Abstract
To develop SIC/SIC fuel cladding to ensure a high level safety to LWIR is the important objective for on-going SCARLET project. Where stability of the cladding under neutron irradiation should be verified and the first reactor irradiation test in HBWR, Halden is scheduled to start by the end of March, 2015, in order to carry out reactor test under BWR dynamic water environment. Helium leak tightness is strictly required. So far only SIC/SIC plate by NITE process has been verifying the potentiality to satisfy the requirement of He leak tightness. However, to fabricate He leak tight SIC/SIC cladding had been successful including other methods like CVI process. This presentation provides the history and the current status of SIC/SIC cladding to satisfy the strict requirement of He leak tightness through the intense R & D of DEMO-NITE process. The most important feature of the DEMO-NITE process R & D is to utilize SIC/SIC intermediate materials consist of SIC fibers coated with polymer based SiC nano powder slurry. By the intermediate materials, He leak tightness has been greatly improved.

Background and Objective
- As the key requirement, FP shielding property is an mandatory. However, as the first step, He gas leak tightness were defined to be the R & D target of SIC/SIC claddings in SCARLET Project.
- The specification of the He gas leak tightness of SiC/SiC for Halden Reactor Irradiation is equivalent for the case of Zircaloy cladding irradiation and is \(4 \times 10^{-7} \text{Pa-m}^3/\text{s}\) (un-fuelled capsule case). This is the current R & D target.
- The underlying objective is to establish the mechanistic understanding of the He leak behavior and micro-structural understanding of SIC/SIC for improving the performance of SIC/SIC cladding.

Helium Leak Tightness vs Density
Measurement of helium leak rate was performed by spray method with a helium leak detector. There are large and clear improvements of He gas leak tightness through G-0 to G-2. He leak rate is depending on density of SIC/SIC, the density over 3.1 g/cm\(^3\) is the bottleneck to satisfy gas leak tightness requirement. He gas leak tightness for G-0 was the maximum about \(10^{-3} \text{Pa-m}^3/\text{s}\) and the average of \(10^{-7} \text{Pa-m}^3/\text{s}\). For the case of G-1 local high leak regions, mainly near one end of cladding were found with the level of \(10^{-5} \text{Pa-m}^3/\text{s}\) and other regions were better than \(10^{-9} \text{Pa-m}^3/\text{s}\). There are clearly the relations between He gas leak tightness and microstructural features, such as density and open porosity. For the more accurate prediction of He leak tightness, quantitative correlation between He leak tightness and microstructural feature should be clarified. Current preparation suggests through thickness cracks with varieties of characteristics are responsible for the leak.

Macro-Structure
G-0: many radial cracks in trans fiber-bundle matrix were introduced. Majority of cracks were observed inner peripheral positions
G-1: many pores and segregations of sintering aids were observed inter-bundle regions, indicating inadequate process control.
G-2: Matrix formation inter- and intra- fiber bundles was excellent to make near theoretical density matrix formation without macro- and micro-crack formation. This feature might be interpreted: high He leak tightness is responsible from macro- and micro- structural features, through micro-thickness channels.

Surface Roughness
Roughness of the outer surface of claddings were measured by 3D laser microscope with automatic correction function into flat surface. G-0 cladding with inferior gas leak tightness presented about 50μm deep porous defects and about 15μm depth traces along fibers were observed. Whereas, G-2 cladding with excellent gas leak tightness presented no detectable porous defects and shallower traces along fibers. In every measures of surface roughness evaluation, G-2 presented great improvements form G-0.

Progress in Helium Leak Tightness
He leak test at OASIS was performed 1mm\(^3\) SIC/SIC tube with the typical pressure difference of \(10^4\) Pa. Thus in this measurement He leak rate can be converted into Gas permeability Coefficient (D) by multiplying in Figure Hino's data is converted into leak rate.

Summary
- Helium gas leak tightness measurement of SIC/SIC fuel cladding by DEMO-NITE process was performed and the excellent He gas leak tightness for G-1 and G-2 DEMO-NITE fuel claddings was confirmed.
- The He gas leak tightness of those DEMO-NITE SIC/SIC fuel claddings has excellent values: for He; better than \(10^{-7} \text{Pa-m}^3/\text{s}\). (That is equivalent to Zircaloy claddings)
- As to the shielding property requirement includes FPs other than He and hydrogen isotopes, leak tightness about those FPs will be evaluated as the next step.
- More precise evaluation of He and other FP leak tightness will be performed by vacuum chamber method and mechanistic investigations based on microstructure and temperature and pressure dependence will be also investigated. Complete data set of FP shielding capability should be and will be prepared under the best efforts.