PbLi and Li Compatibility

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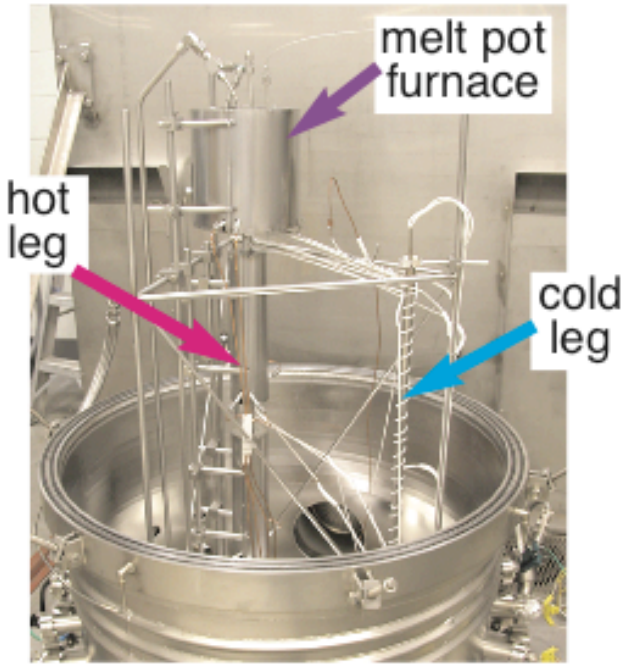
Recent Work (FY08)

- Li (no new work planned in FY09)
  - Opened monometallic V-4Cr-4Ti loop
    - Ran 2,355h from March-June 2007
  - Characterization of specimens in progress
    - Chemistry, tensile (RT and 500°C), MHD coatings
- Pb-Li (100% of future work)
  - Conducted one FY08 series of capsule tests
  - Early planning stages of loop design
    - Location, capabilities, safety concerns, materials

2007: Coatings in flowing Li

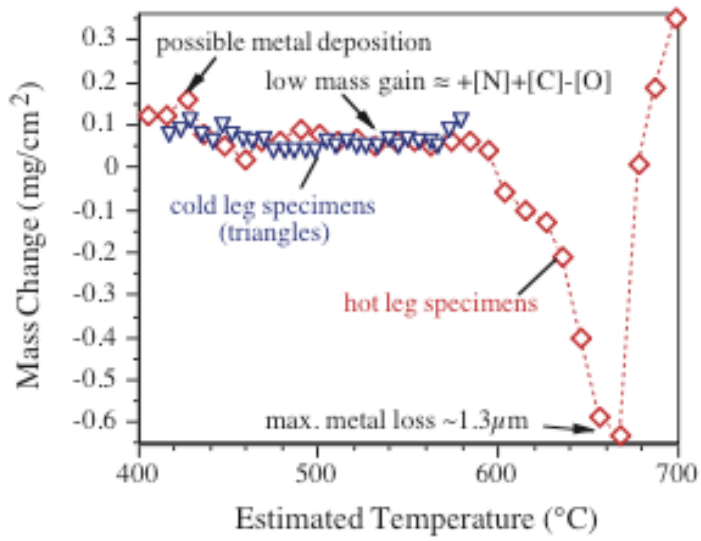
Loop ran 2,350h; Peak 700°C, ΔT~275°C

V-4Cr-4Ti tubing, <10^{-5}Pa vacuum



loop,furnaces,chamber

V/Y_2O_3 coated specimen



2 x 29 V-Cr-Ti specimen chains:

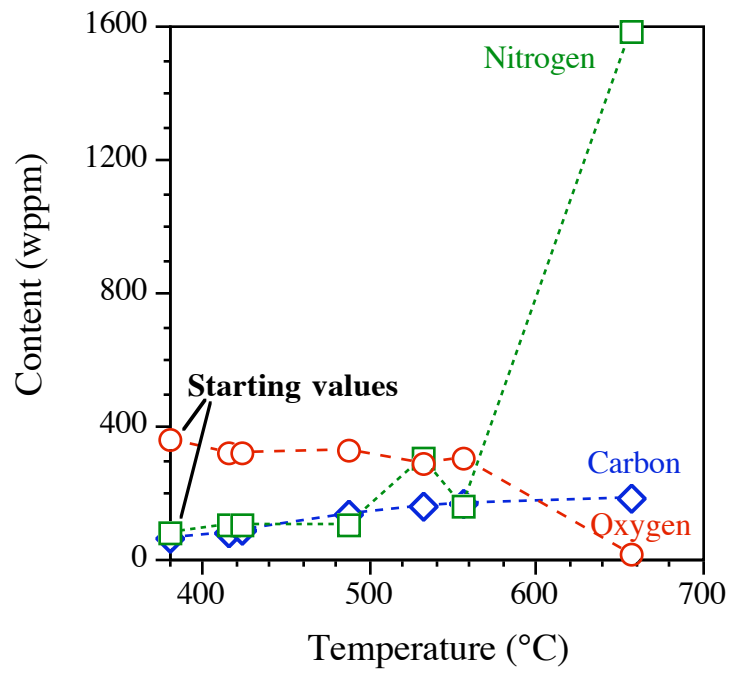
Monometallic: all V-4Cr-4Ti in flowing section

