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Progress in the development of Microfission chamber for ITER
ITERマイクロフィッションチェンバーの開発の進展

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A microfission chamber to be installed in the vacuum vessel has been developed for measurement of total neutron emission rate and fusion power in ITER. In-vessel component including detector, mineral insulated (MI) cable and feedthrough have been designed and prototypes have been made to test feasibility. Conceptual design review has been completed in October 2010 and it was concluded that the present design of MFC was applicable to ITER.

1. Introduction

The microfission chambers (MFCs) measure neutron flux at the vacuum vessel and provide total neutron emission rate and fusion power in ITER [1-4]. MFC units will be mounted on the inner shell of the vacuum vessel behind blanket module at two poloidal and two toroidal locations (total 4 locations) as shown in Fig. 1. One MFC unit consists of two chambers with ^{235}U and a dummy chamber to measure γ-ray background noise.

2. In-vessel components

2.1 *Detector*

MFC is a pencil-size gas counter that was developed as an in-core monitor for fission reactors. A total amount of 10 mg of ^{235}U is coated on the outer cylindrical electrode. Figure 1(A) shows a schematic view of a typical MFC developed for fission reactor. Figure 1(B) shows a drawing of the modified MFC designed to fulfill the requirements of the vacuum vessel environment of ITER. This modified MFC is enclosed in a stainless steel case and connected to guard vacuum pipe to detect gas leak and vent the gas outside the ITER vacuum vessel.

2.2. *MI cable*

Tri-axial mineral insulated (MI) cables will be used to apply bias voltage between the electrodes of the MFC and to carry signals. Particular challenge for implementation on ITER was the development of the in-vessel connector for the tri-axial MI cable. In order to install the MFC and the MI cable at different times, a joint for connecting them in the vacuum vessel is necessary. Vacuum tight tri-axial connector of the MI cable has been designed and prototype has been made [4].

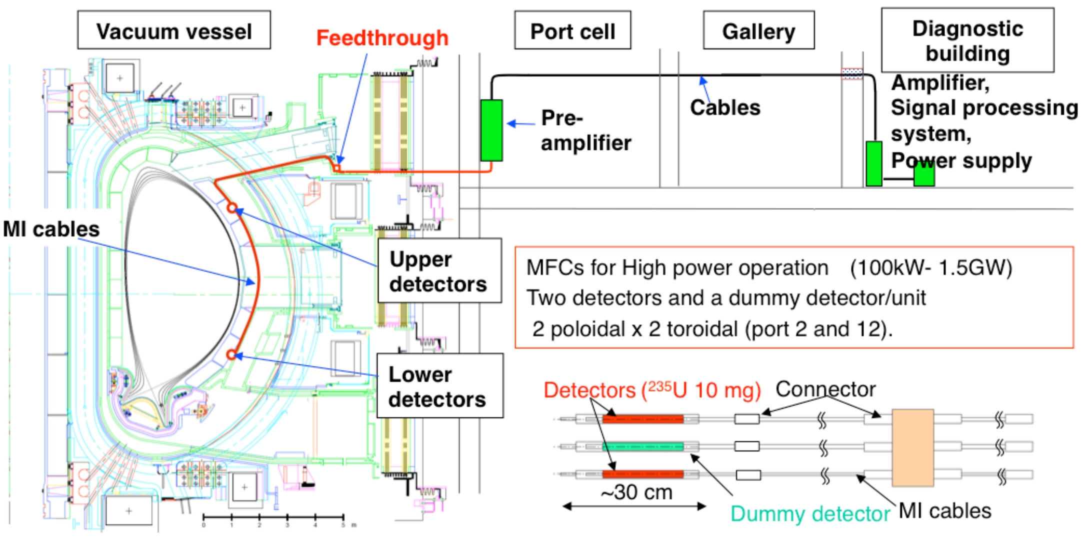

Fig. 1. Schematic layout of microfission chambers in ITER

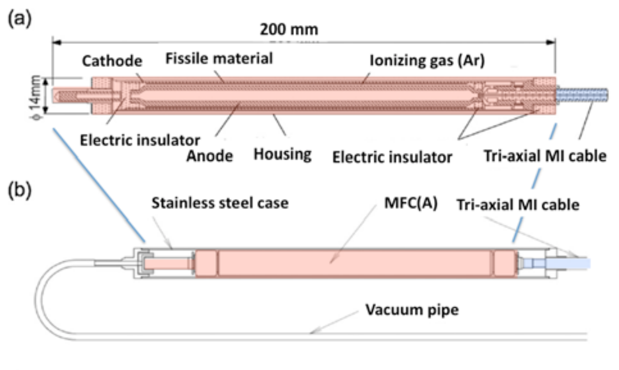

Fig.2. (a) Schematic view of the MFC, (b) the MFC designed for preventing Argon gas leakage

