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Electroless Ni Plating on PC to Improve Adhesion by DBD Plasma Treatment

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The adhesion strength of metal plating on PC was studied. In this study, surface was treated by chemical agents or DBD(dielectric barrier discharge) plasma to imporve the adhesion. The surface roughness, contact angle, gloss of plating and adhesive strength were measured. Adhesion strengths of Ni plating on prepared PC by NaOH and KOH solution were 12.3 kgf/cm^2 and 7.5 kgf/cm^2, respectively. The highest adhesion strength was obtained in the plasma treated one, 27.8 kgf/cm^2.

Keywords *: electroless Ni plating, polycarbonate, plasma treatment, adhesion.*

1. Introduction

PC(polycarbonate) has a high transmittance, a good mechanical properties, low density and cost-effectiveness. So, it have been applied in industrial materials such as bio-engineering, optics, electronic parts, etc.[1] The application of polymer for the wireless communication parts has been limited due to the electromagnetic interference (EMI).[2] The metal plating could be a solution for it. Since plating on polymer has poor adhesion, chemical treatment should be done for good adhesive strength. However, chemical preparation causes environmental pollution, problem of bath control and deterioration of polymer. Plasma treatment, an environmentally-friendly process, modifies polymer surface without a damage.[3]

In this work, dielectric barrier discharge(DBD) plasma was employed to substitute chemical treatment to improve adhesion. The effects of plasma treatment on the contact angle, surface roughness, morphology, gloss and adhesion were studied.

2. Experimental procedures

2.1 Injection of PC

PC(polycarbonate) polymer was used as a substrate. They were made in Samyang Kasei. Co., Ltd, grade 3022IR.

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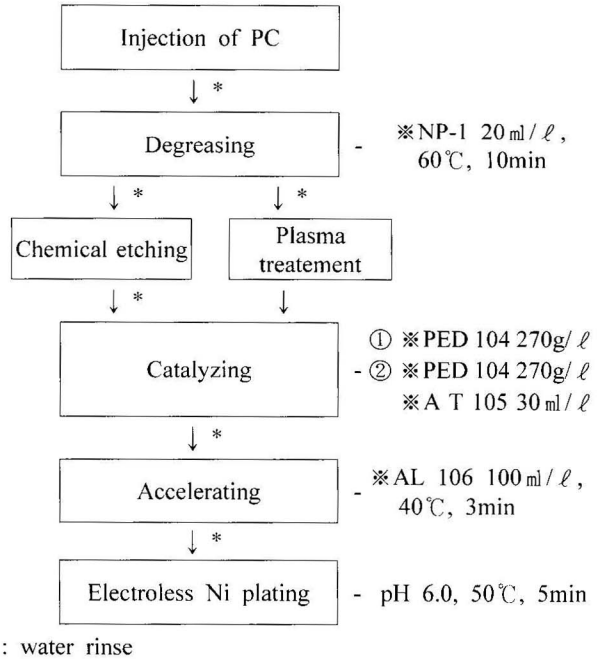
2.2 Specimen preparation for plating on PC

Fig 1. shows the flow chart for electroless Ni plating on PC. In the figure, the compositions of baths in each step are included. Before plating, chemical ethching or plasma treatment were employed as a surface preparation process.

For chemical etching, chemical solutions containing



* : water rinse
※ NP-1: Solution of KPM tech. Co., Ltd.
※ PED 104, AT 105, 106: Agents of Uyemura & Co., Ltd.

Fig. 1. Schematic diagram of Ni plating process.

Table 1. Compositions of electroless Ni plating bath[5)]

Bath composition		
Nickel sulfate	$NiSO_4$-$6H_2O$	29 g/ℓ
Reducing agent	NaH_2PO_2-H_2O	25 g/ℓ
Complexing agent	$C_6H_8O_7$	15 g/ℓ
Accelerater	CH_3COONa	5 g/ℓ
Stabilizer	$PbNO_3$	2 ppm

either NaOH or KOH, 750 g/ℓ were used,[4)] as a etching agents. For plasma treatment, DBD plasma were employed in the atmosphere of He 3slm or He 99%(3slm) with O_2 1%(0.03slm). The operating conditions were 500 eV, 1.10 A, 0.008 m/s(feeding speed), from 5 to 30 pass. Catalyzing consists of two steps that soaked solution ① at 35℃ and immersed agent ② at 45℃.