V overlayer likely experienced some dissolution in Li

Chemistry of V-4Cr-4Ti

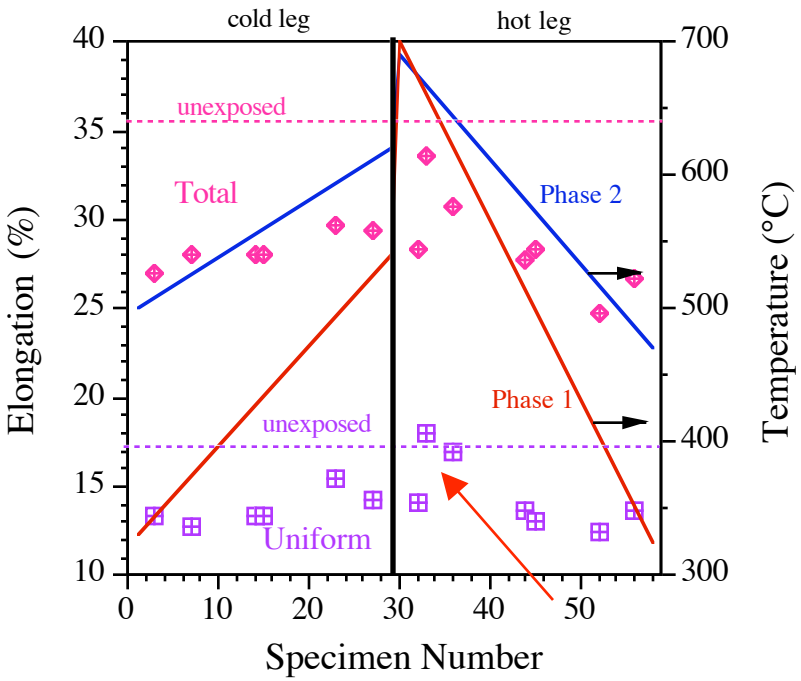
Changes after 2,355h in flowing Li

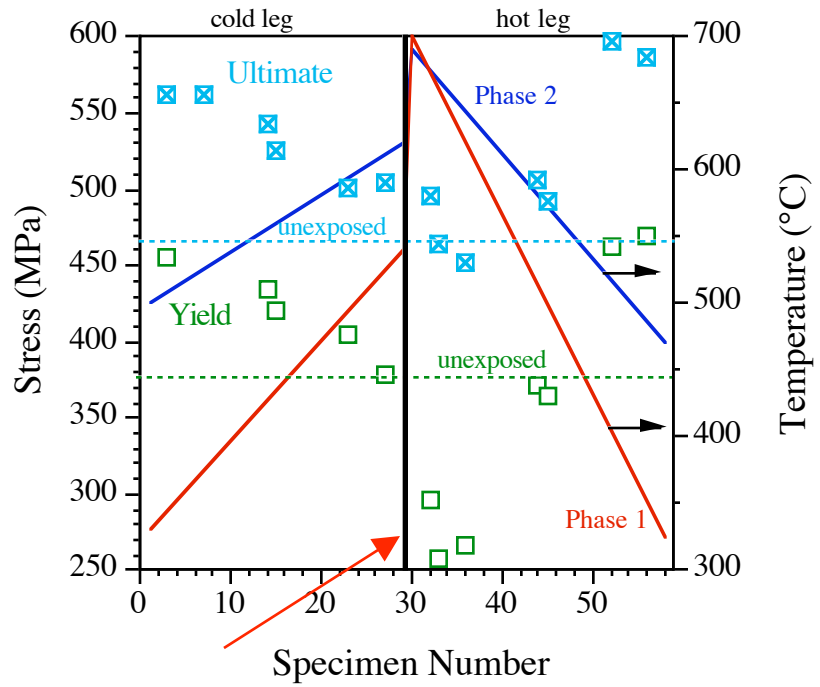
- As expected, Li gettered O, not C, N
- Hottest specimen:
  - low O, very high N
- Future work to look at changing N, O, C contents on Ti(O,C,N) particle composition
- Requires analytical TEM (Hoelzer, Bentley)



