POLYMER'S SURFACE RESISTIVITY IMPROVEMENT USING BY ION [1]

J. H. Ha, Y. S. Cho, B. H. Choi, J. H. Lee, Jae S. Lee, S. J. Lim
KAERI, Taejon, Korea, 305-600

Abstract

We studied the relation between bombarded nitrogen fluence and surface resistivity on the polymers. Especially, we investigated the MPPO (Modified Polyphenylene Oxide) material, which are used for the semiconductor package and transportation tray. During the transportation, the electrical charges induced on the tray surface and it generated the electrical shock to the semiconductor chip. To prevent such damage, we developed the surface treatment to decrease the surface resistivity from 10^{12} up to 10^{6} Ω/sq on tray.

1 INTRODUCTION

Conducting polymers are material of considerable interest for a wide variety of application, such as coatings for protection against electrostatic effects and for electromagnetic shielding, or the production in the future of interconnections in electronic circuits[1,2].

Ion implantation method is world-widely used for high quality semiconductor production, and development for new materials to have special properties [3,4]. Ion implantation technology, which is one of ultramodern technologies, can be used in enhancing chemical and physical properties of materials, such as anti-corrosion, wear resistance and electrical conductivity. Comparing with conventional surface modification technologies, it does not generate toxic wastes, which can threaten the environment. It provides precise control of surface thickness and strong adherence of surface material. Therefore, this technology will be used in surface modification along with steady improvement of ion implantation technology.

This study is intended to transfer KAERI's ion beam technologies to a domestic company so that it can commercialize MPPO modified material for anti-electrostatics. At present, due to high price and low productivity of ion implanter, the technology is used limitedly for high value-added products such as aircraft components, precision machineries, artificial bones, etc. This study is specially focused on manufacture of low price ion implanter and developing anti-electricity material by post-treatment with ion beam implantation method.

[1] Work supported by mid- and long- term project (Project No. 53564-00) of the Ministry of Science and Technology in 2000.

2 A SIMPLE GAS IMPLANTER

The simple gas implanter is designed to applied rather low price material compared with semiconductor as shown

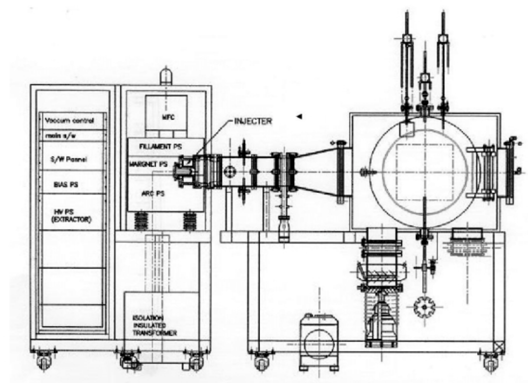

Figure 1: A simple gasimplanter for the commercial mass production of MPPO tray.

in Fig. 1. To achieve these goals, we adopted a simple system without an acceleration tube and an analysing magnet which selects ion species.

It is consisted of duoplasmatron/duopigtron ion source, vacuum system, diagnostic system, power supply, beam transport system, irradiation chamber, targetry and remote control system.

The detail specifications of implanter components are as followings:

- Duoplasmatron Ion Source:
  - Thermal cathode : W Filaments
  - Source Magnet : 10 kG
  - Intermediate Electrode : Mild Steel, Cone Angle of 30 degree
  - Distance between Intermediate Electrode and Anode : 2mm
  - Anode : Mo, 0.8mm dia, 2.38mm depth
- Vacuum System:
  - Dimension : SUS-304, 800mm x 800mm x 800mm
  - Pump : Oil Diffusion, 2000 l/s x 2
  - Ultimate Pressure : 4 x 10^{-7} Torr
- Ion Diagnostics:
  - Scanning Faraday Cup : 5mm dia., 250 Gauss
  - Power Supplies:

- Filament P.S. : DC 10V, 50A
- Magnet P.S. : DC 20A
- Arc P.S. : DC 250, 15A
- Extraction P.S. : 50kV, 100mA

The simple gas implanter can be utilized for developing various types of ion sources through function tests of ion sources as well as for developing sophisticated surface treatment technologies to be used in mass production of small piece products. This implanter designed specially for ion beam treatment of IC tray, which has been planned thanks to preliminary experiments using the simple gas implanter. This implanter does not need additional beam accelerating system, therefore, it can be manufactured with low cost.

