Installation of Ion Beam Facility with Mass Production System for Industrial Use

Chan Young Lee*, Jae Sang Lee*, Yong Gi Kim*, Yi Sub Min*, Dae Han Choi**
**Proton Engineering Frontier Project, KAERI*
***Shinki Intermobile Co.*
chlee@kaeri.re.kr

1. Introduction

Ion beam treatment technology has been used to improve surface properties for over more than four decades. Properties such as hardness, corrosion resistance and friction can be improved without adversely affecting the bulk properties of the material. Some plastic components used in modern automobile interiors require durable metallic look. Until now, pre- and post-treatment operation (painting, coating or vacuum metallizing) has been employed and the Cr coating and/or plating technique is commonly used. However, electroplated baths produce hexavalent chromium, restricted by environmental legislation. Therefore the development of alternative processes is required. The ion beam process has been known to be environmentally friendly because the processing is done in a vacuum environment and only a small addition of the elements is required to change the optical properties of the polymeric components effectively.

In earlier stage of study, it had been studied the change of PC/ABS polymer (polycarbonate (PC) / acrylonitrile-butadiene-styrene (ABS)) surface glossiness after ion beam irradiation. As a result, surface degradations can be prevented or greatly reduced under long term UV (Ultra-violet) and visible light exposure test [1].

To apply manufacturing of industrial products, we designed and installed ion beam equipment with mass production system which is the simplest and most economical process for economic feasibility. The objective of the study is the development of a ion beam accelerator with about 90keV/30mA used for industrial applications on the basis of experiences obtained from the construction of the DuoPIGatron ion source and acceleration tube. Also, We submitted design approval and received its confirmation for sale from KINS *(Korea Institute Nuclear Safety)*.

2. Design of ion beam facility and its components

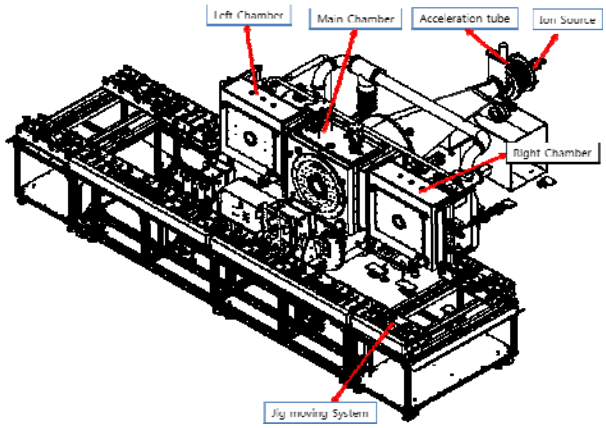
A ion beam facility with beam energy 90keV and current of 30mA and its components such as ion source, acceleration tube, interlock system and radiation shielding case was designed for industrial applications. Fig. 1 shows the specification of installed ion beam facility.

Remarks	Specifications
Energy@ Ion Source	45 keV
Energy@ Acceleration tube	45 keV
Beam Current	>30mA [Helium + Nitrogen Standard]
Beam Demension	400mm × 400mm
Irradiated Ions	He + N [simultaneous irradiation]

<Fig. 1. Specifications of ion beam facility>

2-1. Design of ion beam facility

Ion beam facility is composed of ion source, acceleration tube, vacuum chamber (left/main/right), power supply, and jig moving system as shown Fig. 2 and Fig. 3. The vacuum chamber is divided of three parts (left/main/right) and horizontal in-line system transmits the substrate with horizontal orientation from left to right chamber. Most of the functions related to operation of vacuum chamber and jig moving system were controlled automatically by program.

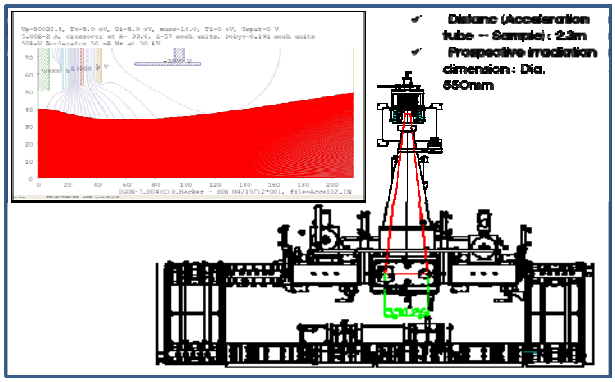


<Fig. 2. Design of ion beam facility>

<Fig. 3. Installed ion beam facility>

2-2. Design of ion beam facility components

Ion source and acceleration tube were designed based on the experimental data and IGUN code simulation which is able to control the in optical properties for the compensation of the space charge effect. Fig. 4 shows the result of IGUN code simulation for acceleration tube.