2.3. *Feedthrough*

Feedthrough, which carries the signal from inside to outside of the vacuum vessel, has been designed. Space for the feedthrough is limited as shown in Fig. 3. To meet the ITER vacuum requirement, guard vacuum is needed. A prototype of the feedthrough was fabricated to assess its feasibility. Helium leak test was conducted and it was confirmed that the leak late was less than 10^{-12} Pa•m^3/s, which meets ITER requirement (10^{-10} Pa•m^3/s).

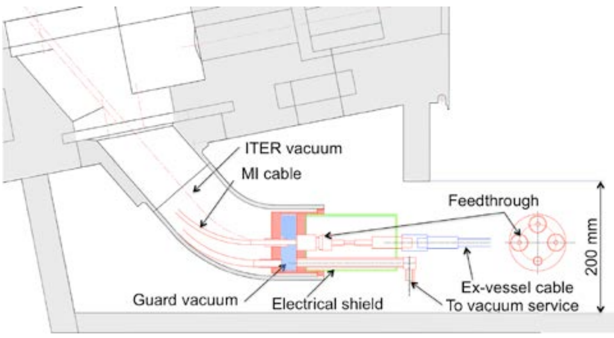

Fig. 3. Design of feedthrough of tri-axial MI cable.

3. Effect of high γ-ray dose on electronics

Gamma-ray dose rate in the port cell, in where pre-amplifier and signal processing unit will be installed, is estimated to 1 - 2 Gy/h due to activation of cooling water during plasma operation at fusion power of 500 MW. The activity from water arises because of the production of ^{16}N due to ^{16}O(n,p)^{16}N reactions. Energy of γ-ray is 6.13 and 7.12 MeV.

Expected lifetime limit of many commercial analog electronics is around 50 Gy of γ-ray exposure. Functional errors are also expected for digital circuits. Integrated dose in 4600 hours full plasma operation is 4600 - 9200 Gy at the port cell. Then reduction of γ-ray by 2 - 3 orders of magnitude and radiation-hardened electronics are needed.

In the previous design, a pre-amplifier and digital processing unit will be installed in the port cell as shown in Fig. 4 (a). To prevent functional errors of digital circuits, digital processing should be installed in diagnostic building as shown in Fig. 4 (b). Pre-amplifier and power supplies should be shielded by lead of 10 - 20 cm thickness.

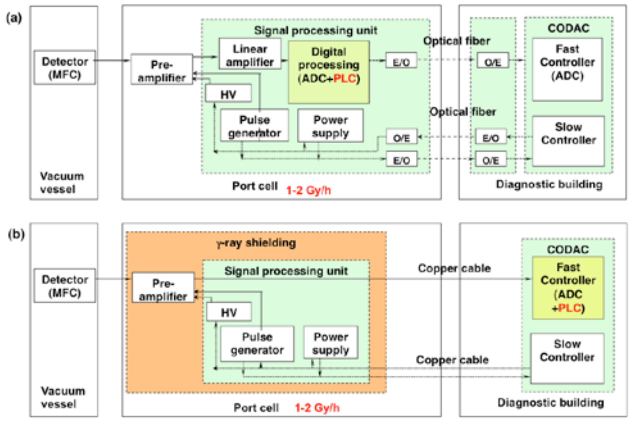

Fig. 4. Schematic diagram of signal processing. (a) Previous design (b) Revised design

4. Conclusion

Conceptual design review has been completed in October 2010 and it was concluded that the present design of MFC was applicable to ITER. Procurement arrangement of MFC between ITER organization and Japan Atomic Energy Agency will be signed early in 2012 and detail design also will start in 2012.

Acknowledgments

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