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The Electrochemical Approaches for the Development of a Liquid Blanket System

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ABSTRACT

The electrochemical technique is effective to develop liquid blanket system, not only for the molten salt one but also for the liquid metal ones. Based on the experiments using metallic tritium breeder and LiCl-KCl molten salt, new liquid breeding system using Li-Pb intermetallic compound and LiCl-KCl salt is proposed. Hydrogen transport behavior in the system is experimentally investigated and rough tritium and heat balance in the 3GW$_{th}$ system is calculated as well, which is shown to be feasible.

BACKGROUND

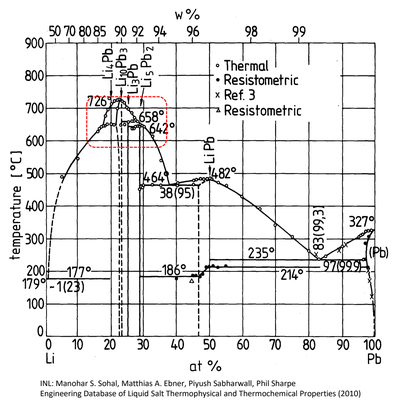
- Electrochemical purification has been investigated mainly for the molten fluoride (FLiBe) system (removal of TF, Ni, Fe, H_2O etc.)
- Recently, electrochemical impurity removal for liquid metal breeder (Li, $Li_{17}Pb_{83}$ eutectic) is shown to be possible using compatible molten salt such as LiCl-KCl.
- High m.p. Li-Pb intermetallic compound (Li3Pb, Li10Pb3, etc.) has not been well investigated because of its difficulty in T recovery (high T solubility) while it may be possible using compatible molten salt (LiCl-KCl) and electrochemical method.
- Behavior of blanket system with Li-Pb intermetallic compound and chloride molten salt is completely unknown, so that basic "experimental investigation" and "tritium and thermal balance calculation" are required.

CHALLENGES

Chloride molten salt for liquid breeder purification

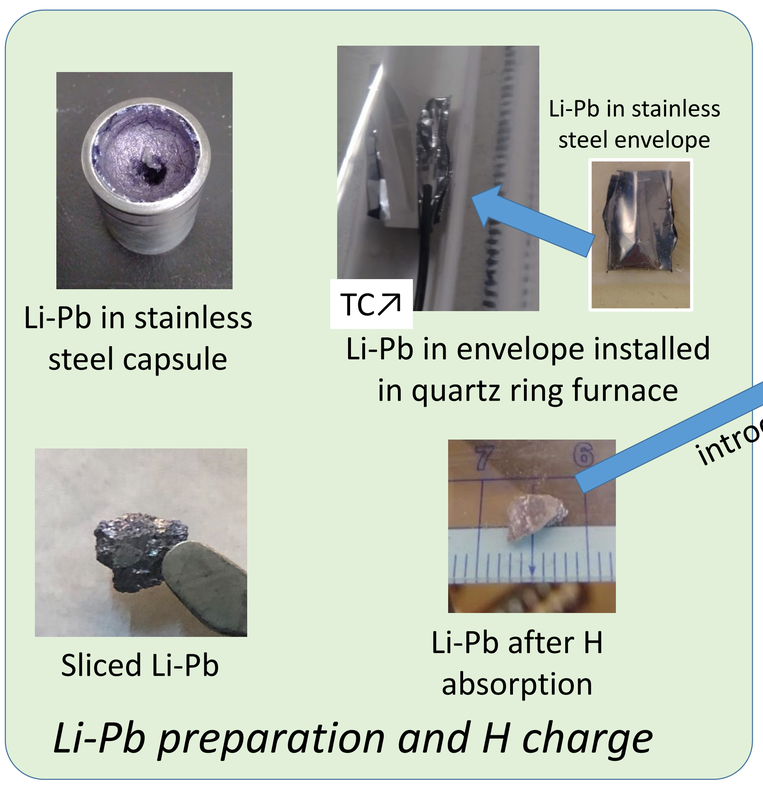
Feasibility of electrochemical purification of liquid breeder metal (Li-Pb eutectic, Li) using LiCl-KCl has been shown (O in Li-Pb, N in Li, etc.) as well as the T extraction from liquid Li.

Li-Pb intermetallic compound(Li-Pb) is compatible with LiCl-KCl (unlike FLiBe). Li-Pb can function as i) neutron multiplier, ii) tritium breeder(*solid*), iii) redox reagent (reacts with TCl etc.).
Furthermore, Li-Pb pebble in molten salt flow will increase the heat transference.



If generated T in Li-Pb pebble easily transported to LiCl-KCl (as LiT), tritium recovery from the system can be done with electrochemical process.

