Surface hardness characteristics change of dual ion implanted electroless Ni-P / Al7075

Chan Young Lee*, Dong-Seok Kim, Myung-Hwan Jung, Yong Seok Hwang, Chorong Kim, Jae Kwon Suk, Sunmog Yeo and Jae Sang Lee
[a]*Korea Multi-purpose Accelerator Complex, Korea Atomic Energy Research Institute, Gyeongju 34057, Korea*
**Corresponding author: chlee@kaeri.re.kr*

1. Introduction

Electroless Ni-P plating technology is widely used in the electronic parts industry, automobile / aviation industry, and industrial machinery for the purpose of preventing corrosion, excellent hardening, increasing lubricity, and improving adhesiveness. In the United States, Japan, and European countries, energy reduction by weight reduction of products, high value-added through various functional characteristics, and long-life cost reduction technology development are concentrated [1].

In this study, a basic study on ion implantation was performed to improve the durability of the core element parts plated with Ni-P constituting an automotive painting system. The painting system across industries including automotive parts, home appliances, and shipbuilding parts is Bell atomizer, Bell cup, CCV (color change valve), paint transfer device, static electricity generator, and various other types. Among these, the electroless Ni-P plated bell cup has high wear due to the high-speed spraying of the paint and a short replacement cycle, causing problems in productivity. It is necessary to develop a technology for improving durability that can extend the useful life without changing dimensional tolerances while maintaining the basic performance of Ni-P. Accordingly, the ion beam was irradiated to the Ni-P plated Aluminum sample by using the ion beam facility in KOMAC (KOrea Muliple Accelerator Complex). It was confirmed that the surface hardness value increased from 8 GPa to 16 GPa after ion implantation. In addition, a field test was preformed using an automotive painting system to check the durability change before and after ion implantation for prototype bell cup.

2. Methods and Results

2.1 Material basic Analysis & sample preparation

Since the Bell cup supplier keeps all information about the Bell cup private, the substrate and plating information (thickness, material composition, plating type etc) are not disclosed at all. Therefore, the basic physical property analysis of the material was performed by using a non-contact analysis method for the prototype. The plating thickness, substrate material, and plating compositions of the prototype were confirmed by XRF (X-ray fluorescence). The accuracy of the analysis was improved by reconfirming the substrate material and plating components through SEM-EDS. Analysis results are as follows:

- Substrate material: Al7075 (T6)
- Plating type: Electroless Ni-P plating(NP-1900)
- Ni-P plating thickness: about 5μm

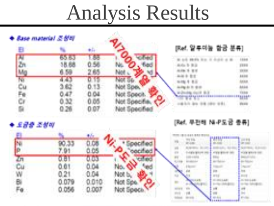
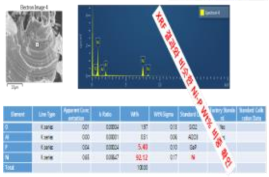
	Analysis Results	Analysis device
Portable XRF (Substrate material & plating type)		
SEM-EDS (Substrate material & plating type)		
XRF (Plating Thickness)		

Fig. 1. Material basic analysis

2.2 Dual Ion beam implantation for surface treatment

Metal ion and reactive gas ions were implanted on the Ni-P plating layer by a dual ion beam to perform a basic surface treatment study with superior corrosion resistance, abrasion resistance, and high hardness [2,3]. The implantation experiments for Nano-indentation measurement was carried out using a 150keV / 1mA metal ion beam facility and 200keV / 1mA gas ion beam facility in KOMAC shown in Figure 2. Irradiation conditions were as follows:

- Metal ion beam: Cr^+, 140keV, 1E16#/cm^2
- Gas ion beam: N_2^+, 90keV, 1E17#/cm^2

Metal Ion beam facility	 *Irradiation Conditions : Cr^+, 140keV, 1E16#/cm^2*
Gas Ion beam facility	

Fig. 2. Metal and Gas ion beam facility at KOMAC

The vacuum pressure was about 10-6 Torr. The Electroless Ni-P plated Al7075 specimens of 1.5cm x 1.5cm x 0.5cm for nano-indentation measurement were mechanically polished to achieve an optically flat surface.

2.2 Nano-indentation

To identity surface hardness change for ion implantation, Nano-indentation was carried out. This allows the hardness and elastic modulus to be measured as a function of indentation depth without the need for running multiple load-unload cycles. Figure 3 shows the depth dependence of the hardness before and after ion implantation under R.T conditions. The slopes became gentle over the indentation depth of 150 nm. The ion beam irradiation induced hardening in Ni-P/Al7075. The hardness gradually decreased with increasing depth and became close to the un-irradiated values, which can be explained that the plastic region by the indentation penetrates the damaged area and the contribution of the irradiation hardening becomes less at the deeper depth.

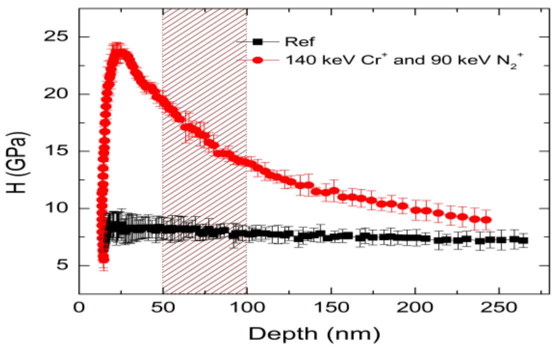


Fig. 3. Nano-indentation result before and after ion implantation

3. Conclusions

Overcoming the limitations of physical properties of lightweight materials and improving durability are very important in terms of cost reduction and preservation of finite resources through the long life of related parts and materials.

In this study, dual ion implantation (metal and gas ion) was performed at room temperature to improve the surface hardness Ni-P/Al7075(T6). As results, surface hardness was improved from 8GPa to 16GPas in range 50~100nm depth. In the future, we will perform research on changes in mechanical properties such as friction coefficient and surface hardness corrosion resistance according to various ion beam irradiation conditions (by energy, ion species and ion fluences etc.)

4. Acknowledgments

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