PHYSICS DESIGN FOR PHOTO FISSION ION SOURCE (PFIS)

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Abstract

Photo Fission Ion Source (PFIS) which is a part of conceptual designs of KoRIA has been carried out by PTL, KAPRA (Physico Technology Laboratory, Korea Accelerator and Plasma Research Association). The design parameters such as asymmetric magnetic field, cooling, neutron reflector and modulator (high density graphite), UC_x target, bremsstrahlung power, microwave power, and fission fragments (ions) are under consideration.

In this paper, physics design of fission chamber and electron cyclotron resonance source based on the ion distribution, radiation distribution, and thermal distribution, et al will be presented.

INTRODUCTION

Recently, Korea Government (Ministry of Education, Science and Technology) approved the conceptual designs project of the construction of KoRIA (Korea Rare Isotope Accelerator) for the production of exotic beams, rare isotopes, and for basic research. It will be one of few mega-projects for research facility in Korea. Both In-flight fragmentation method and ISOL(Isotope Separation On-Line) method are chosen in target design, 1-GeV driver linac with 2pμA, 200MeV/u for uranium ion will be designed. Before the KoRIA construction, the conceptual designs of KoRIA have been underdeveloped by PTL, KAPRA. Photo Fission Ion Source (PFIS) study is one of the conceptual designs of KoRIA.

The uranium fission fragments as gas ion sources are being developed in diverse methods, for example, the spallation fragments being produced by hitting uranium target using deuterium, He ion beam, hundreds of MeV accelerated proton beam, and fission fragments being produced by hitting uranium target using fast neutron from the accelerated electron beam, fission fragments by hard X-ray (bremsstrahlung radiation) due to the high-energy electron beam hitting to the tungsten target have been reported [1][2].

Of described above methods, photo fission reaction by electron accelerator has a lot of advantages on the point of accelerator design, fabrication cost, beam control, and spallation fragments yields, and so on.

Photons are commonly produced as bremsstrahlung radiation by electron accelerators. For example, electron accelerators with energies up to 25MeV are used to produce bremsstrahlung beams in many radiation oncology facilities worldwide. Photon-induced reaction cross-section data are important for a variety of current or emerging applications.

In this study, physics designs of photo fission fragments for exotic beam and ion source have been studied.

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MODELING

Electron beam is produced from the 50MeV 10~100mA L-Band Klystron (Thales Electron Device) Linac electron accelerator [3][4][5][6].

Neutron flux is emitted by hitting uranium target using produced electron beam, and fission fragments are generated by nuclear fission reaction in UC_x target with neutron flux and bremsstrahlung radiation simultaneously as shown Fig. 1.

Uranium carbide is a hard refractive ceramic material. It comes in several stoichiometries(UC_x), such as uranium monocarbidee(UC, CAS number 12070-09-6), uranium sesquicarbide(U_2C_3, CAS number 12076-62-90, and uranium dicarbide(UC_2, CAS number 12071-33-9).

As shown in Fig. 1, UC_x is located in the central zone. Temperature is to be maintained approximately 1,000°C during the operation in order to the fission fragments as gas state flowing into the ion chamber (Fig. 2).

The cylindrical zircaloy sheet is for maintaining high temperature, shielding radiation, and small neutron absorption cross section.

Zircaloy tube is designed for vacuum condition and well transmission of the reflecting neutron from the graphite.

The generated heat is to be controlled by the water cooling off and leak neutron is to be absorbed to the surrounded boron wall after thermalization. Hard X-ray, ɣ-ray, others are to be shielded by the lead sheets and movable concrete blocks. Diffused isotopes from the fission chamber are blocked with filters. Depending on the degree of radiation contamination during repairs, decontamination shall be done after radiation cooling time.

When the electron beams are bombarding on the target, beam density should be controlled below melting temperature. Assuming the electron beam energy 50MeV, electron beam current 10mA, velocity v≃c(light velocity), and beam transfer efficient 50%, generated heat is 26.2kW by the numerical calculation (photon neutron yield Y is =3.27×10^{12}neutrons/s kW from the Swanson's experimental results, 1979).

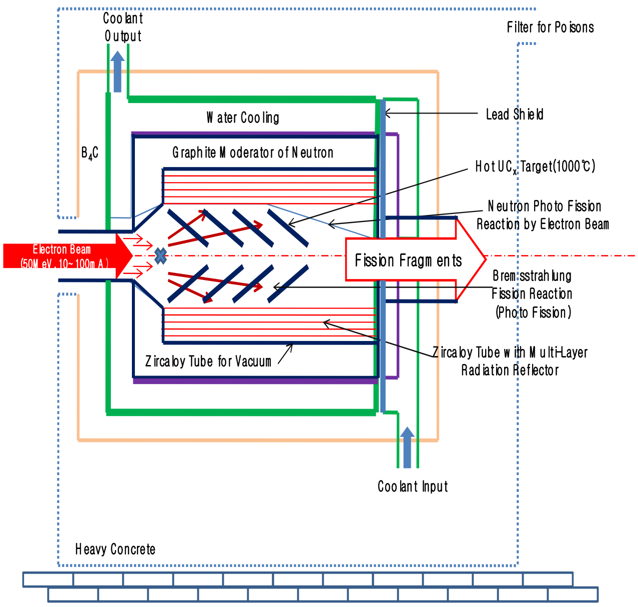

Figure 1. Physics Design of ECR Target (Fission) Chamber with SC Coil

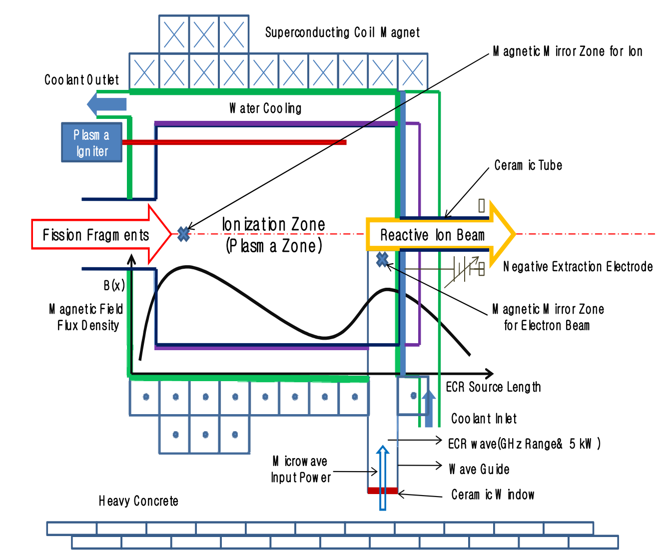

Figure 2. Physics Design of Electron Cyclotron Resonance Source

Fission fragments generated in the process are being maintained with ~10^{-4} torr vacuum condition and asymmetric magnetic field are to be driven to the ion source zone.

Intensity of the first B-field is to be controlled in order to reflect the plasma, and the 2nd B-field to reflect the electrons. Ions move to the extraction electrode for the next processing continuously.

Fragment ionization is done by supplying Microwave in ECR chamber with low vacuum condition. To reduce the out-gassing, target pre-heating or baking are needed to carry out with about 1000°C, the rest is removed by the mass separator.

Reverse flow of fission fragments could be adjusted by the ratio of inlet and outlet of the beam aperture.

FURTHER STUDY

As a next step, the engineering designs of Photo Fission Ion Sourec (PFIS) based on the numerical calculations will be studied.

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