<u>In this work, transport of H in Li-Pb and from Li-Pb to LiCl-KCl is investigated and based on the result, feasibility of Li-Pb/LiCl-KCl blanket system is also investigated.</u>



Li-Pb preparation and H charge

Electrochemical H^- oxidation in LiCl-KCl

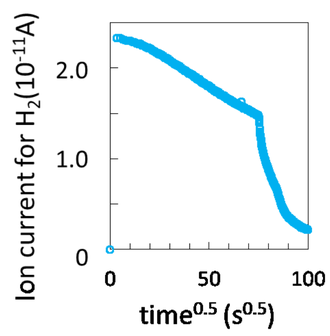
OUTCOME

<u>H transport from Li-Pb to vacuum and to LiCl-KCl</u>

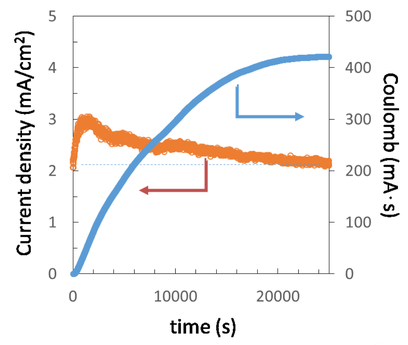
-H_2 release from Li-Pb to vacuum was almost linear to the square of the time. This result indicate the diffusion limited transport. D~$10^{-10}m^2/s$ (773K)

-Current correspond to the LiH in LiCl-KCl rapidly increased when H absorbed Li-Pb is introduced to the salt. The increase of the current was almost the same as that quantified by the result in vacuum.

-H transport from Li-Pb to LiCl-KCl is found to be good, using them in blanket system will be feasible.



H release from Li-Pb in vacuum (diffusion limited)



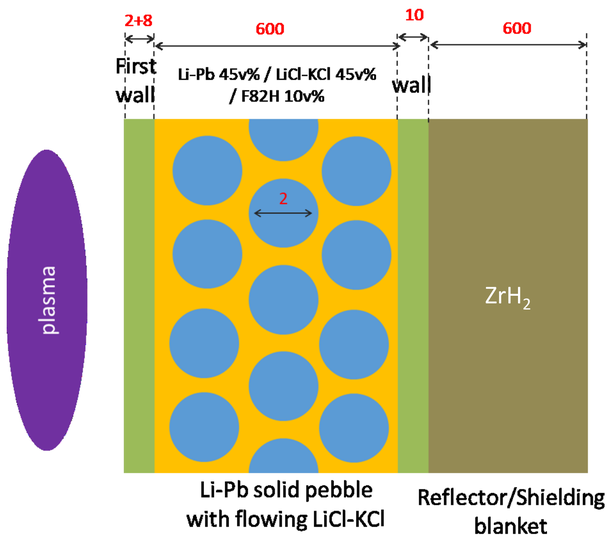
Electrochemical removal of H in Li-Pb through LiCl-KCl

Almost the same amount

<u>Transport of H from Li-Pb to LiCl-KCl is smooth!</u>

<u>Chloride molten salt blanket system with Li-Pb intermetallic compound</u>

- Diffusivity in the Li-Pb is supposed to be $10^{-10}m^2/s$
- 1 dimensional TBR calculation is done.
- Enrichment of ^6Li and ^{37}Cl is preferable for TBR
- As a structure material, F82H is selected.
- T flow in the Li-Pb pebble (2mm) and thermal balance are calculated.
- Tritium transport at the Li-Pb/salt surface is supposed to be smooth.



-TBR is found to be enough.
-Low m.p. of LiCl-KCl enables ⊿T~170K using RAFM steel.
-Tritium inventory in Li-Pb is not severe.

Blanket system	
Breeding coolant	LiCl-KCl (59-41at%)
Bleeding multiplier	$Li_{10}Pb_3$
^6Li enrichment [%]	90
^{37}Cl enrichment [%]	90
local TBR	1.22
Li-Pb/salt zone volume [m^3]	900
Thermal balance	
thermal output [GW]	3.0
Coolant flowrate [10^3 kg/s]	13.4
Coolant temp. in/out [K]	653 / 823
Tritium balance	
Tritium flow [10^{-3}g/s]	4.6
pebble diameter [10^{-3}m]	2.0
Max. T conc. in pebble [g/m^3]	0.1
T inventory in pebble [g]	22.5

SUMMARY

- Li-Pb intermetallic compound with high melting point is prepared and its hydrogen release behavior in vacuum and in LiCl-KCl salt is experimentally investigated.
- H release in both cases were almost similar, which indicate the H transport through Li-Pb/LiCl-KCl boundary is smooth.
- Rough TBR and heat/T balance is calculated.
- Li-Pb/LiCl-KCl blanket has good TBR, wider ⊿T than FLiBe system
- Further investigation is necessary, including activation of Cl etc., cost for Cl enrichment, fabrication of Li-Pb pebble, long time compatibility, etc.

ACKNOWLEDGEMENTS / REFERENCES

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