3 EXPERIMENT

The nitrogen ions are generated using by duoplasmatron and duopigatron ion sources up to 10mA and accelerated up to 50 keV. The ion source can be considered N^+ and N_2^+ species as according with the plasma generation mechanism of a ion sources. The ion species, therefore, will be measured in near future.

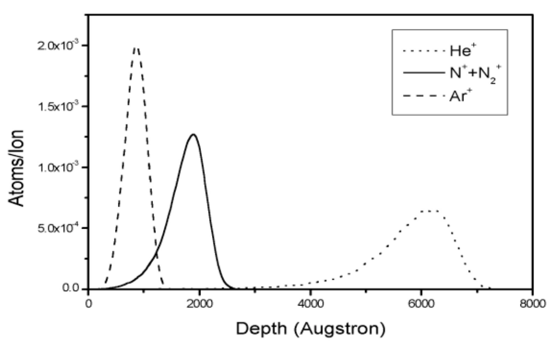

Figure 2: Various ion ranges for MPPO at 50kV energy

The N, Ar and Xe ion ranges with 50 kV acceleration voltage are calculated by using the TRIM code, shareware software, on the MPPO polymer material. The calculation result is shown in Fig. 3, in which nitrogen ions species was considered as mixed with nitrogen atom and molecule.

The beam profile is measured by a linear scanning system based on a Faraday cup with 5mm diameter. The typical profile is shown in Fig. 3. The secondary electrons produced inside the Faraday cup by the primary incident ion beams are suppressed by a magnetic field generated by the toroidal permanent magnet with 250 Gauss static field strength. The measured beam profile is used to calculate an ion fluence irradiated on any MPPO surface position.

We survey the surface resistivity with respect to nitrogen fluence from 10^{15} up to 10^{17} ions/cm^2. The nitrogen ion current irradiated on MPPO keeps 3mA to reduce systematic error, and varied an exposure time. We also measured the critical temperature which produced the mechanical and physical modification of MPPO, which is important our system without an additional cooling system.

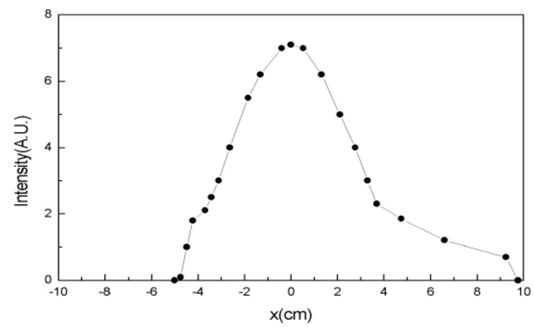

Figure 3: Nitrogen beam profile measured by a Faraday Cup

4 DISCUSSION

We have implanted nitrogen ions onto the surface of the MPPO, and found out that the conductivity is changed from 10^6 up to 10^9 Ω/sq as increasing ion fluence 10^{15} up to 10^{17} ions/ cm^2, which is enough to prevent electrostatics. Fig. 4 is the result of the surface resistivity dependency as a function of irradiated ion fluence.

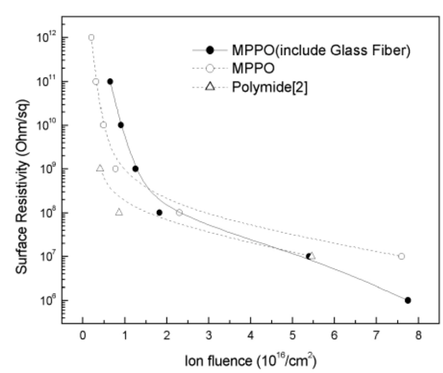

Figure 4: MPPO surface resistivity result as a function of ion fluence

We observed that the surface resistivity is rapidly decreased near 10^{16} ions/cm^2 fluence and saturated over 10^{17} ions/cm^2 fluence. The phenomenon of the decreasing surface resistivity with respect to ion fluence is considered that the CH_3 bonds in polymer are broken by ion irradiation, and result in making carbon layer by unsaturated, chain scission and cross-linking effects. The saturation of the surface resistivity over 10^{17} ions/cm^2 ion fluence means that all of CH_3 bonding are broken, and made a carbon bondings(carbonization), but it is still open question[5,6].

