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FUNDAMENTAL IRRADIATION STUDIES ON VANADIUM ALLOYS

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FUNDAMENTAL IRRADIATION STUDIES ON VANADIUM ALLOYS

B. A. Loomis (Argonne National Laboratory), F. A. Garner and A. M. Ermi (Hanford Engineering Development Laboratory)

1.0 Objective

The object of the effort is to study the response of simple vanadium alloys to fast reactor irradiation and thus provide a basis for the development of vanadium alloys which are suitable for fusion reactor service and which will also exhibit reduced long-term radio-activation.

2.0 Summary

A joint experiment on the irradiation response of simple vanadium alloys has been initiated under the auspices of the DAFS and BES programs. Specimen fabrication is nearly complete and the alloys are expected to be irradiated in lithium in FFTF-MOTA Cycles 7 and 8.

3.0 Program

Title: Irradiation Effects Analysis (AKJ)
Principal Investigator: D. G. Doran
Affiliation: Hanford Engineering Development Laboratory

4.0 Relevant DAFS Program Plan Task/Subtask

Subtask II.C.1 Effects of Material Parameters on Microstructure

5.0 Accomplishments and Status

5.1 Introduction

Three commercial vanadium-base alloys (V-15Cr-5Ti, Vanstar-7 and V-3Ti-1Si) are currently being irradiated in the FFTF fast reactor in the Materials Open Test Assembly (MOTA).[1] In order to determine the role of each elemental constituent in the phase stability and irradiation response of these alloys, a joint experiment between the DAFS and BES (Basic Energy Science) programs has been initiated.

This experiment will use a series of simple alloys produced earlier in the BES program. No helium will be added to these alloys. Specimens will be primarily in the form of TEM disks although miniature SS-3 tensile specimens will also be irradiated for some of these alloys. Irradiation under static lithium in TZM capsules is planned for Cycles 7 and 8 in FFTF-MOTA. In this experiment three capsules are designated as DAFS/BES capsules. Two of these are at level 2 in MOTA (420° and 600°C) accumulating ~26 dpa/year and one is at level 1 (520°C) at ~14 dpa/year. In addition other specimen subsets will be included in the HEDL ADIP capsules in levels 1, 2 and 5. These capsules will also contain one-third size Charpy specimens constructed from V-15Cr-5Ti.

5.2 Alloy Descriptions

The alloys can be categorized in the following subsets.

Vanadium Impurity Series: These alloys study the effects of impurity levels and variations in relative amounts of major impurities (carbon, oxygen, nitrogen).

Vanadium-Chromium Series: Ion bombardment data already exist for these alloys which contain chromium levels of 10, 15 and 20%. In addition to phase stability and swelling data, this subset of specimens will provide a correlation between ion and neutron irradiation behavior in a simple vanadium alloy system.

Vanadium-Titanium Series: Ion bombardment experiments on this alloy series are currently in progress. In addition to providing a neutron-ion correlation it is desired to determine the composition of the precipitates that form before and during irradiation.

Vanadium-Other Solute Series: In addition to chromium and titanium, three other solutes were chosen (Ni, W, Mo) to provide a range of elements varying from slow to fast-diffusing species. Both solute segregation and the diffusion relationship to swelling and other property changes will be studied.

V-15Cr-xTi and V-Cr-Ti-Zr Series: These alloys will be used to study the interplay between titanium's role in both fabricability and swelling and also to study the consequences of total or partial substitution of zirconium for titanium.

Reference Alloy Series: The three ADIP alloys described earlier will be included for comparison with the results of on-going ADIP studies.

5.3 Status of Experiment

All of the alloys shown in Table I have been prepared as TEM disks and delivered to HEDL for engraving and encapsulation. A total of 546 disks is currently available for irradiation. Some alloys (V-20Cr, V-Cr-Ti-Zn series) are still being prepared. Preparation of miniature tensile specimens is also in progress.

