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Overview of the TITAN project

T. Muroga [a,*], D.K. Sze [b], K. Okuno [c]

[a] National Institute for Fusion Science, Toki, Gifu, Japan
[b] University of California San-Diego, San-Diego, USA
[c] Shizuoka University, Shizuoka, Japan

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ABSTRACT

This is an overview paper of the joint TITAN (Tritium, Irradiation, and Thermofluid for America and Nippon) project of the Japan–USA fusion cooperation program. The objectives, tasks structure, and technical highlights of the TITAN project are presented, as well as the direction of the project toward its end in March 2013.

1. Introduction

The Japan–USA fusion cooperation program has a history of more than 30 years. Five joint projects have been carried out within this framework. Table 1 summarizes the history of the joint projects [1,2].

The initial three projects (RTNS-II, FFTF/MOTA, and JUPITER) focused on neutron irradiation effects on fusion materials using neutron irradiation and post irradiation examination (PIE) facilities in the US. The next project (JUPITER-II) extended the subject of the initial projects to include key issues for advanced blankets using facilities for tritium and thermofluid tests in the US, in addition to those for neutron irradiation.

The use of unique US facilities is the major incentive in this collaboration. The contributions of the Japanese side include the supply of high-quality test materials and characterization technologies for microstructures, mechanical properties, tritium distribution, thermofluid performance, among others.

2. Objective, task structure and facilities

Fig. 1 schematically shows a comparison between the TITAN and the JUPITER-II projects. The JUPITER-II project focused its efforts on several critical issues regarding advanced blankets such as molten salt Flibe blankets, liquid lithium blankets with a vanadium alloy structure, and high-temperature gas-cooled blankets with a SiC/SiC composite structure.

The TITAN project extended the scope of the JUPITER-II project by including not only first wall issues but also focusing on interface issues among the first wall, blanket, and recovery system. Particular interest was placed on obtaining fundamental understanding for establishing tritium and thermofluid control. The experiments were designed for testing under conditions specific to fusion, such as intense irradiation, high heat/particle flux, and circulation in a high magnetic field. The results will be applied using integrated modeling to advance the design of tritium and heat control in MFE and IFE systems.

Table 2 summarizes the tasks, subtasks, facilities, and research subjects. The project has three tasks and seven subtasks. Task 1 is about transport phenomena that consider mass and heat flow in the first wall, blanket, and recovery system. Special emphasis is placed on mass transfer during the interaction of mixed plasma of D/He/Be with the first wall, tritium transfer in liquid breeders, and the thermofluid control in liquid breeders in a magnetic field. Task 2 focuses on the irradiation effects of materials with an emphasis on the synergistic effects of irradiation and tritium or other impurities including transmutation-induced helium. The common task is a unique group organized by those who are engaged in other tasks and take care of the modeling. This task performs integration modeling of materials performance, thermofluids in magnetic fields, tritium and mass transfer for the enhancement of reactor system design, including the evaluation of the available modeling codes and the enhancement of reactor system designs.

The major facilities are the High-Flux Isotope Reactor (HFIR, Oak Ridge National Laboratory) with PIE facilities, the STAR (Safety and Tritium Applied Research, Idaho National Laboratory) including TPE (Tritium Plasma Experiment), the MTOR (Magneto-Thermofluid Omnibus Research Facility, University of California, Los Angeles),

* Corresponding author. Tel.: +81 572 58 2257; fax: +81 572 58 2628.
E-mail address: muroga@nifs.ac.jp (T. Muroga).

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Table 1
History of the joint project in Japan–USA fusion cooperation program.

Project name	Period (JFY[a])	Representatives & coordinators	Major test facilities	Core subjects
RTNS-II	1981–1986	M. Cohen D. Doran/ K. Kawamura K. Sumita	RTNS-II	Lowdose D-T neutron irradiation
FFTF/MOTA	1987–1994	T. Reuther F. Garner/ A. Miyahara S. Ishino A. Kohyama	FFTF EBR-II	High fluence neutron irradiation
JUPITER	1995–2000	F. Wiffen R. Jones/ K. Abe A. Kohyama	HFIR ATR HFBR	Temperature variation effects Transient effects for ceramics Radiation creep
JUPITER-II	2001–2006	S. Berk G. Nardella S. Zinkle D.K. Sze/ K. Abe A. Kohyama S. Tanaka	HFIR STAR MTOR	Keyissues for advanced blankets
TITAN	2007–2012	G. Nardella B. Sullivan P. Pappano D.K. Sze/ K. Okuno T. Muroga	HFIR TPE/STAR MTOR PISCES	Mass and heat transfer Irradiation-tritium synergism Coating/joining

[a] Japanese Fiscal Year starts April and ends March of the next year.

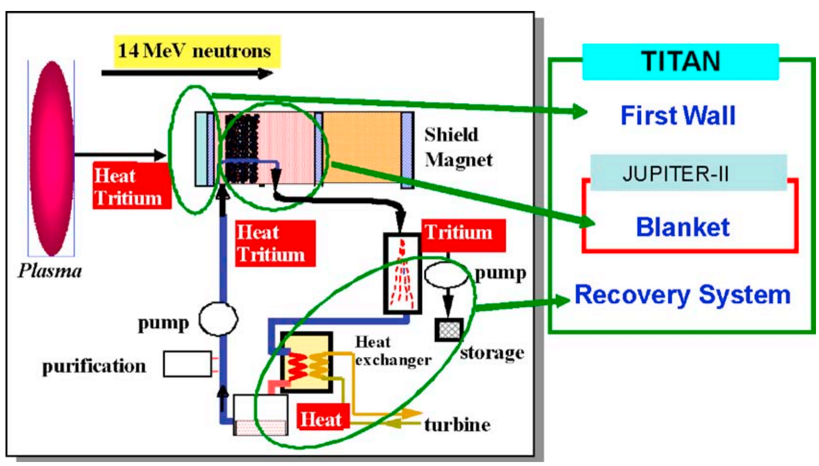

Fig. 1. Schematic illustration showing the scope of the TITAN project compared with that of JUPITER-II project.

Table 2
Task structure and research subjects of the TITAN project.

Task	Subtask	Facilities	Research subjects
Task 1 Transport phenomena	1-1 Tritium and mass transfer in first wall (concluded March 2010)	STAR/TPE PISCES	Tritium retention and transfer behavior and mass transfer in first wall
	1-2 Tritium behavior in blanket systems	STAR	Tritium behavior through elementary systems of liquid blankets
	1-3 Flow control and thermofluid modeling	MTOR	Flow control and thermofluid modeling under strong magnetic fields
Task 2 Irradiation synergism	2-1 Irradiation-tritium synergism	HFIR STAR	Irradiation effects on tritium retention and transfer behavior in first wall and structural materials
	2-2 Joining and coating integrity	HFIR	Synergy effects of simultaneous production of tritium and helium on healthiness of joining and coating integrity
	2-3 Dynamic deformation	HFIR	Effects of irradiation and simultaneous production of tritium and helium on dynamic deformation of structural materials
Common task System integration modeling	MFE/IFE system integration modeling		Integration modeling for mass transfer and thermofluid through first wall, blanket and recovery systems of MFE/IFE