# 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 low activation structural materials study, efforts are focused on developing low activation vanadium alloys including enhancement of performance at high temperature and in irradiation and corrosive environments. Efforts are also made for characterizing microstructures and mechanical properties of Oxide Dispersion Strengthened (ODS) low activation ferritic steels. These studies contribute to extending blanket design criteria. Also being investigated is the technology for dissimilar joining of structural materials, for application both to in-vessel and out-of-vessel structure, such as joining of vanadium alloys and Reduced Activation Ferritic/Martensitic (RAFM) steels with commercial austenitic stainless steels. The blanket components will need to be protected against the plasma by covering with an armor layer. For this purpose, coatings of vanadium alloys with W are being studied.

In the Fusion Engineering Research Project, ceramic coatings for application to liquid blankets are being investigated. 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. Technologies of coating fabrication are being developed which are capable of covering complex surfaces including duct interiors. Currently MOD (Metal Organic Decomposition) and MOCVD (Metal Organic Chemical Vapor Deposition) are being investigated. In addition, nitriding and chromizing of steel surfaces are investigated for application to anti-corrosion coating for liquid blankets. Also being carried out is the compatibility studies for liquid breeder blankets such as vanadium alloys with liquid lithium, and low activation ferritic steels with Li-Pb or molten salts. In addition to materials degradation, mass transfer in the blanket flowing system is under investigation including that of hydrogen.

Plasma-wall interaction (PWI) and plasma facing component (PFC) studies are also being carried out, some of which are performed mainly in the LHD Projects. In the Fusion Engineering Research Project, fundamental studies on hydrogen transfer throughout the first wall and the structural components including plasma-driven permeation and counter flow from the breeding materials to the first wall, and plasma-surface interactions using steady-state H and He plasmas are studied using RAFM as the first wall material.

Atomic and Molecular Process studies are being carried out in NIFS extensively. In the framework of the Fusion Engineering Project, those studies which are relevant to plasma-wall interactions, impurity transfer from the first wall to edge plasma, and atomic process in materials in irradiation environments are mainly being carried out. These include database development for improved spectrometry of the first wall impurities such as W Fe and Li in highly charged states, and for advanced analysis of impurity gas puffing effects on radiation cooling.

These researches are closely connected in the Fusion Engineering Research Project with Helical Reactor Design activity. In the NIFS collaboration, in addition to the above researches, those with wider scopes are being carried out with more extensive options for materials, blankets and first wall/divertors.

As research summaries in fiscal year of 2010, 20 reports by NIFS staffs and SOKENDAI students and 26 collaboration reports are presented in the field of in-vessel materials and component studies. The researches are categorized into three fields, namely materials/blanket studies, PWI/PFC studies and atomic and molecular process studies as fundamentals for plasma-wall interactions.

For the materials and blanket studies, 26 reports were presented in total. These include efforts to improve high temperature mechanical properties and radiation resistance of low activation vanadium alloys by compositional and microstructural control such as optimization of thermomechanical control, addition of Y, increase in Cr level, and nano-particle dispersion and reduction of grain sizes by mechanical alloying. Also carried out are characterization of ODS Ferritic Steels, characterization of ceramic materials, including SiC/SiC composites, by irradiation-induced luminescence, electrical property measurements and thermal desorption spectrometry, small specimen test technology, joining of dissimilar materials and coating fabrication and characterization for use as the first wall. Blanket researches include design, development and characterization of coating and functionary gradient layers for MHD pressure drop mitigation, tritium permeation reduction and corrosion protection for liquid breeder blankets, compatibility of liquid breeders with structural materials, and permeation of tritium in cooling pipes.

For the PWI/PFC studies, 6 reports are presented including plasma and gas-driven permeation of hydrogen, plasma interactions with RAFMs, retention of H and He, erosion and mass transfer of Plasma-Facing Materials including thermal loading effects, and critical heat flux of water-cooling tubes.

For the atomic and molecular process studies, 14 reports in total are presented including radiation charge exchange and power loss by impurity puffing in divertor, fundamental data for spectrometry of W and Fe, atomic collision and plasma process of W and Li, linear polarization of emitted photons from neutrals at the first wall, atomic and molecular database such as charge transfer cross sections, and model and simulation of H diffusion and microstructural evolution in materials under interactions with plasma particles and neutrons.

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