues. Then it is necessary to develop new technologies which can realize direct bonding between glass and PET films.
We tried to bond two sheets of PET films without glues, and found that oxygen-implicated plasma exposure was effective [3], and they could be bonded with, for instance, glasses at low temperatures.

Experimental

Plasma equipments and irradiation
It has been known so far that unique chemical reactions occur on the surface of polymer resins when they are irradiated by plasma. However, the effects are usually kept only in short periods, say one week at most [4]. We tried to obtain the plasma equipment system which assures persistent effects of the plasma modifications [3].
PET polymer films (Lumirror, Toray) were used as the flexible plastic samples, those have 100 mm width, 200 mm length, 100 μm thickness and surface roughness of around 0.46 nm. As the glass sample, SLIDE GLASS (ASONE) was used. It is a float glass having 20 mm width, 75 mm length and 1 mm thickness.
The plasma system with bell-jar type vacuum chamber is shown in Fig.1. The PET sample was irradiated by the oxygen plasma for around 10 sec with energy of E=200 W·min/m^2. It should be noted that the glass sample is not irradiated by the plasma.

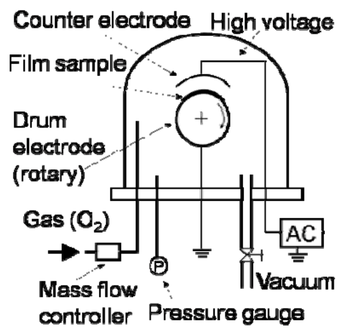

Fig. 1 Plasma irradiation system. Sample film is attached on the rotating drum electrode. Plasma is generated between the drum and counter electrodes.

Bonding process and sample characterizations
The glass sample was lapped with the oxygen plasma treated PET film with its irradiated surface faced to the glass surface, then they were pressed at 100 kg/cm^2 at various pressing temperatures Tp for 10 min using a press machine. Bonding strength was measured on the laminated sample using a peel test machine based on the JIS-C2151 standard. It gives 180°-peel strength Sp. The surface morphologies were observed using AFM. The sample surface was chemically analyzed by XPS.

Results and Discussions

Bonding
The result of 180°-peel strength Sp (N/cm) is shown in Fig.2 as a function of Tp. We can find that they can be directly bonded at Tp=70℃. This temperature is lower than the melting point of 258℃ for PET. However the laminated PET is flaked off easily in high moisture environment.

Surface chemical analyses
AFM surface morphology and a sectional profile of the glass are shown in Fig.3. The surface roughness Ra is 0.22 nm. The surface roughness of the irradiated PET film was 0.53 nm. They are atomically smooth, then there is no possibility of anchor effect for mechanism of the bonding.

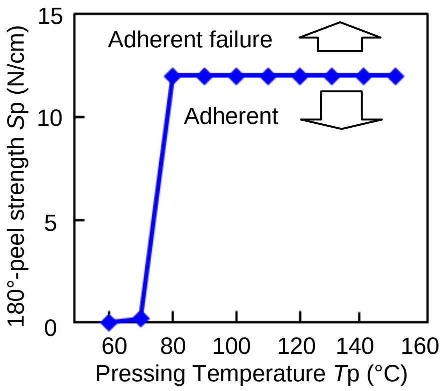

Fig.2 180°-peel strength *Sp* as a function of pressing temperature *Tp* for the bonded glass and irradiated PET film.

The surface of irradiated PET was analyzed by XPS, and the results were already reported by the previous paper [3]. Here we mention just on the results shortly, oxygen-related functional groups, as -OH and -COOH, were detected.

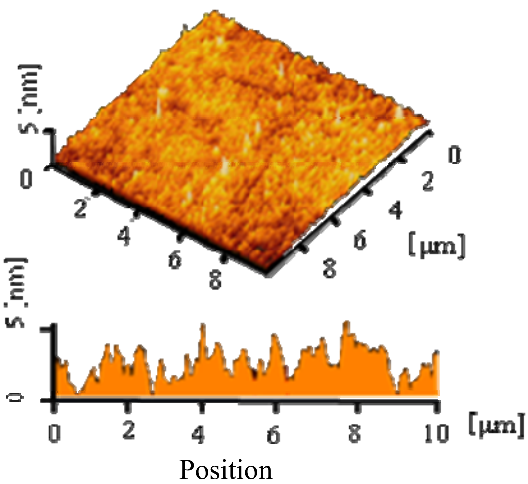

Fig. 3 AFM surface images (upper) and sectional profile (lower) for the used glass sample (Ra=0.22 nm).

The result of XPS for the used glass surface is shown in Fig.4. We found a peak for hydroxyl group (-OH) behind a large C1s related peak. Then OH group exists on the nonirradiated glass surface. Carbon is included in the glass as impurity.

The above results indicate that there is a possibility of hydrogen bond between the glass and the irradiated PET, concerning to naturally existing -OH on the glass surface and chemically active functional groups of -OH and -COOH created by the plasma on the PET film surface. In the case of bonding between the irradiated PET films, we proposed the possible mechanism of condensation reactions. In the present case, however, there is a small possibility of the condensation reactions, because it is easy to be flaked off by the moisture. Normally the bonds induced by the condensation reactions is much stronger (about 20 times) than hydrogen bonds.

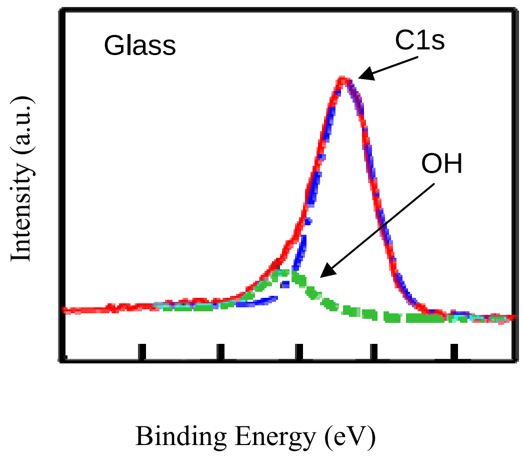

Fig. 4 XPS spectrum for the glass. A peak for OH is behind a large C1s-peak.

Summary

The non-irradiated glass and plasma-irradiated PET film were bonded tightly. Its possible mechanism may be the hydrogen bonds. We, however, have the problem of easy flaking by the moisture. It is already solved now, then we will report it by the next paper.

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