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Hydrogen transport in yttrium hydride under asymmetric heat

May 2024

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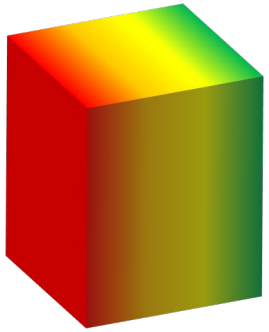
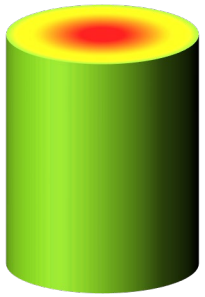
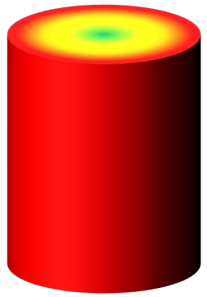
Background

- Hydrogen diffusion in metals is driven by:
  - A hydrogen concentration gradient:
    $$-D\nabla c$$
  - A temperature gradient:
    $$-D\frac{Q^* c}{RT^2}\nabla T$$
- Thermal diffusion (Soret effect) is often neglected because:
  - Assumed uniform temperature.
  - The Soret coefficient is unknown (experiments are difficult).
- The need to consider the Soret effect:
  - Any hydrogen situation where there is a temperature gradient.
    - Any pin or tube e.g. hydrate moderator
    - Fusion plasma facing surfaces.







Diffusion model

$$J_{dif} = -D\nabla c - D\frac{Q^* c}{RT^2}\nabla T$$

$D[m^2 s^{-1}]$ = diffusivity
$c[m^{-3}]$ = dissolved Q atom concentration in metal
$Q^*[J\ mol(Q_2)^{-1}, or\ J\ m^3]$ = Soret coefficient
$R = 8.3145 \times 10^{-3}\ kJ\ mol^{-1}K^{-1}$
$T[K]$ = temperature

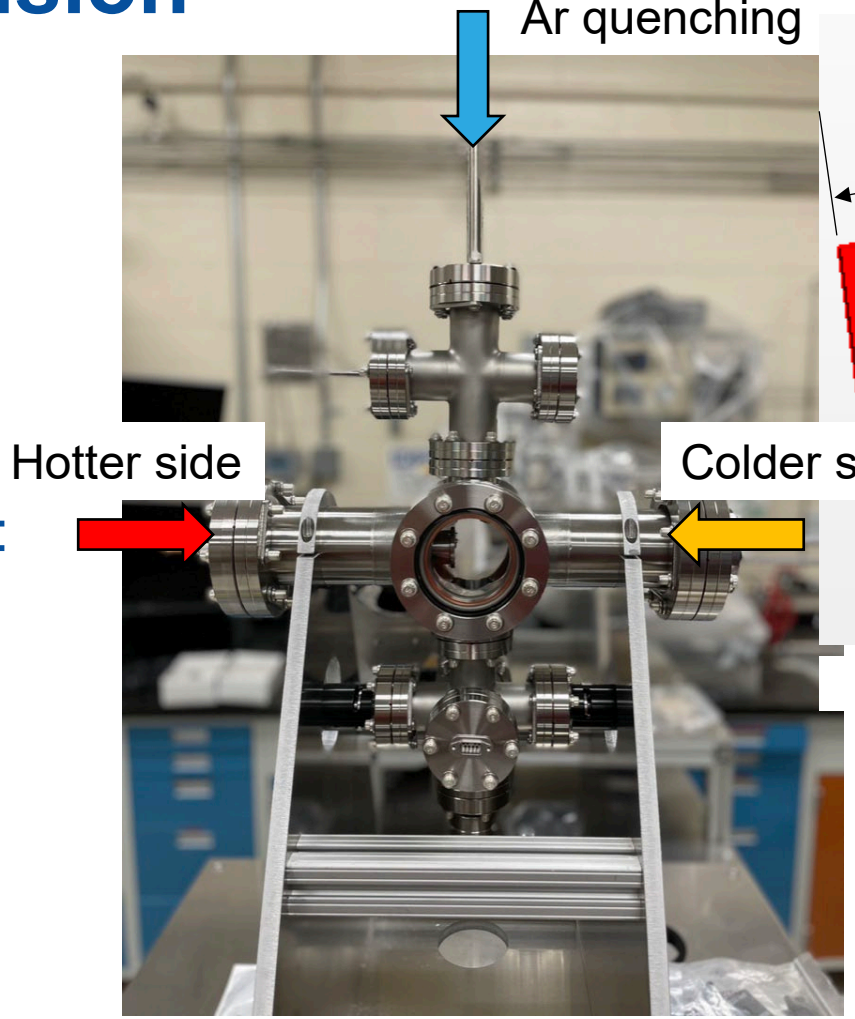
Experiments are difficult

- Imposing a temperature gradient causes the hydrogen to redistribute.
- Releasing the gradient will cause the hydrogen to redistribute, again.
- **Possible solutions.**
  - Assess the hydrogen distribution while a temperature gradient is imposed.

