SAND2018-10052C

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Post-test examination of a Li-Ta heat pipe exposed to H plasma in Magnum PSI

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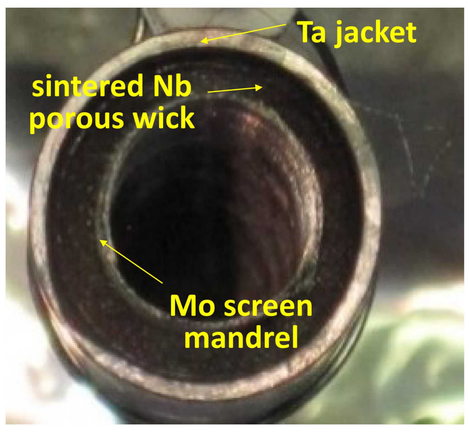
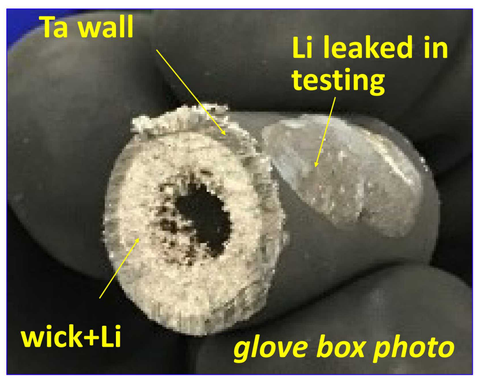
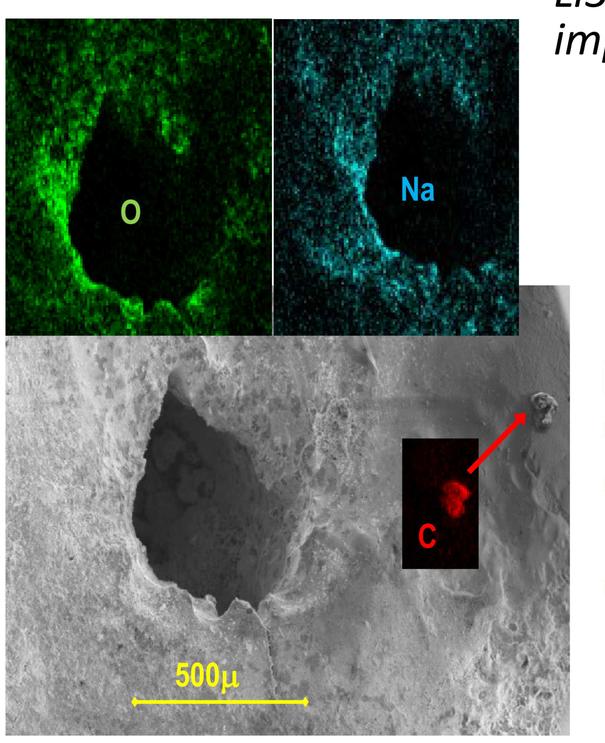
HP just after removal from Magnum PSI

HP before end cap weld







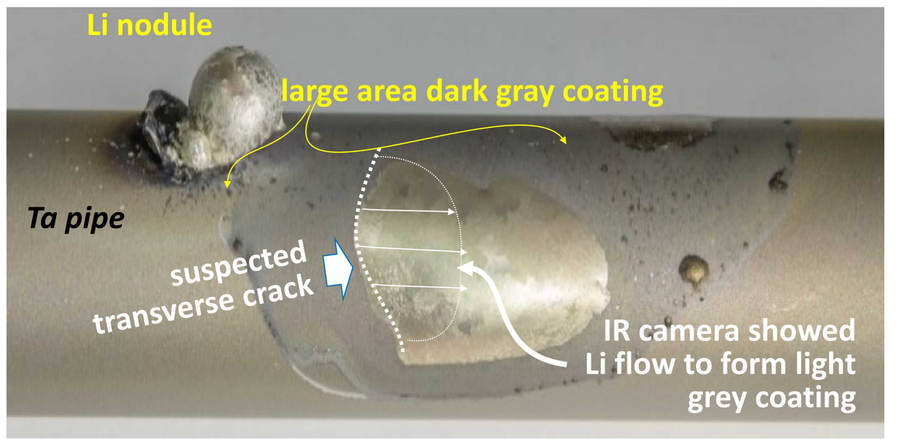
ABSTRACT

We exposed a radiatively cooled, Li-filled Ta heat pipe (HP) to a H plasma in Magnum PSI for ~2 hours.

Tilts of 30-45° gave peak heat loads of 7.5-13 MWm^2 and peak temperatures of 1220-1280° C.

