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Development of a permeation sensor made of vacuum flanges to measure hydrogen isotopes in liquid metal breeder

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1. Introduction

Test Blanket Modules (TBMs) using liquid metal as a breeder have been studied during the past decades to develop a tritium breeding technology for a fusion reactor in International Thermonuclear Experimental Reactor (ITER) [1-5]. One of the major issues of the studies is how to extract the tritium produced in liquid metal by neutron and to measure tritium concentration in the liquid breeder. Several permeation sensors have been developed in Europe; however, response time of the sensors does not meet practical needs. In this study, therefore, a vacuum flange type permeation sensor is proposed to dramatically improve response time of the sensor and to endure hydraulic pressure in the liquid breeder during operation.

2. Design of the Flange Type Permeation Sensor

A hollow type and an annular capsule type sensors have been developed and shown better performance than the other proposed permeation sensors [6]. However, these sensors still does not satisfy to apply measuring hydrogen concentration in liquid metal because of the very long time (tens of minutes) necessary to reach the hydrogen pressure equilibrium. And, manufacturing permeation sensors with thin hydrogen permeable membranes are difficult because it is hard to be welded between the thin membranes each other and high flux heat from welding process cause surface oxidation, disturbed hydrogen permeation, on the membrane.

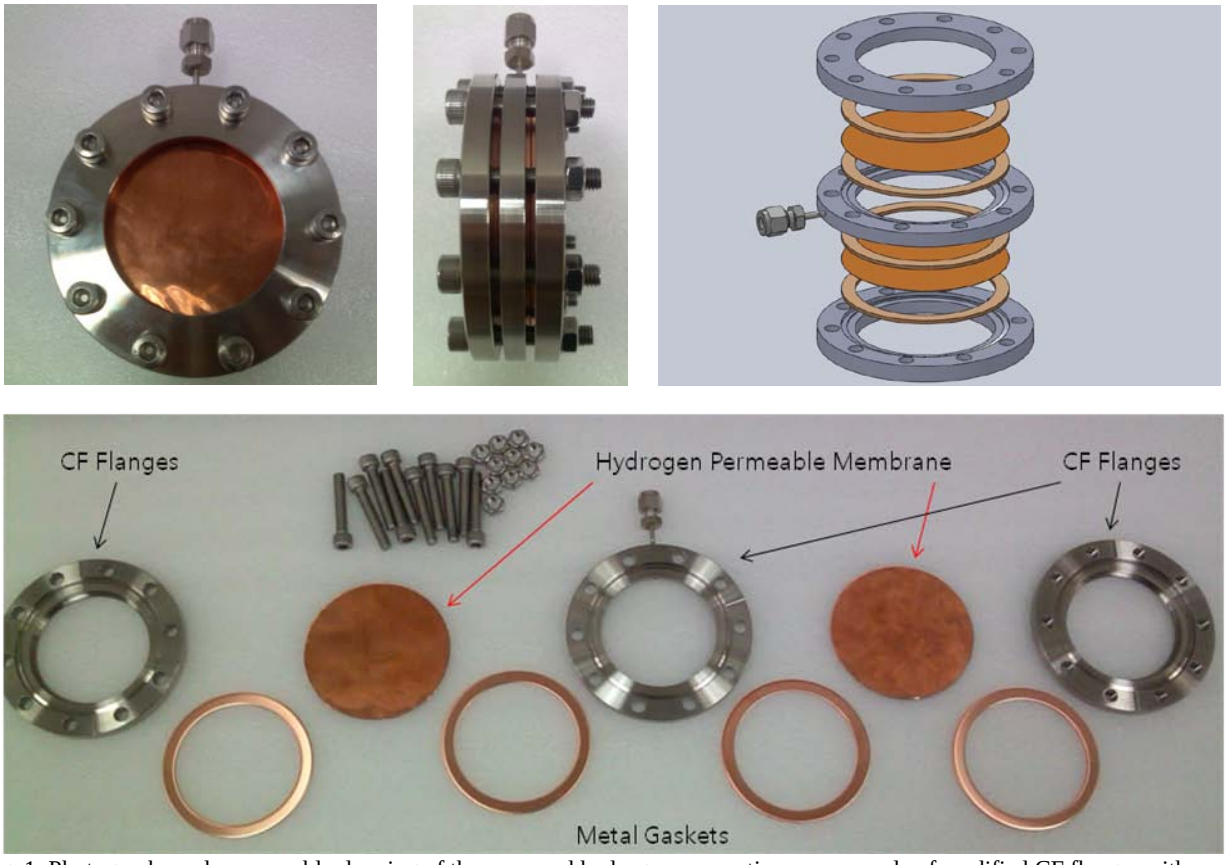

Fig. 1. Photographs and an assembly drawing of the proposed hydrogen permeation sensor made of modified CF flanges with hydrogen permeable membranes

The response time of the permeation sensors could be improved by optimizing the sensor geometry: with reduction of the ratio 'total volume/permeation surface of sensor' and of the membrane wall thickness [6].

In present study, a permeation sensor made of vacuum flanges with a porous plate inside is proposed 1) to reduce the thickness of membrane, 2) to increase surface area of sensor per unit volume, 3) to endure high pressure operational condition, and 4) to eliminate the manufacturing difficulties which are mentioned above (Fig. 1).

3. Verification and Performance Test of the Permeation Sensor

The proposed sensor will be tested with various membranes to evaluate its performance (response time) in a vacuum chamber with various partial pressure of hydrogen from 100 to 10,000 Pa at total pressure of 5 bars, which is the maximum operational hydraulic pressure of the liquid type TBMs. And then the developed sensor will be tested in liquid PbLi eutectic, which is mainly considered as the liquid breeder of TBMs, with various partial pressure of hydrogen.

4. Conclusions and Further Works

In present study, a permeation sensor made of vacuum flanges filled with a porous disk to improve response time and it is expected that performance of the proposed permeation sensor will be higher than the hydrogen permeation sensor of TRIEX (TRItium Extraction) [7]. The proposed permeation sensor was designed and manufactured to evaluate performance of the sensor in a vacuum chamber and in liquid PbLi eutectic with various partial pressure of hydrogen gas.

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