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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

IMR

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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

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- Precipitates
  - Most of the precipitates are interstitial impuriy originated.
  - “Pure V”:VC; V-5%Ti:Ti_2O, TiO, TiO_2; V-Cr-Ti(-Si): TiO, Ti(O,C,N) , Ti_5Si_3, 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

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- 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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