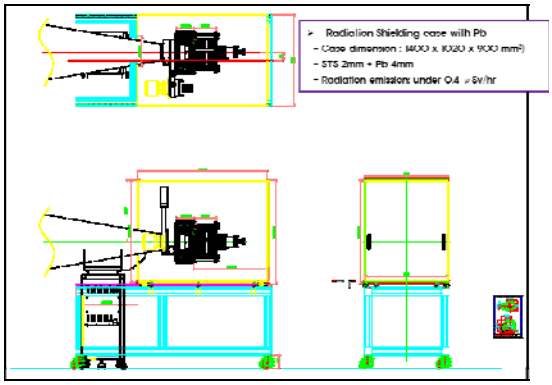


<Fig. 4. IGUN code simulation of acceleration tube>

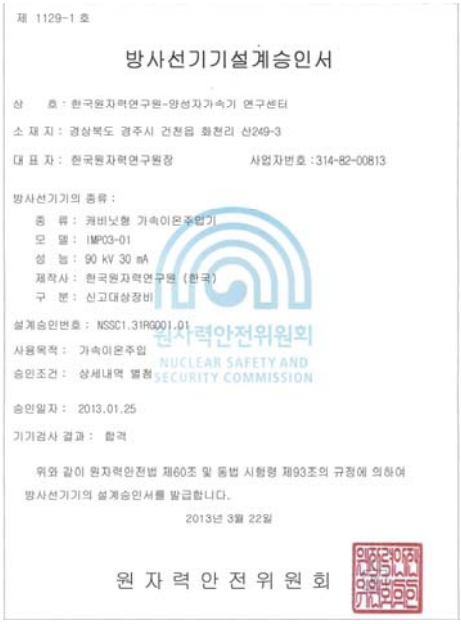
Radiation shielding case was designed to shield ion source and acceleration tube with rectangular type and installed lead (2mm thickness) between stainless steels (2mm thickness). The data for determining the thickness of the lead is radiation shielding formula and radiation measurement by survey meter without radiation shielding. The value of radiation emission was measured under 0.3μ Sv/hr after radiation shielding case installation at the 90keV/30mA beam extraction. Fig. 5 shows designed radiation shielding case.

3. Design approval acquisition from KINS

For sale, Constructed ion beam facility has to be acquired radiation safety license from KINS (Korea Institute Nuclear Safety). Therefore, we prepared design approval material related to facility and received equipment inspection. The radiation emission rate was measured under 0.3μSv/hr after radiation shielding case at the 90keV/30mA beam extraction. Also, interlock system for radiation source (Ion source and acceleration tube) was checked.



<Fig. 5. Design of Radiation shielding case>



제 1129-1 호

방사선기기설계승인서

상 호 : 한국원자력연구원-양성자가속기 연구센터
소 재 지 : 경상북도 경주시 건천읍 화천리 산249-3
대 표 자 : 한국원자력연구원장 사업자번호 :314-82-00813

방사선기기의 종류 :
종 류 : 캐비닛형 가속이온주입기
모 델 : IMP03-01
성 능 : 90 kV 30 mA
제작사 : 한국원자력연구원 (한국)
구 분 : 신고대상장비

설계승인번호 : NSSC1.31RG001-01
사용목적 : 가속이온주입
승인조건 : 상세내역 별첨
승인일자 : 2013.01.25
기기검사 결과 : 합격

위와 같이 원자력안전법 제60조 및 동법 시행령 제93조의 규정에 의하여 방사선기기의 설계승인서를 발급합니다.

2013년 3월 22일

원 자 력 안 전 위 원 회

<Fig. 6. Design approval from KINS>

3. Conclusions

A ion beam facility with beam energy of 90keV and current 30mA had designed and constructed for industrial application.

(a) Design and construction of the ion beam facility
(b) Design and construction of ion source and acceleration tube.
(c) No-load discharge test for arcing and beam extraction test for 90keV/30mA
(d) Design approval acquisition from KINS for sale.

REFERENCES

[1] J. W. Park, J. S. Lee, B. H. Lee, M. K. Kim, B. S. Moon, C. H. Lee and B. H. Choi, Radiation Physics and Chemistry, Vol(84), 126-128, 2013.