2.3 Measurements and test

Contact angle and roughness of treated PC surface were measured by wettability tester(SEO 300A, SEO. Co., Ltd), AFM(XE-100, PSIA. Co., Ltd), surface profiler(ET3000). The contact angle with distilled water was measured in 1000 class clean room at 18℃ and 40% humidity. Adhesion test were performed according to pull test(ISO 4624) and tape test(ASTM D3359) after boiling for 1h at 100℃.

3. Results and discussions

3.1 Contact angle

As increasing etching time and the number of pass of plasma treatment, contact angle of PC surface was decreased. Etching by NaOH solution showed the increase of wettability and surface energy than a treatment in KOH agent. However, roughness of plasma treated substrate showed the low contact angle compared with chemical treated PC. And surface energy of $He+O_2$ plasma treated PC was higher than He plasma. The contact angles compared in Fig. 2.

3.2 Surface topology and roughness

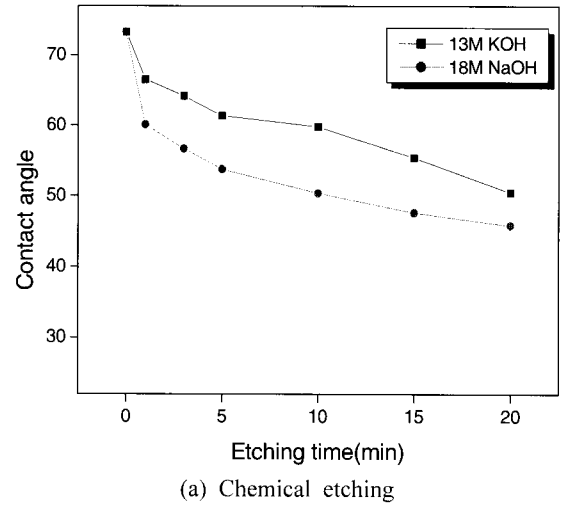
The surface topography of prepared PC was measured by AFM after etching or plasma treatment, in order to observe the topographic changes of the surface. Morphology and roughness of chemical and plasma treated PC surface were shown by Fig. 3 and 4. Fig. 3 shows AFM images obtained at 200 nm × 200 nm scanning size. RMS of the untreated PC showed a smooth surface(15nm). After immersion of PC in KOH solution for 1min at 60℃, many holes(∅: 0.4㎛, depth: 15㎚) on surface were observed. In the case of plasma treated PC, roughness of substrates (RMS) showed 15.2 nm, He plasma treatment, 32.2 mm, $He+O_2$ plasma treatment, respectively.

As shown in the Fig. 4, when PC was etched in chemical solutions, roughness was increased with the increase of etching time. However, when substrate was treated by plasma, RMS roughness change was not noticeable with the increase of plasma pass, which is equivalent to plasma treatment time.

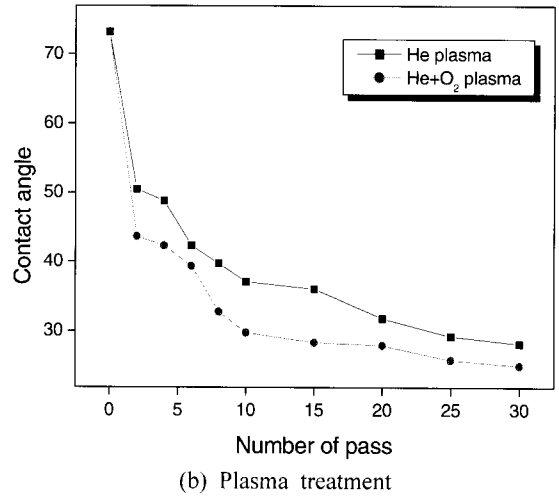
3.3 Adhesion

3.3.1 Pull test

The test was conducted by miro-load frame in accordance with ISO 4624 with 100N capacity load cell at the head speed of 8 mm/min. The specially designed T-shape attachments, made of PC, were employed in this test. The bonded area to the Ni plating was 10×10 mm^2. As shown Fig. 5, to prepare this test, two of attachments were bonded on both planes of plated PC by Araldite(Huntsman

