Microstructure and hydrogen storage properties of FeTi + x wt.% Hf alloys (x = 0, 4, 8 and 12)

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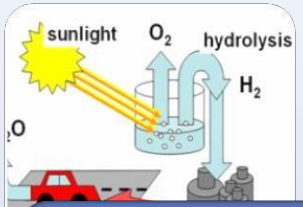
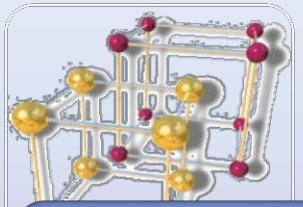


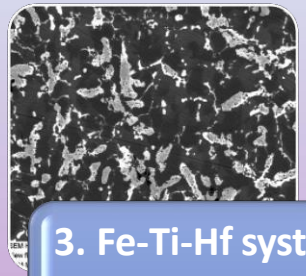
1. State of art

- Renewable energy
- Hydrogen



2. Metal Hydride

- FeTi alloy



3. Fe-Ti-Hf system

- Microstructure
- First hydrogenation properties

4. Conclusion

- Outlook
- Perspectives

Energy : big challenge of the XXI century

High population growth

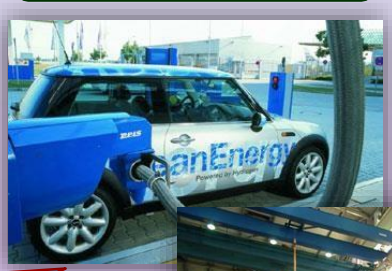
