Licensing and Safety Analysis of the Ion Accelerator for Manufacturing

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1. Introduction

Proton Engineering Frontier Project (PEFP) has been established as a 21C Frontier R&D project by the Ministry of Education, Science and Technology of Korea (MEST) in 2002. One of objectives of the PEFP is to help matured technologies become industrialized in a frame of the Frontier R&D Program of MEST, and to realize applications of the accelerator technology.

High-current ion accelerator has been developed to be applied on an industrial utilization in applications of the accelerator technology.

In order to accomplish this object, we got the license that is required to a manufacturer of radiation generator (RG) by nuclear law of Korea. A RG should be manufactured by an authorization institution through the process of the design approval.

In this report, we will focus on describing the 4 types of the RG which is licensed from NSSC.

2. Development of Low Energy Ion Accelerators: Ion Implanter

Ion beams have been well known as powerful tools for the modification of materials as well as characterization by means of bombarding materials with energetic ions. Ion accelerator gives energy to an ionized gas, which is extracted from an ion source, through an accelerator tube in the KeV up to the MeV range. A schematic diagram of ion accelerator is shown in figure 1.

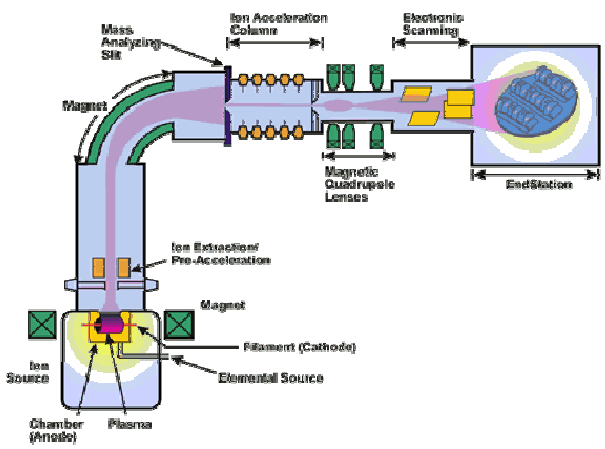

Fig. 1. Schematic Diagram of Ion Accelerator

The consists of an ion accelerator are classified with 4 types according to the design parameter as shown figure 2 and table 1.

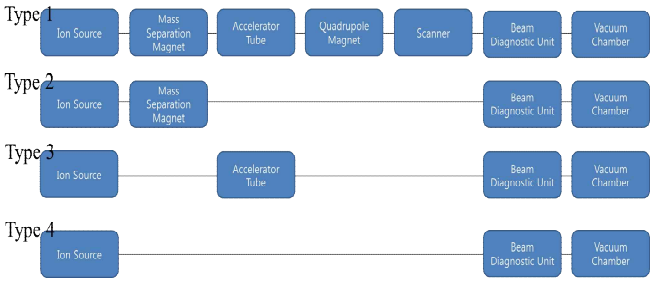

Fig. 2. Types of the Ion Accelerator according to design purposes

Table 1. Extracted Energy and Ion Source according to the Type

	Designed Energy and Current of the Ion	Ion Source Type
Type 1	300keV / ~10mA	Bernas / DuoPIGatron
Type 2	50keV / ~150mA	Bernas / Bucket
Type 3	200keV / ~100mA	DuoPIGatron
Type 4	50keV / ~1A	Bucket / DuoPIGatron

Type 1 and 2 are to be applied to a semiconductor production. Because ion accelerator of this field needs to study on an interaction of bombardment ion with a solid material, it has consists of various components. Specially, type 2 is to be applied to a field which is needed a separated ion in low energy. Type 3 and 4 are consisted as simple as possible due to economy, is to be applied industrial application. Type of ion sources is shown in fig. 3 to 5.

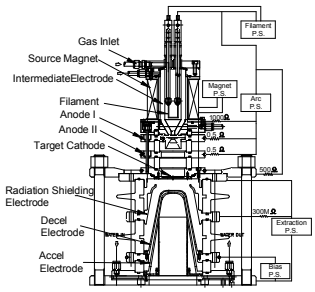

Fig. 3. DuoPIGatron Ion Source

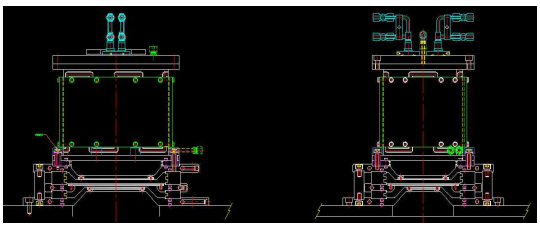

Fig. 4. Bucket Ion Source

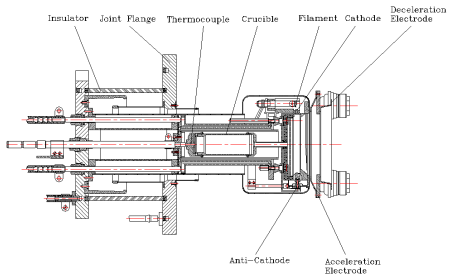

Fig. 5. Bernas Ion Source

3. General Design Safety Criteria and Facility

RG manufacturing facility is classified as a nuclear utilization one. So, the safety criteria of facility are regulated as a nuclear one. In radiation aspect, the radiation shielding of the accelerator facility should be capable of reducing the radiation levels, by keeping the occupational doses and doses to the members of the public as low as reasonably achievable (ALARA). For the safety design, PEFP must have some dose criteria according to zones classification listed in Table 1. [1] As shown in Table 2, the zones are divided by three classifications according to the workers' access availability and frequency. The design values have been made as a half value of the law in order to ensure the safety margin.

Table 2 Design Criteria (Zones Classification)

Zone Designation	Design Value (uSv/hr)
General Public Area	DL≤0.25
Radiation Worker Area	0.25<DL≤12.5
High Level Radiation Area	DL>12.5

Shielding must have enough performance such following that the areas in the building where worker's in and out is frequent are not admitted to exceed the amount of 1 mSv per week. [2] These limitations described above are regulated by the nuclear law of Korea. On the manufacturing process of RG, it is needed to optimized beam optics as well as many other parts. It is easy to realize that radiation is more produced than an expected one. So, shielding design and safety program is assumed worst case in the planning of RG production.

5. Summary

We have successfully developed several types of ion accelerator. And then, by obtaining the license of RG production, we prepared the basis of the technology transfer of RG to industries. Furthermore, this license is the first time in domestic of Korea. In this paper, the status of license of RG is reported and is briefed on 4 types of the licensed RG. This license is only cover the facility's producing ability of the RG. To the next step, we will prepare the design approval of accelerators for each type.

REFERENCES

[1] Enforcement Decree of the Act, Korea
[2] Radiation Protection Design Guidelines for 0.1-100 MeV Particle Accelerator Facilities, March 1, 1977. NCRP Report No. 51
[3] Arthur B. Chilton, J. Kenneth Shultis and Richard E.Faw, "Priciples of Radiation Shielding," 1984.