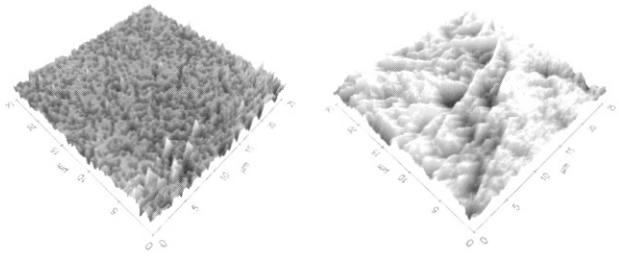


(a) Chemical etching

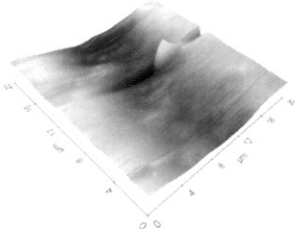


(b) Plasma treatment

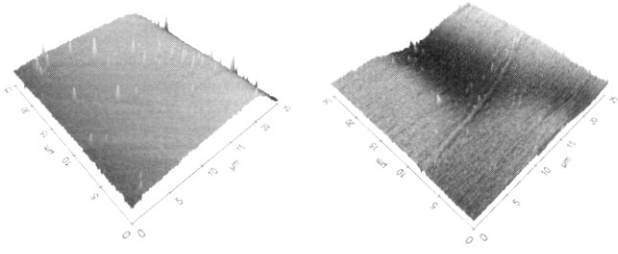
Fig. 2. Contact angle of PC surface by etching and plasma treatment.



(a) Immersed in KOH solution (b) Immersed in NaOH solution

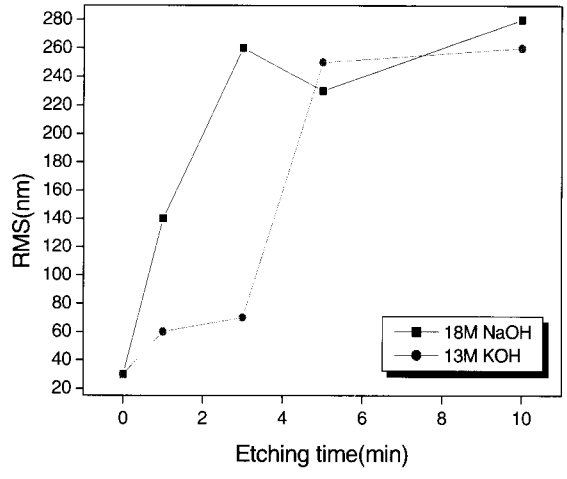


(c) Normal PC surface

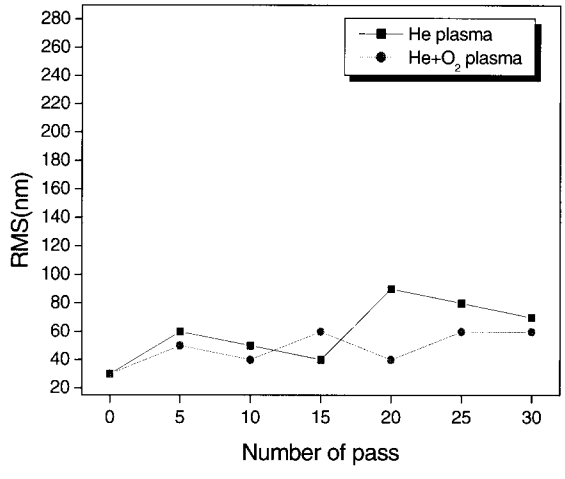


(d) He plasma treatment (e) He+O_2 plasma treatment

Fig. 3. 3-D images of prepared PC's surface.



(a) Chemical etching



(b) Plasma treatment

Fig. 4. The roughness of treated PC by chemical and plasma.

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In the absence of plasma treatment, adhesive strength was 7.5 kgf/mm^2 in the sample of treated with KOH while PC prepared with NaOH was 12.3 kgf/mm^2. In the case of plasma treated PC, adhesion of between Ni plating layer and PC surface showed 27.8 kgf/mm^2.

3.3.2 Boiling and peel test

In the tape test, Ni plating showed 5B except two of conditions that etched in NaOH or KOH solution at 60℃ for 1 min. The test fail to explain the effect of pretreatment on the adhesion strength. The boiling test was chosen to get quantitative data of adhesion. All plated samples were immersed in boiling water at 100℃ for 1hr. And adhesive strengths were measured by tape test after drying.