Quench the sample.

HEATD Hydrogen Experimental Apparatus for Thermal Diffusion

- Hotter side temperature:
  - Heater is able to reach closer to 1000ºC.
  - Planned: ~900ºC
- Colder side temperature:
  - Heater is able to reach closer to 1000ºC.
  - Can range from RT to close to hot side temperature



Front

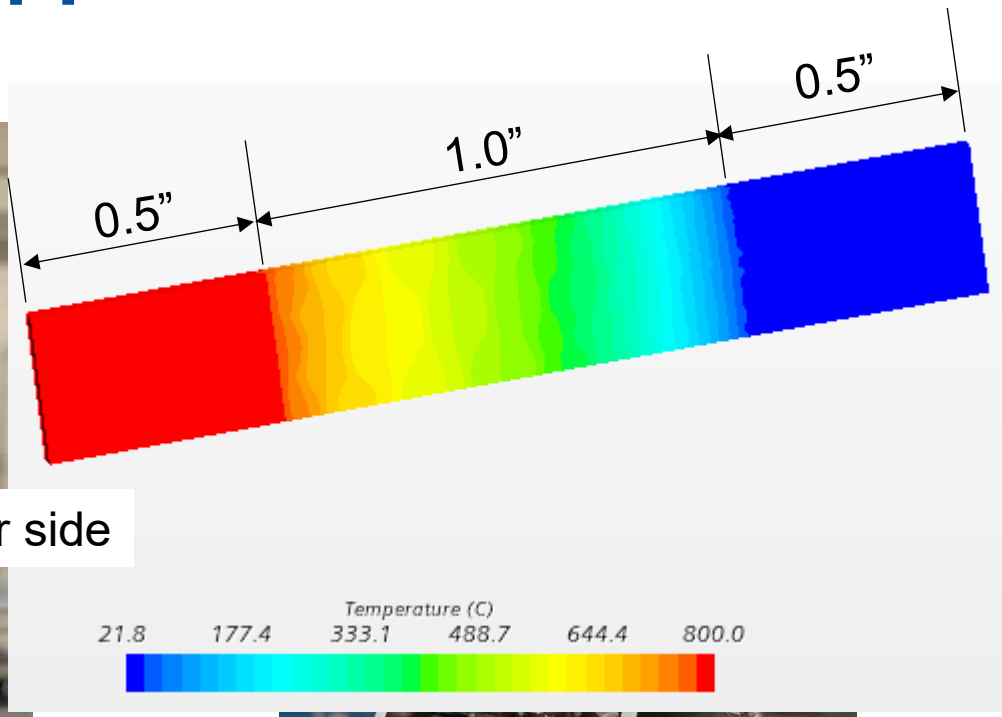
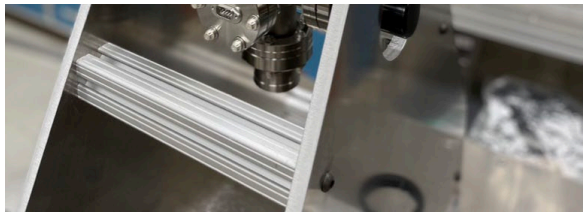


