

6th IEA & JUPITER Joint Workshop on
Vanadium Alloys for Fusion Applications
Loews Ventana Canyon Resort
Tucson, Arizona
June 21- 22, 2002

Session II – Microstructural Evolution -Summary

Effect of impurities and alloying additions (binary V-X systems) on the formation of dislocation loops, voids, and precipitates during irradiation

The logo for IMR (Institute for Materials and Radiation) is located on the left side of the slide. It consists of a vertical black line intersecting a horizontal black line. To the left of the vertical line, there are three overlapping rectangular blocks: a blue one at the top, a red one in the middle, and a yellow one at the bottom. The letters "IMR" are printed in a bold, sans-serif font, centered vertically between the horizontal line and the bottom of the colored blocks.

IMR

H. Matsui

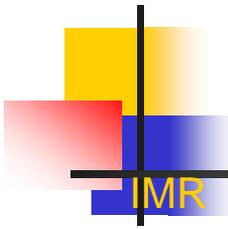
IMR, Tohoku University



Summary

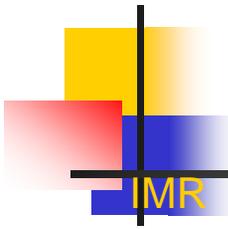
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- Fundamental point defects parameters
 - Point defects parameters in the literature, both theoretical and experimental studies, are summarized.
 - HVEM in situ experiments provide real engineering material relevant data.
 - Many of the parameters depend only on computer simulation studies, and accurate experimental data is necessary to validate simulation data.
 - *Knowledge on impurity effects are not sufficient, and more work is necessary.*
- Dislocation loop and cavity formation
 - Based on low dose neutron irradiation TEM and positron annihilation data, the temperature range where nucleation or growth occurs has been identified for several binary V-X alloys.
 - Vacancy mobility is significantly retarded by oversized atoms, especially by Ti.
 - Effect of interstitial impurities is significant and complex. Alloys purified with “Zr-treatment” contain typically only approx 10ppm O and N. Density and size of loops formed at 400C are not significantly affected by Zr-treatment while channeling tendency is significantly reduced.
 - *More work using controlled amount of O, N, C is necessary*



Summary

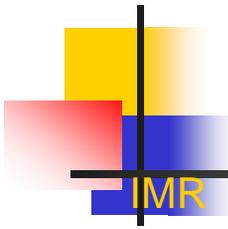
- Precipitates
 - Most of the precipitates are interstitial impurity originated.
 - “Pure V”: VC; V-5%Ti:Ti₂O, TiO, TiO₂; V-Cr-Ti(-Si): TiO, Ti(O,C,N) , Ti₅Si₃, etc.
 - O, N, C, should be considered as alloying elements in vanadium, analogous to carbon in steel; development of better control technique of O, N, C is required.
- Hydrogen effects
 - After cathodic charging an additional hardening takes place in neutron-irradiated V and V alloys (300 C, 0.01 dpa), as well as radiation hardening.
 - Disappearing Luders Strain by irradiation:
 - In un-irradiated V and V alloys Luders strain develops after cathodic charging, but it disappears in irradiated samples.
 - Reduction in free hydrogen in irradiated samples.



Summary

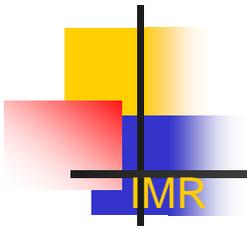
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- Variable temperature irradiation results
 - Can result in significant change in microstructure, especially when the temperature excursion occurs between nucleation regime and growth regime.
 - Precipitate stability may be influenced significantly by temperature variation.
 - *Theory and modeling on variable temperature effects is necessary.*



Summary

- High dose irradiation tests are lacking.
 - Fully utilize existing facilities and irradiation opportunities
 - JOYO, HFIR,
 - Utilize irradiated specimens left over from previous irradiation campaigns: FFTF/MOTA, DHCE, EBR-II..?
 - *AI: Kurtz will provide information to JP on the existing irradiation specimens in PNNL*
- He and H effects are still need to be addressed intensely.
 - Qualitative understanding has been obtained, while quantitative evaluation is not possible with high accuracy.
 - Fusion neutron source is awaited;
 - *Simulation technique, e.g. DHCE may be useful.*



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