# 2-3. In-Vessel Materials and Components

In the Fusion Engineering Research Project, in-vessel materials and components are among the key research subjects. For the structural materials study, efforts are focused on developing low activation materials, i.e. RAFM steels, ODS steels and vanadium alloys, including fabrication and basic characterization of advanced ODS steels, estimation of tensile properties of RAFM steels after long-term aging, ion irradiation–induced hardening of V-4Cr-4Ti alloys, and HIP joining of ODS steels with RAFM steels. These studies contribute to extending the blanket design criteria.

Ceramic coatings for application to liquid blankets are being investigated in the Project. Major efforts are directed to development of $Er_2O_3$ coatings, which are promising candidates for MHD insulator coating for liquid lithium and Li-Pb blankets and tritium permeation barrier coating for Li-Pb and molten-salt blankets. Technological improvement of coating fabrication and characterization are being made for MOD (Metal Organic Decomposition) and MOCVD (Metal Organic Chemical Vapor Deposition) processes including optimization of fabrication parameters for MOD processes, adhesion strength evaluation by nano-scratching for MOCVD coating, structural analysis by ion-beam induced luminescence and investigation on the underlying basic information such as energy level of Er ions in the crystal.

The liquid breeder blankets are the major target of blanket systems of the Project. For the liquid blanket development, control of mass transfer is essential. A construction of gas-pressure driven test loop for mass transfer analysis of liquid breeders was carried out. In addition, hydrogen transport in FLiNaK thin film was investigated for evaluation of hydrogen diffusivity and inventory in the system.

Hydrogen retention and permeation in the first wall influences strongly the particle control and the fuel inventory. Experimental investigation of the hydrogen transport was carried out including the effects of concurrent plasma-driven and gas-driven permeation and the effects of He bombardment.

Divertors were the key component for magnetic-confinement fusion reactors. In the Project, research on divertors are being carried out both for enhancing component technology and controlling plasma-wall interactions, the former including blazing of Cu and W with various fillers targeting on technological enhancement of the component fabrication, and the latter including estimate of diverter wetted area in FFHR-d1 and analysis of radiation power loss due to impurity gas puffing for heat load control to divertor.

Atomic and Molecular Process studies, including database development and management is being carried out extensively but largely oriented to plasma-wall interaction issues in the Project, such as EUV spectrum study of highly charged W ions by electron beam trap and collisional radiative modeling of W ions in plasma.

The abovementioned researches are motivated by and influencing strongly the ongoing Helical Reactor Design activity.

As research summaries in fiscal year of 2013 in the field of in-vessel materials and component studies, 18 reports by NIFS staffs and SOKENDAI students, and 25 collaboration reports were presented. The research was categorized into three fields, namely materials/blanket studies, PWI/PFC studies and atomic and molecular process studies as fundamentals for plasma-wall interactions. In the NIFS collaboration, researches with wider scopes are being carried out with more extensive options for materials, blankets and first wall/divertors and other systems, including underlying fundamental studies.

Out of 25 collaboration reports, 14 collaboration research reports were presented for the materials and blanket studies. The materials researches include comparison of 9Cr-ODS steel and RAFM, He-bubble induced hardening, fatigue damage of SiC/SiC, specimen size effects on fracture of vanadium alloys, fabrication and characterization of oxide double-coating, self-healing of the functional coating, thermal diffusivity of shielding materials and hydrides as neutron shielding materials. The blanket –oriented research includes three-surface insulted coating for MHD pressure drop suppression and transient critical heat flux of subcooled water flow. In addition, radiation effects of hydrogen permeation barrier coating, defects formation in CVD processed SiC and estimate of backward-angle scattering cross section of 14MeV neutrons were carried out.

9 collaboration research reports were submitted for PWI/PFC studies, including formation of fuzz structure in W, H and He behavior in RAFM exposed to mixed plasma, H isotope retention in PFM under complex ion irradiation, H retention in SiC/SiC, surface modification of W, first wall cooling of Flibe blanket, H permeation measurements by ESD method and H isotope trapping in a deposition layer.

A report was presented concerning atomic and molecular database for light elements. Also submitted was a report on the impact of excited states of reflected H atoms on their recycling.

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