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Industrial Application of Ion Beams in KOMAC

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1. Introduction

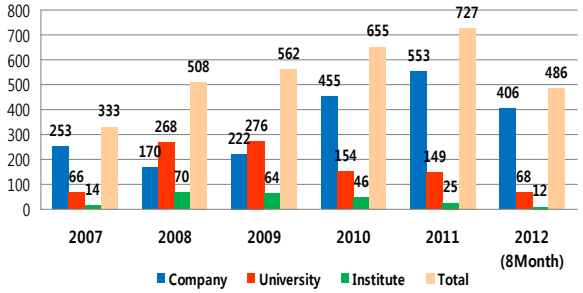
Ion implantation method is world-widely used for high quality semiconductor production, and development for new materials to have special properties [1,2]. Ion implantation technology, which is one of ultramodern technologies, can be used in enhancing chemical and physical properties of materials, such 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.

For the last 5 years, we have performed extensive R&D efforts by ion beam to characterize metallic, ceramic, polymeric materials and have supported users from a broad range of institutions, including a large number of industries. So, in this study, through verification on the industrialization feasibility by experiments, it is going to get it started, with cooperation of participatory company, to enter into markets with developed technology and products.

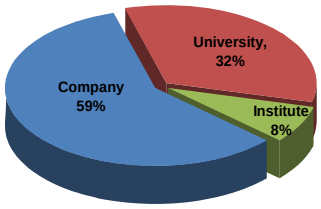
2. Experimental

To supply the ion beams required for either various R&D or industrial applications, we need ion implanters that meet the requirements of 1) precise control of impurity density, 2) accurate control of the depth distribution, 3) uniformity across target materials, and more importantly, and 4) both high-current and large irradiation-area for mass processing. By utilizing accelerator technology, we have developed various ion implanters and irradiators, such as a gas-ion implanter, a dual-ion irradiator, a metal-ion implanter, and high current implanter, which are capable of providing users with a wide variety of ions in terms of species, energy, and current.

For the last 5 years, all the ion implanters have been implemented for beam service, a total of 3,271 ion beam services have been provided for users from a total of 66 institutions. In Fig. 1, (a) shows the statistics of annual ion-beam services and (b) represents the user distribution at their affiliations. As clearly indicated in Fig. 1, the number of ion beam irradiations has dramatically increased, and it should be noticed that a third of the irradiations were performed for industrial users. Some of R&D projects performed by using ion implanters are listed in Table 1, in which each R&D project has an industrial counterpart because it is intended for direct industrialization. Therefore, reviewing the R&D activities, notable R&D is discussed in more detailed.



(a)



(b)

Fig. 1. (a) Statistics of ion-beam irradiation and (b) user distribution.

Table 1. R&D activities by using ion beams

- Alignment properties of liquid crystals by ion beam
- Cu coating cohesion improvement on Metal PCB
- Surface modification of polymer for luminance and anti-UV
- Super-hydrophilic surface modification of cooling-pin

3. Results

Alignment properties of liquid crystals by ion beam

We investigated LC alignment capabilities and variation of pre-tilt angles with Ar^+ ion beam treatment on DLC film. The surface micro-structural change was effected to the liquid crystal cell performance due to the magnitude of their polarity. Ion beam alignment process has good electric-optical curve as well as response time in LCD display.[3] The optimum ion beam condition for LC alignment was 3keV, $3\sim5\times10^{15}$ions/㎠. Using

the ion beam alignment process, 5 inches LCD pilot product manufactured and operation successfully tested. (Fig.2)

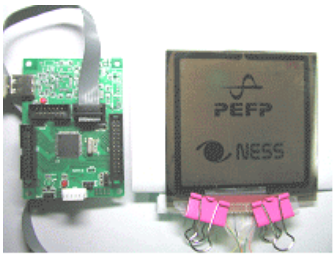


Fig. 2. LCD pilot product by using ion beam alignment process

Cu coating cohesion improvement on Metal PCB

We successfully deposited the thick conductive film(30 ㎛ thickness) of Cu on metal PCB by using the combined treatment of ion beam mixing, additional coating, and heat treatment, After Pull-off test of film, the strength of adhesion achieved up to 3.02MPa, which value is 4 times of other coating films. The adhesion improvement of film is shown in Fig. 3.(ASTM D3359 tape test)