The result of tape test after boiling test of Ni plated PC are shown in Fig. 7. The adhesion of Ni plating on PC increased as etching as well as plasma treatment time. Adhesive strength of plasma treated PC was higher than chemically treated PC. It was considered that plasma

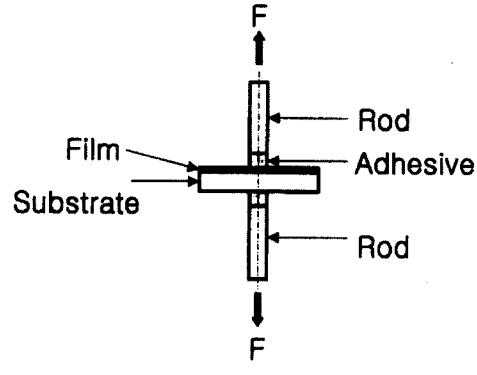

Fig. 5. Schematic diagram of pull test.

treatment lower the roughness and contact angle on the surface of PC compared to the chemical etching. It must be abundant sites of palladium nucleation on PC by

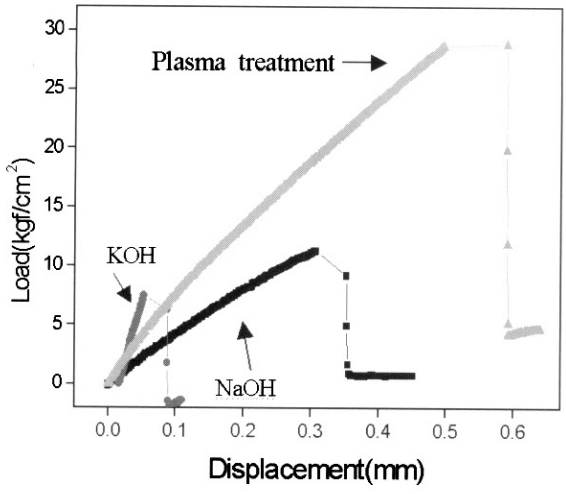

Fig. 6. Adhesive strength of plating layer on PC by pull test.

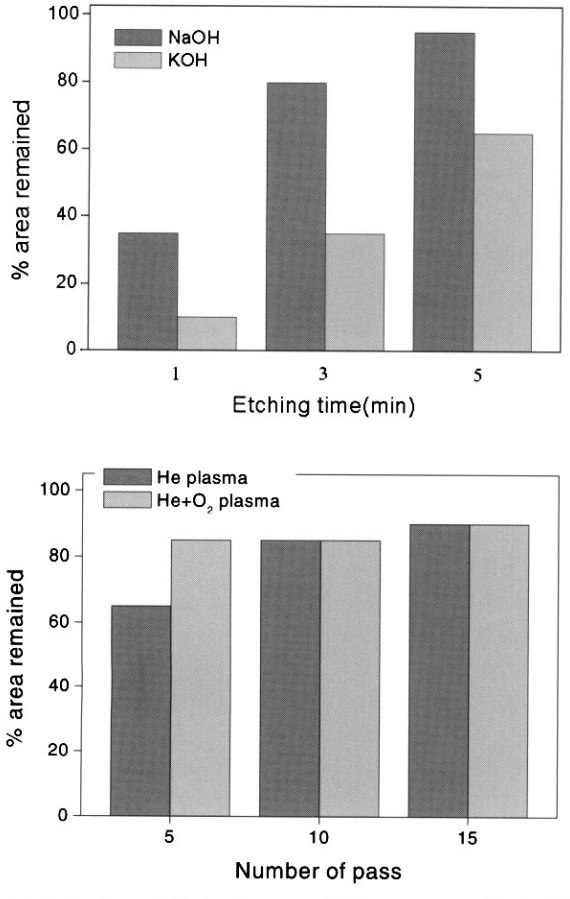

Fig. 7. Adhesion of plating layer on PC by tape test after boiling test.

cleaning. Therefore, adhesive strength was improved by plasma treatment than chemical etching.

4. Conclusion

1. By increasing etching and plasma treatment time, wettability of PC's surface was increased.
2. PC substrates had a fine surface by plasma treatment.
3. Adhesive strength showed 27.8 kgf/mm^2 for plasma treated PC, while 12.3 kgf/mm^2 and 7.5 kgf/mm^2 for NaOH and KOH solution etched PC, respectively, by pull test.
4. The adhesion of DBD plasma treated and Ni plated PC were better than chemical treated PC.

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