6.0 References

1. A. M. Ermi, "FFTF Fusion Irradiations-FFTF Cycles 4-6," Alloy Development for Irradiation Performance Semiannual Progress Report for Period Ending September 30, 1984, DOE/ER-0045/13 p. 21.

7.0 Future Work

Preparation of tensile specimens will continue.

8.0 Publications

None.

Vanadium-Base Alloys for Irradiation in FFTF

Reference No.	Alloy Composition	Facility	DAFS	ADIP	ADIP	ADIP	ADIP	DAFS	ADIP	ADIP	ADIP	DAFS	Total No.	Primary Purpose for Irradiation
		Temp.(°C)	420	420	420	420	420	520	520	600	600	600		
		DPA	26	26	26	52	78	14	28	10	30	78		
			Number of 3-mm Discs in Irradiation Facility											
BL-1	V-2.5Mo		2		3	2	2	2	2	2	2	2	19	Solid state parameters for swelling and solute segregation
BL-2	V-8.5W		2		3	5	5	2	2	2	2	2	25	Solid state parameters for swelling and solute segregation
BL-3	V-10Ni		2		3	2	2	2	2	2	2	2	19	Solid state parameters for swelling and solute segregation
BL-4	V-10Cr		2		3	2	2	3	2	2	2	2	20	Neutron/ion comparison
BL-5	V-15Cr		5					1	2	2	2	2	14	Neutron/ion comparison
BL-8	V-20Ti-5Y			2					2	2	2		8	Corrosion; surface spallation
BL-10	V-15Ti-7.5Cr		5			5	5	3	2	2	2	2	26	DBTT; swelling; candidate alloy
BL-11	V-5Ti-0.13O_2		3			3	3	2	2	2	2	2	19	DBTT; precipitates; high O_2
BL-12	V-10Ti-0.13O_2		3			3	3	2	2	2	2	2	19	DBTT; precipitates; high O_2
BL-13	V-15Ti-0.13O_2		3			3	3	2	2	2	2	2	19	DBTT; precipitates; high O_2
BL-15	V-20Ti			3				3	2	2	2	2	14	High O, N, C; DBTT; candidate alloy; precipitates
BL-16	V-20Ti		5			5	5		2	2	2	2	23	Low O, N, C; DBTT; candidate alloy; precipitates
BL-19	V				3				2	2	2	2	11	Neutron/ion comparison; high O, N, C
BL-20	V		5			5	5	3	2	2	2	2	26	Neutron/ion comparison; low O, N, C
BL-21	V-15Cr-5Ti		3	2		5	5		2	2	2	5	26	Reference alloy; O, N, C level; neutron/ion comparison; DBTT
BL-22	V-15Cr-5Ti		5			5	5		2	2	2	5	26	Reference alloy; O, N, C level; neutron/ion comparison; DBTT
BL-23	V-15Cr-5Ti		5			5	5		2	2	2	5	26	Reference alloy; O, N, C level; neutron/ion comparison; DBTT
BL-24	V-15Cr-5Ti		5			5	5	3	2	2	2	5	29	Reference alloy; O, N, C level; neutron/ion comparison, DBTT
BL-25	V-15Cr-0.3Ti		5						2	2	2	2	13	Fabricability; swelling; neutron/ion comparison; DBTT
BL-26	V-15Cr-1Ti		5			5	5	1	2	2	2	2	24	Fabricability; swelling; neutron/ion comparison; DBTT
BL-27	V-3Ti-1Si		5			5	5	3	2	2	2	5	29	Candidate alloy; corrosion resistance; DBTT
BL-28	VANSTAR-7		5			5	5	1	2	2	2	2	24	Candidate alloy; swelling; DBTT
BL-34	V-5Ti		5		1	5	5	3	2	2	2	2	27	Precipitates; low O, N, C; DBTT
BL-35	V-10Ti		2		3	5	5	3	2	2	2	2	26	Precipitates; low O, N, C; DBTT
BL-37	V-15Cr-5Ti(20%CW)			2	2	5	5	3	4	4	4	5	34	Thermo-mechanical; DBTT; neutron/ion comparison
											Total		546	