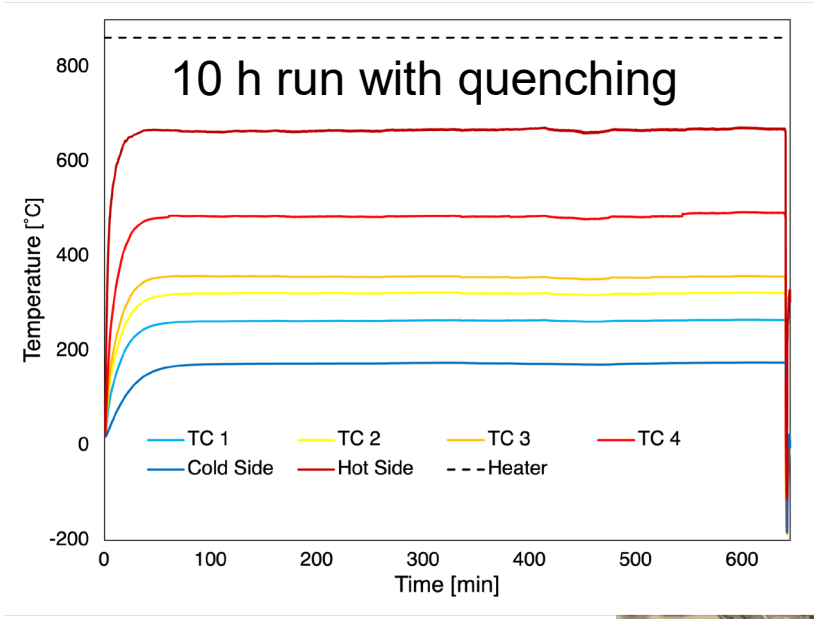
Figure 4: Temperature distribution of the YH2 sample

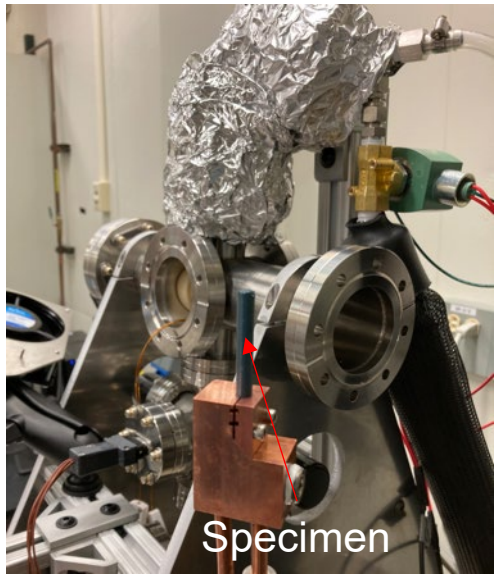


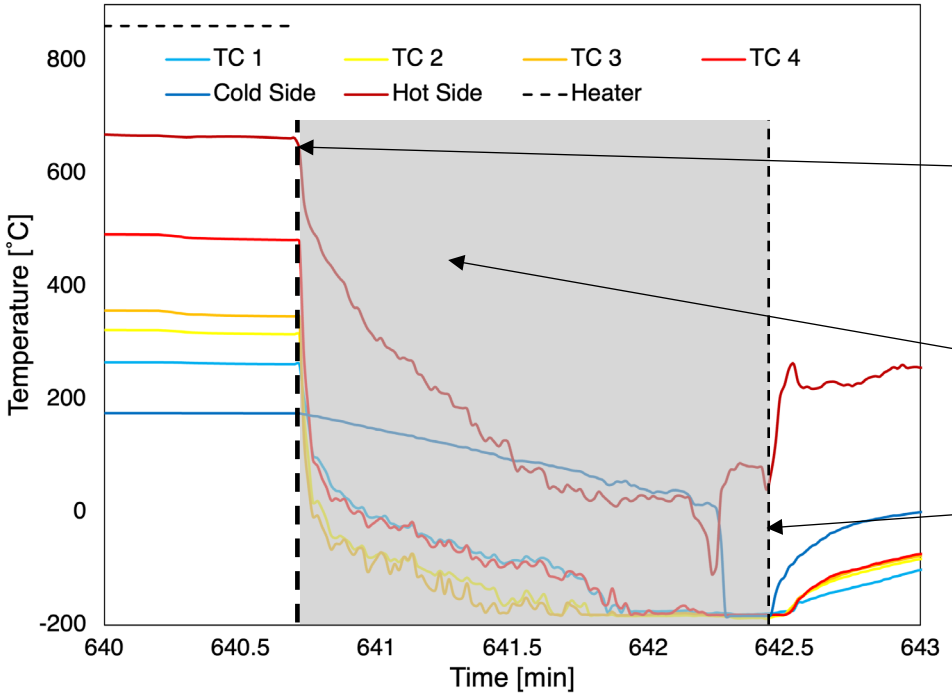
Front-right

Current status and Experiments of HEATD

- Successful set up of system
- Successful heating for 1h, 10h, 100h and subsequentially liquid Ar quenching







Liquid Ar quenching starts, Heater off

Quenching and specimen disassembly

Specimen is out quenching is stopped