We compared other data of a previous study of polymide polymer, which performed with nitrogen ion and at 50 keV energy[2]. It shows similar tendency with MPPO case, since they are considered as a governed same physical modification mechanism.

We also investigated the mass dependency effect of an implanted ions as showed in Fig. 5. As ion mass increase, the surface resistivity decreases with same ion energy and fluence. It think that the carbonization effect is not related on implanted ion. The function of implanted ion is destruction of molecular bondings, and help the carbon recombination process to produce new carbon layer on MPPO surface.

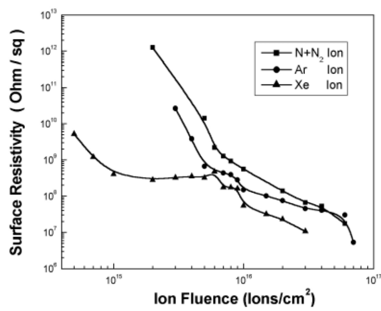

Figure 5: Surface resistivities of Ar, N and Xe ion fluence.

Fig. 6 is the result of depth profile for 50 keV nitrogen irradiated MPPO. The abundancy of a C-N bonding in MPPO changed dramatically as a function of depth upto 3000 Augstron, which did not observed at a pristine material. The other bondings, OH, C-C, are just showed small abundancy fluctuation as a function of depth.

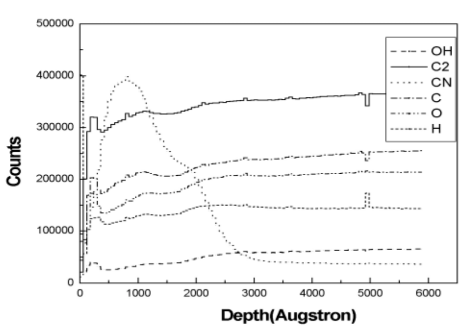

Figure 6: SIMS analysis result for irradiated MPPO with a 50 keV nitrogen

The increasement of C-N bonding is also observed at the XPS analysis. Fig. 7 is the XPS analysis result on MPPO surface as a function of binding energy. The C-N bonding expected at binding energy 287eV which mixed together with C-O-C, C-C and C=0 bondings within energy resolution.

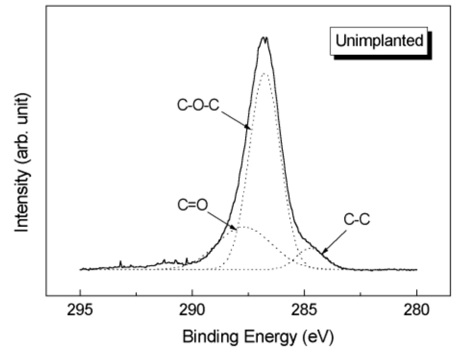

Figure 7: XPS analysis result for MPPO with nitrogen implantation

More studies are need for invastigation of the surface resistivty mechanism.

5 CONCLUSION

Irradiating a low energy ion beam to polymer, specially MPPO, as an electric insulator can change drastically its electric resistivity. The origin of the conductive surface layer has concerned with a formation of C-N bonding in polymer. The SIMS and XPS analysis proposed that a C-N bonding on the MPPO surface is deeply related with surface conductiveiy, but need more study.

The surface resistivity on MPPO is very important to prevent electrostatics for plastics. The semiconductor chip in the tray package can be damaged because of electrostatics. For the mass production we developed a simple gas implanter without acceleration tube and analysing magnet.

REFERENCES

[1] C. B. Duke, J. Vac. Sci, Texhnol, A3 (1985) 732.
[2] J. Davenas, X.L. Xu, G. Boiteux and D. Sage, Nucl. Inst. and Meth. B39 (1989) 754.
[3] J. K. Hirvonen, C. A. Carosella and G. K. Hubler, Nucl. Inst. and Meth 189 (1981) 103.
[4] H. Loh, R. W. Oliver and P. Sioshansi, Nucl. Inst. and Meth. B34 (1988) 337.
[5] G. Marletta, S. Pignataro and C. Oliveri, Nucl. Instr. and Meth. B39, (1989) 773.
[6] L Cakagno and G. Foti, Nucl. Inst. and Meth. B59/60 (1991) 1153.