We show here the post-test analysis to date and discusses Li HPs with materials other than Ta.

Poster XX (Matthews, Wed) describes the experiment.



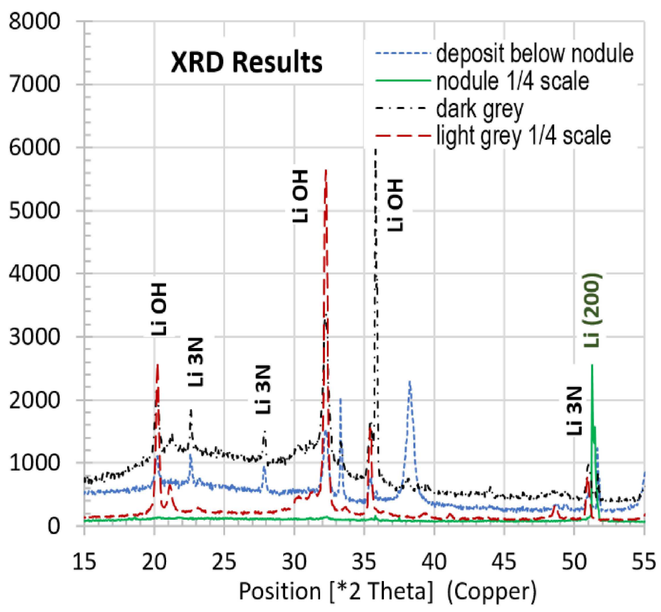
POST-TEST SUMMARY

- Pinhole, 1st leak site
- Dark grey coating *(DGC) Li3N+LiOH+???, role of impurities not clear*
  - No tube wall crack
  - Light grey coating *(LGC) only LiOH*
  - Ta recrystallized, one or a few grains thru wall

HYPOTHESES

- DGC fluid was in HP.
- DGC solidified, cracked (Li3N solidifies 813°C).
- Li below DGC flowed up thru crack, formed LGC.

We cleaned the sample for other analyses and cannot verify hypothesis.

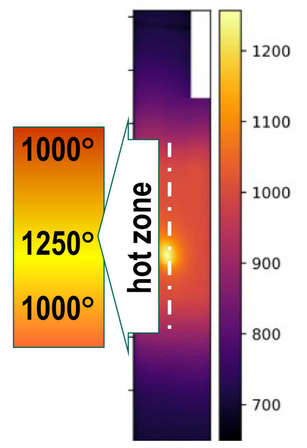


MATERIAL

- We would not pick Ta for PFCs.
- This Ta was old (1980's project).
- 7 wt% C is very high, non-typical.
- Embrittlement not evident (H/Li)

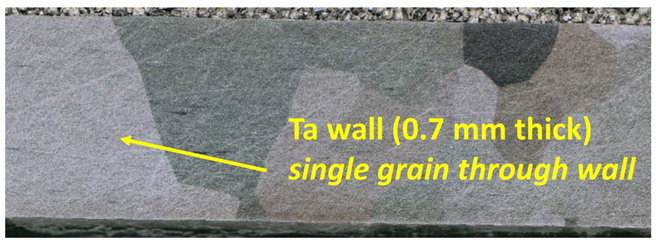
LEAK SUMMARY

- Li leak; orange plasma; Li → nodule
- H off; Li+? → *DGC*
- Delay; HP cools Li → *LGC*