Room temperature tensile properties

V-4Cr-4Ti SS-3 specimens after 2,355h in loop





Most specimens with mass gain showed higher yield and less elongation, consistent with interstitial uptake

Mass loss specimens (arrow) showed lower yield stress

Current characterization work

V-Li loop specimens

- MHD specimens
  - Need to develop test protocol
  - V overlayer prevents Y_2O_3 resistance measure
  - Curvature change due to stress relief of reaction?
- 500°C tensile tests of V-4Cr-4Ti

  - recalibrating vacuum test equipment
- Thermal anneal simulation (T effect, no Li)

  - 2,350h, 700°C, quartz ampoule

  - tensile specimens (check RT and 500°C)

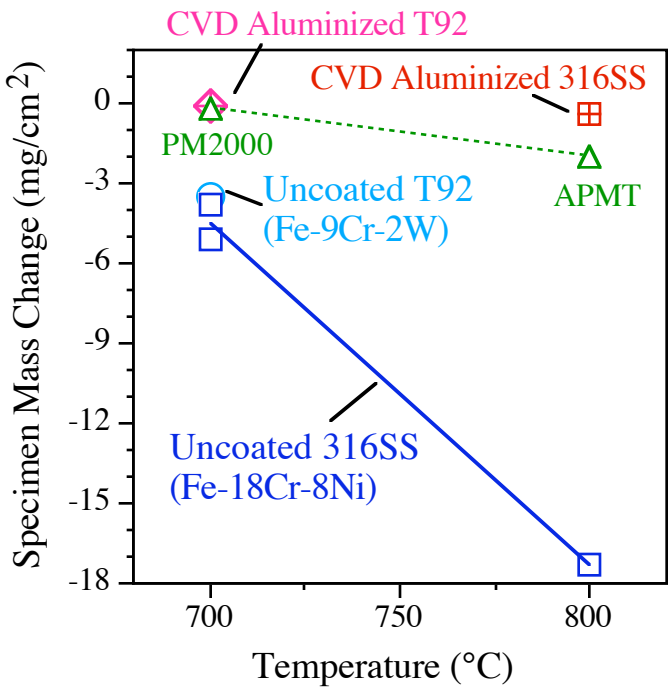
  - MHD specimen (change in curvature?)

Goals for Pb-Li capsule tests

- Study oxide transformation in Pb-Li
  - Followup study on Al_2O_3 -> $LiAlO_2$ (JNM, 2008)
  - Characterize reaction SiO_2 -> $LiSi_xO_y$
    (relevant to building quartz loop)
- Al-rich corrosion resistant coating
  - Exposed coating on Fe-9Cr-2W
- Baseline reaction rates of materials
  - SiC work largely completed
  - FeCrAlMoY tube alloy (Kanthal APMT)
  - Future: effect of Ni, Fe impurities in Pb-Li

Al-rich corrosion coatings for Pb-Li
1000h capsule tests on Fe-base substrates

- Alloys dissolve in PbLi (Ni>Fe,Cr)
- FeCrAl-type alloys less dissolution: APMT, PM2000
- CVD Al coatings reduce dissolution of 316, T92
- Coatings are ~50μm ferritic Fe(Al) layer (18at.%Al surface)
- Need flowing Pb-Li to confirm corrosion-resistant performance
- How perform in purified (low O) Pb-Li capsule?



Pb-Li loop planning

- Identified likely location at ORNL
  - Vacuum chamber for Li loop not needed
  - Completed initial safety assessment
- Design

  - harp-shaped thermal convection loop similar to V-4Cr-4Ti
  - removable specimens for repeat use
  - loop material: Quartz vs. PM FeCrAlMoY
  - temperature capability to 800°C
- Experiment plan
  - Begin at 500°C
  - Increase subsequent experiments at ~50°C increments
  - Materials: Ferritics, coatings, SiC

FY09 compatibility goals

- Complete V-Li loop MHD specimen characterization
- Complete final Pb-Li capsule tests
  - loop material: Quartz vs. PM FeCrAlMoY
  - kinetics of transformation (Li-thiation) of Al and Si oxides
  - corrosion resistant Fe(Al) coatings on Fe-9Cr-2W
  - impurity effects on dissolution rates
- Complete design and begin construction on Pb-Li loop
- No TITAN/JAEA work