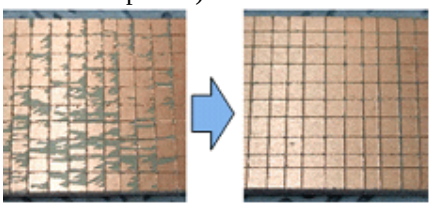


Fig. 3. The adhesion improvement of film by ion beam mixing process

Surface modification of polymer for luminance and anti-UV

PC/ABS blend polymer used in the inner parts of automobiles was ion-beam-irradiated to produce metallic looking glossy surfaces.(Fig. 4) After dual ion beam irradiation (Nitrogen and Helium ion) to polymer at 90keV, 2×10^{17}ions/㎠, the luminance of surface increased up to 2 times and surface hardness increased up to 3.5GPa(as hard as steel) and anti-scratch property improved by 3H or more. After UV light exposure to the irradiated polymer during 21 days, we did not observe the loss of luminance and the delamination of surface.[4]

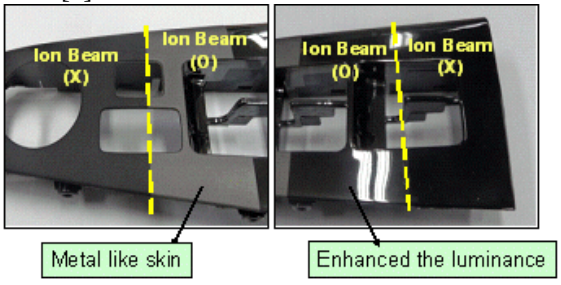


Fig. 4. The surface luminance change of automobile components

Super-hydrophilic surface modification of cooling-pin

After high-flux nitrogen ion beam irradiation(40keV, 5×10^{17}ions/㎠, 100 ㎂/㎠) to the aluminum sheet which used in cooling pin of heat exchanger, the surface characteristic was initially changed to super-hydrophilic surface due to the formation of AlN layer and micro-structure change.[5] And then, the contact angle stayed in 25 degrees or less after 30 day durability test.(Fig.5) We are anticipated that this technology will be applied to the enhancement of energy efficiency in refrigerator and air conditioning.

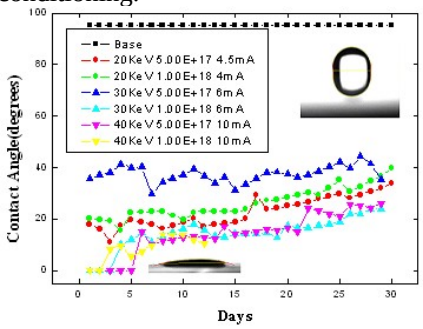


Fig. 5. Durability test of hydrophilic property for cooling-pin by high current ion beam.

4. Conclusions

Through the ion beam service to users by using ion beam facilities in KOMAC, we are successfully achieved several industrial applications by ion beams. Based on verification on the industrialization feasibility by experiments, we hope to get it started to enter markets with developed technology and products.

ACKNOWLEDGMENTS

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REFERENCES

[1] J. K. Hirvonen, C. A. Carosella and G. K. Hubler, Nucl. Inst. and Meth. 189 (1981) 103.
[2] H. Loh, R. W. Oliver and P. Sioshansi, Nucl. Inst. and Meth. B34 (1988) 337.
[3] J. S. Lee, C. Y. Lee and B. S. Kim, Surface &Coatings Tech. 206 (2011) 986
[4] J. W. Park, J. S. Lee, B. H. Lee, M. K. Kim, B. S. Moon, C. Y. Lee and B. H. Choi, Radiation Physics and Chemistry 84 (2013) 126
[5] C. Y. Lee, J. S. Lee, H. J. Choi and J. Y. Song, Journal of the Korean Physics Society 61, No.2 (2012) 254.