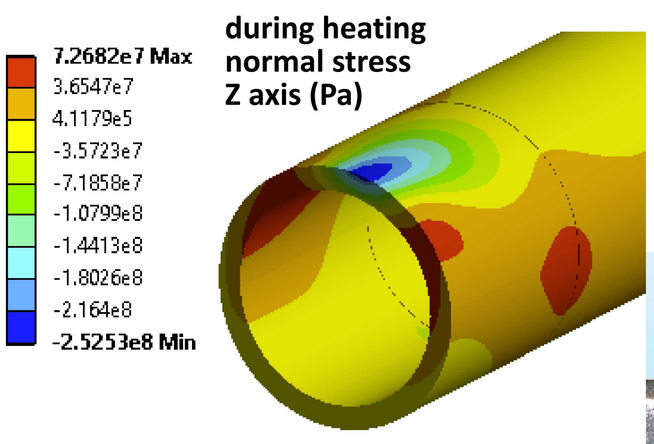


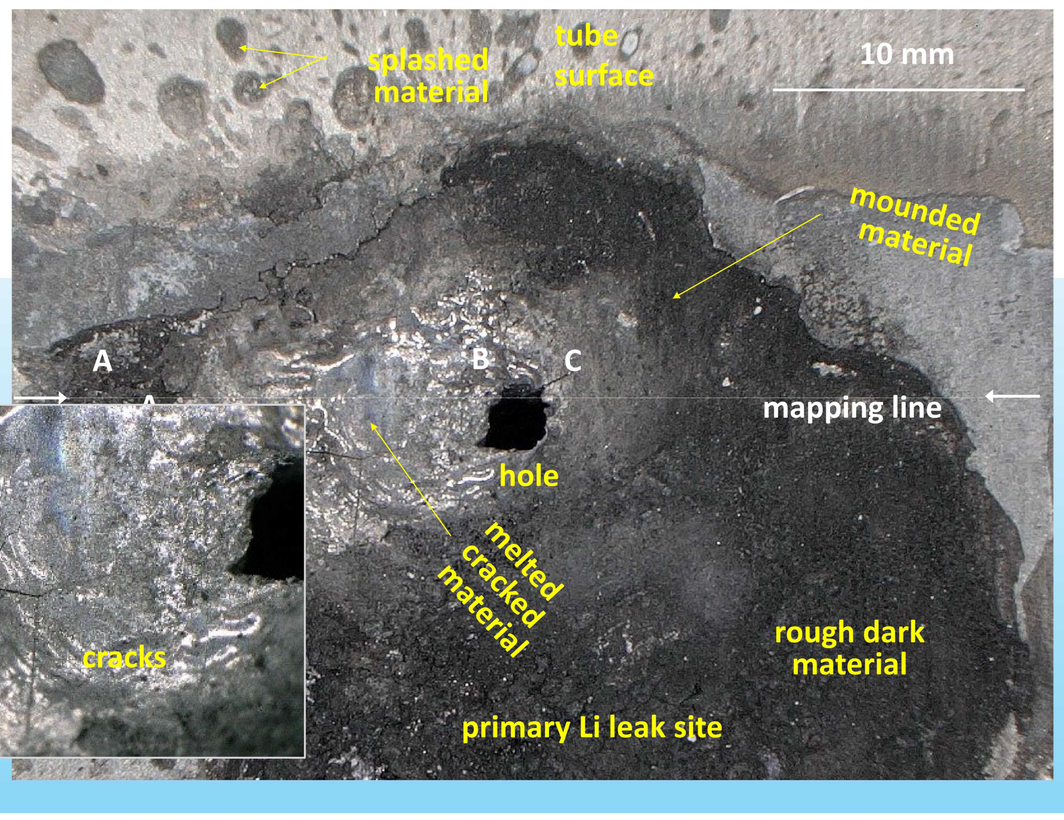
LI HP CAPABILITIES

- ATI estimates the Li HP can accept ~2.8 kW input power operating at 1400°C (ε=0.5), ~4X what we saw in DIFFER.
- Li is the best working fluid for refractory metal HPs in PFCs due to their high performance, and the temperature range is good for reactor/DEMO PFCs.
- Testing at higher powers and magnetic fields (and long pulses to see MHD drag) is needed.



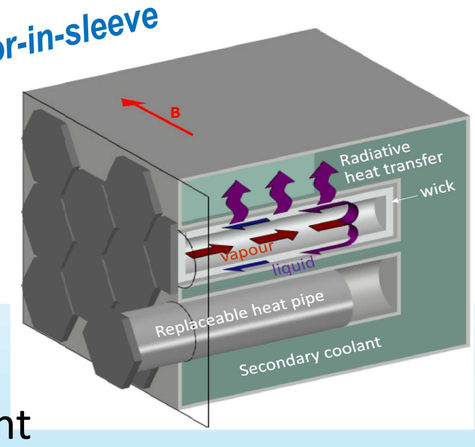
- We would like to make new HPs with refractory metals, as funding permits, but avoid a materials R&D project. W and Li are compatible, but W is a challenge. C103 (Nb alloy) and W-Re or W-Ta are available commercially.





Component	Material	Dimensions
Jacket, pebble-milled surface	Ta	OD ID L (mm) 17 15.6 197 0.7 emissivity
Sintered wick	Nb particles	ID 0.088-0.25 mm 55% porosity
Screen	Mo mesh	0.15mm grid
End caps	C-103 Nb alloy	6mm thick
Fill tube	Nb (1%Zr)	
Working fluid	Li	~5g

condensor-in-sleeve concept



- Radiatively coupled HPs have no vacuum boundary joint with a secondary heat exchanger.
- This is very attractive for remote maintenance, particularly got divertors and other special components that need interim replacement, e.g., shielding for RF launching structures.

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