The Study of Wettability by Nitrogen Ion Beam Treatment into Aluminum Surface

Chan Young Lee, Jae Sang Lee, Hyuk Jun Choi, Ji Yun Song
Proton Engineering Frontier Project, KAERI
chlee@kaeri.re.kr

1. Introduction

Aluminum and its alloys have superior characteristics of lightness, strength, machinability and surface treatability. Aluminum is the most widely used material in many applications due to such above properties. Surface modification for the improvement of hydrophilic property of most metals can be accomplished through coating techniques, such as anodization. But, Such coatings methods gives to limitation to attempts to extend the application field because of defects or poor adhesion. Therefore up to date, many extensive studies have been performed to improve the wettability of surface such as corona discharge, plasma discharge and other techniques.

In this study, we have investigated the change of contact angle at surface as well as structural modifications and mechanical properties of aluminum implanted by nitrogen ions with different energies and different fluencies.

2. Methods and Results

In this paper, ion beam irradiations were performed for commercial pure aluminum (Al 1050) in order to investigate the surface hydrophilic property through a contact angle measurement using distilled water. Aluminum nitride (AlN) layer was formed by nitrogen, ion beam treated into aluminum with a high dose range 1E17 ~ 1E18 ions/cm^2 at the irradiation energy of 20 ~ 40keV.

Square specimens (30mm x 60mm) were cut from a 0.3mm thick sheet of Al 1050. The specimens were cleaned with alcohol before ion beam treatment. Ion beam treatments were carried out Ion Beam System which was manufactured by PEFP (KAERI) technology [1]. During the ion beam procedure, the vacuum was kept at a 5x10^{-5} Torr due to beam quality and beam profile which is related to beam dimension and current density was measured by Faraday cup and the current density was kept at 30μA/cm^2. After ion beam treatment, the contact angle was measured by sessile drop method. Furthermore, through XPS (X-ray Photoelectron Spectroscopy) analysis, we noticed that the implanted nitrogen ions increase the formation of AlN layer. And the composition of nitrogen ion beam treated aluminum alloy and nitrogen ion distribution profile were analyzed by Auger Electron Spectroscopy (AES).

2.1 Contact Angle measurement

Wettability is one of the most important factors for investigating hydrophilic property and generally, its change is carried out by contact angle measurement. The contact angle of water for the untreated Aluminum (Al) surface is about 92°. The contact angle was measured for 30 days consistently in the air (below humidity 40%) considering aging effect. Figures 1 show the change of surface contact angle with different energies and fluences. Contact angles after ion beam treatment were reduced to around 20~40°.

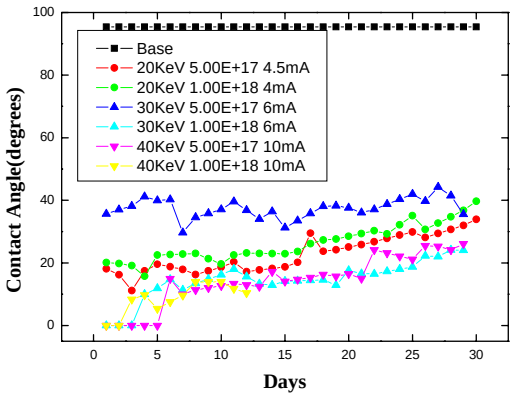

Fig. 1. The changes of contact angle according to time before and after ion beam treatment (in the air).

2.2 XPS analysis

XPS analysis is a particularly powerful tool for the investigation of AlN(Aluminum Nitride) formation and we used XPS depth profiling for investigation of the aluminum surface layer [2]. A series of Al 2p spectra for different depths (sputtering times) for an Al 1050 sample, ion beam treated at 40 keV energy and 5x10^{17} ions/cm^2 fluence, is shown in Figure 2. This enables the determination of different chemical species. An aluminum peak shows at a binding energy of 72.8 eV. And AlN layer which is implanted nitrogen is from 73eV to 74.8eV and the thickness of 1.2μm was anticipated.

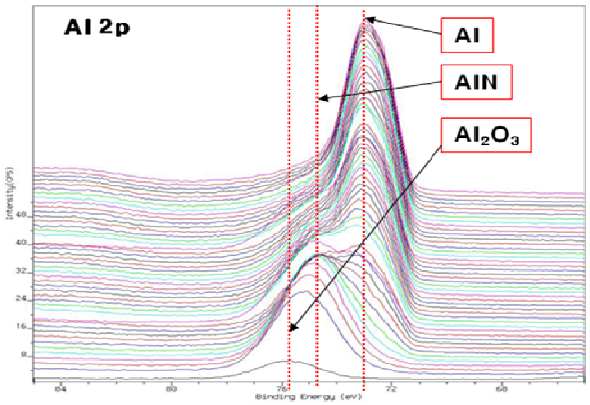

Fig. 2. A series of Al 2p spectra for different depths profile under ion beam conditions of 40 keV energy and $5x10^{17}$ ions/cm^2 fluence

3.3 AES analysis

The AES(Auger Electron Spectroscopy) analysis indicated the formation of AlN by nitrogen ion beam treatment and the AlN was formed in the surface region within the nitrogen ion range. The AES depth profile of each element for ion beam treatedsamples is shown in Figure 3. where the treatment time was 2h with fluence of $5x10^{17}$ ions/cm^2. As seen in Fig. 1,implanted nitrogen shows a roughly Gaussian profile, with concentration at the very surface. We anticipated AlN formation at the surface is effect to the improvement of wettabiltiy.

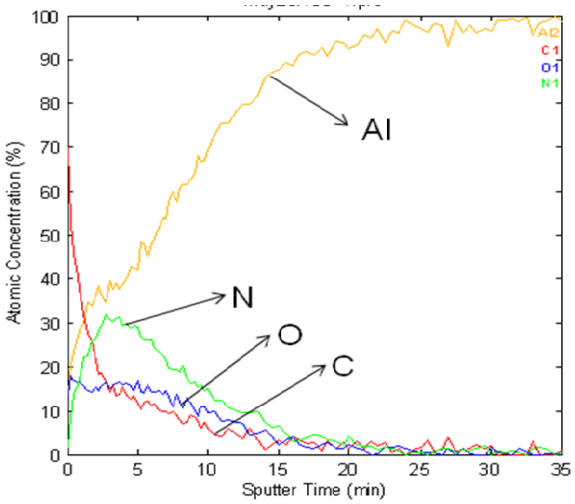

Fig. 3. AES depth profile of each element for ion beam treatment sample (energy : 40keV, fluence : $5x10^{17}$ ions/cm^2 , exposed to air)

3. Conclusions

Nitriding of aluminum surface by ion beam treatment gives hydrophilic property. The thickness of the AlN layer depends on the ion energy and target temperature. Radiation enhanced diffusion effect leads to changes of the surface constitution during ion beam treatment. The wettability of aluminum was improved by ion beam treatment with various ions and energies. Results are as follows.

(1) The contact angle of hydrophobic aluminum surfaces were remarkably up to around 20º by ion beam treatment.

(2) We obtained results that formation of AlN layer and thickness effect to wettabilty of Al surface through XPS and AES analyses.

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