Principal Researcher	Masayuki Hasegawa	**Number of Reserchers**	6
Research Institution • Department • Title	Professor, Institute for Materials Research, Tohoku University	**Location of Institution**	Sendai City

Title of Project	Clarification and Control of Irradiation-Induced Nano-Precipitates and Defects in Nuclear Reactor Pressure Vessel Steels
Abstract of Research Project	More than 30% electricity in Japan is provided by nuclear reactors. Ensuring safe operation of these reactors is a current vital issue since the reactors of the first generation are going over their initially designed operating lifetimes. The present project focuses one of the major concerns about the safety - embrittlement of the reactor pressure vessel (RPV) steels resulted from irradiation-induced Cu precipitates. A newly developed experimental technique for the precipitates, positron annihilation spectroscopy (PAS), is employed and is further supplemented by the 3D atom probe and electronic-structure calculations. The unique power of the techniques has been demonstrated by our recent finding that positrons sensitively probe not only vacancies and nanovoids but also Cu precipitates in model alloys of RPV steels. RPV steel and its series of ternary model alloys with various dopants (Fe-Cu-Mn, Fe-Cu-P, etc.) will be prepared and irradiated with neutrons and electrons. The irradiated-induced vacancy-type defects, vacancy-dopant complexes, nanovoids, and Cu-rich precipitates will be investigated by the PAS. The results will be compared with the 3D atom probe observations. The first-principles full potential linearized augmented plane wave and kinetic Monte Carlo methods will be employed to simulate diffusion and precipitation of vacancies and dopants. The follows can be clarified in this project, 1) the nano-structure of the irradiation-induced defects and nanosize Cu-rich precipitates, which are beyond the resolution of even the most powerful microscopes up to now, and 2) the role of the dopants and the defects in precipitate formation and evolution. By the reliable techniques developed in this project the microscopic mechanism of the macroscopic embrittlement phenomena can be clarified, which guides certainly the in-service thermal annealing of the embrittled RPV steels.
References	1) Y. Nagai, T. Chiba, Z. Tang, M. Hasegawa, et al.: “Fermi Surface of Nano Crystalline Embedded Particles in Materials: bcc Cu in Fe“, Phys. Rev. Lett. 87**,** 176402-1 ～ 4, (2001). 2) Y. Nagai, Z. Tang, M. Hasegawa, et al.: “Irradiation-induced Cu aggregations in Fe: An Origin of Embrittlement of Reactor Pressure Vessel Steels”, Phys. Rev. B63**,** 134110-1 ～ 5, (2001).
Term of Project	Fiscal years 2003-2007 . （5years）

Budget Allocation (in thousand of yen)	FY2003	FY2004	FY2005	FY2006	FY2007	TOTAL
	32,300	22,600	12,600	6,200	4,700	78,400

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