Limited reserves of fossil fuel

Reduction in emissions of greenhouse gases

Renewable energy

HYDROGEN

Urban transport



Electronic

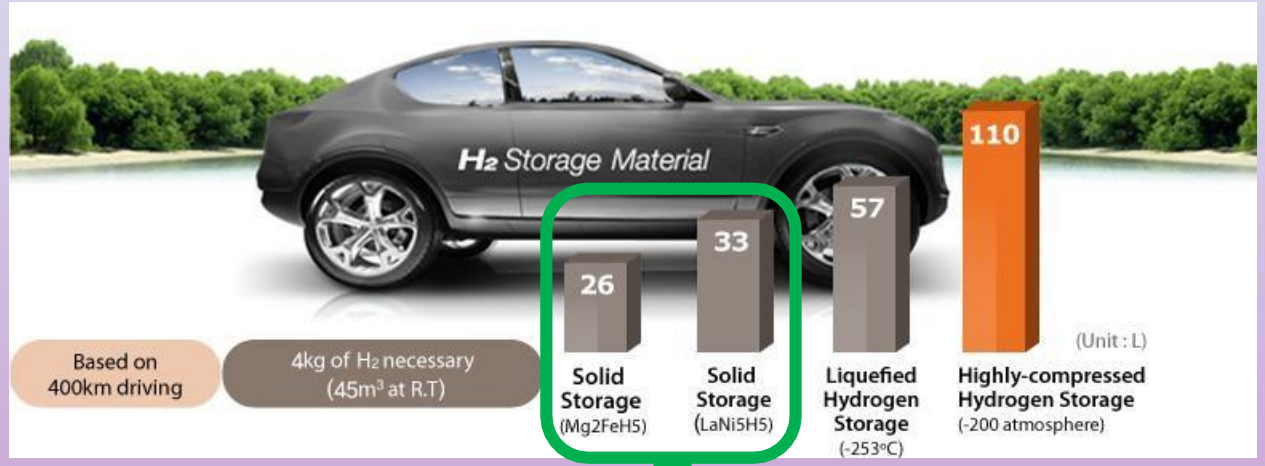
« Stationary » application

Hydrogen storage

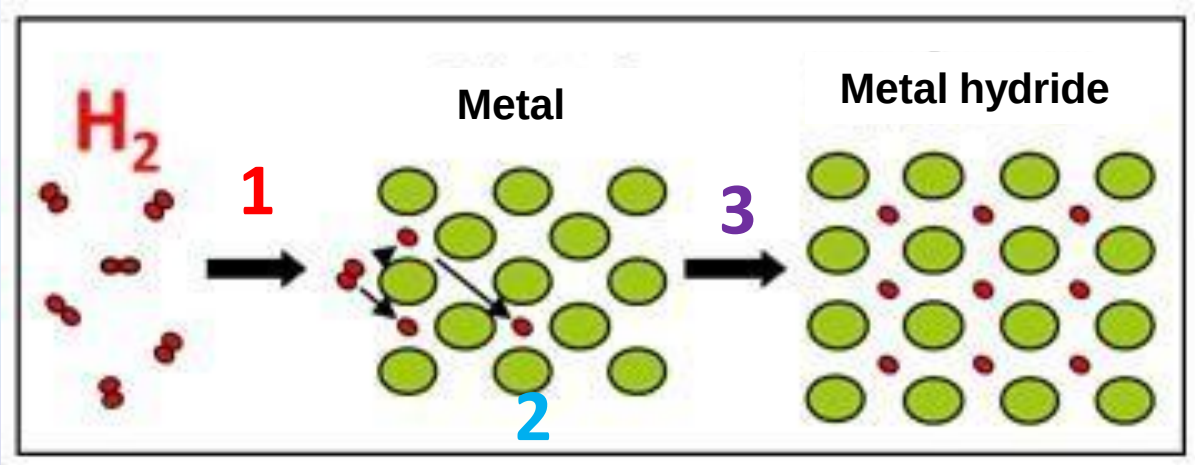
Hydrogen liquid
-253°C / 1 atm

Compressed
25°C / 350 to 700 atm

Metal hydride
25°C – 1 atm



Best way to store hydrogen

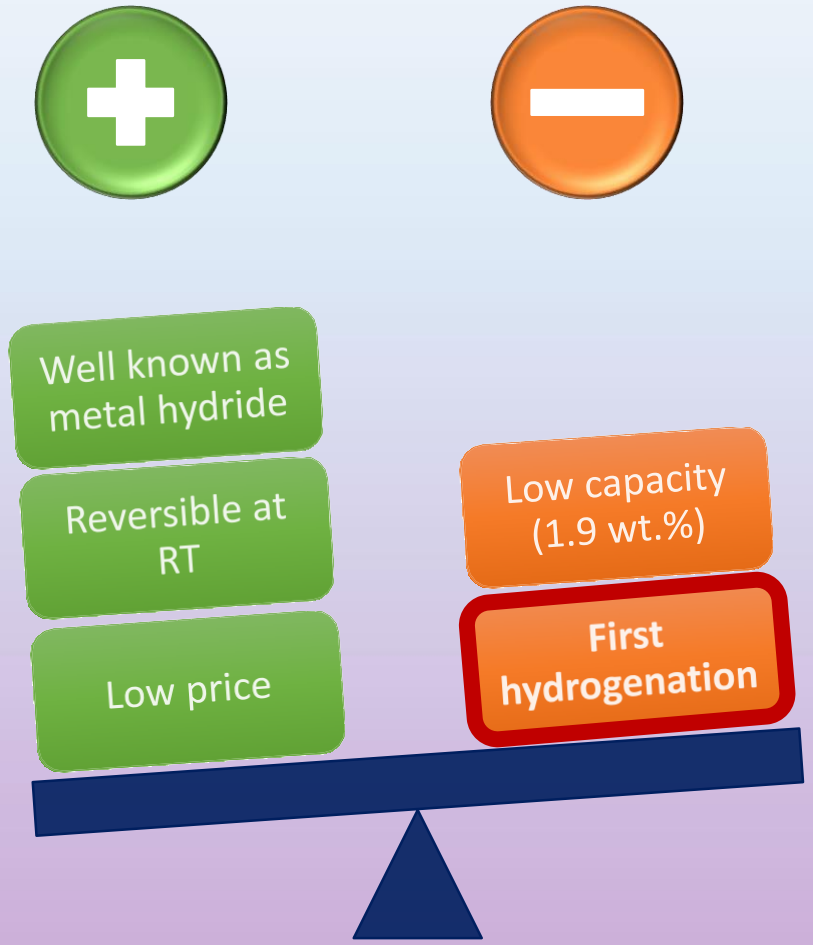


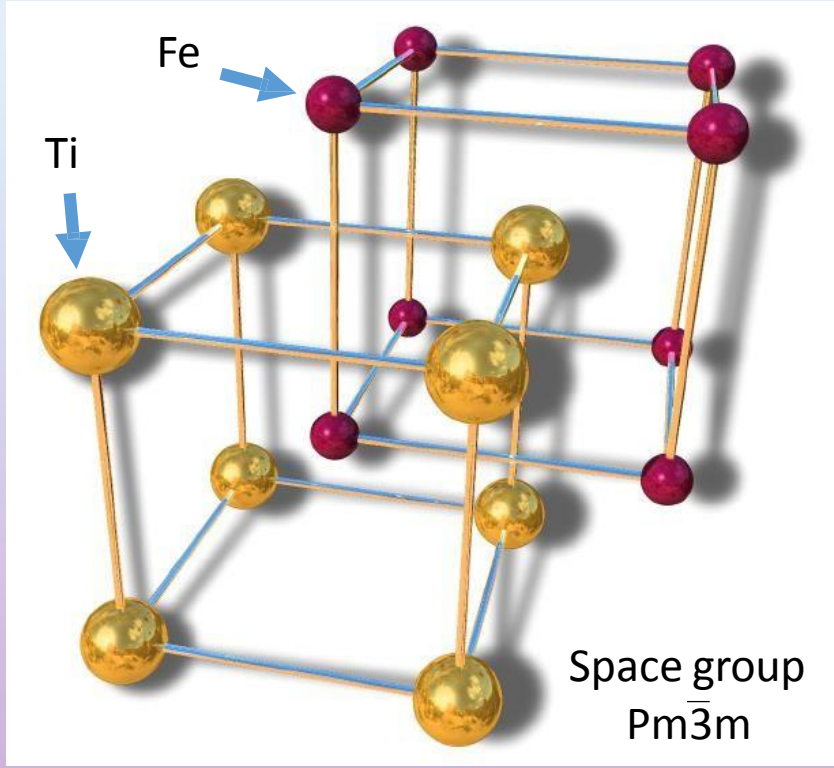
1. Adsorption (and dissociation) of hydrogen

2. Diffusion of hydrogen (absorption)

3. Total absorption of hydrogen in the material

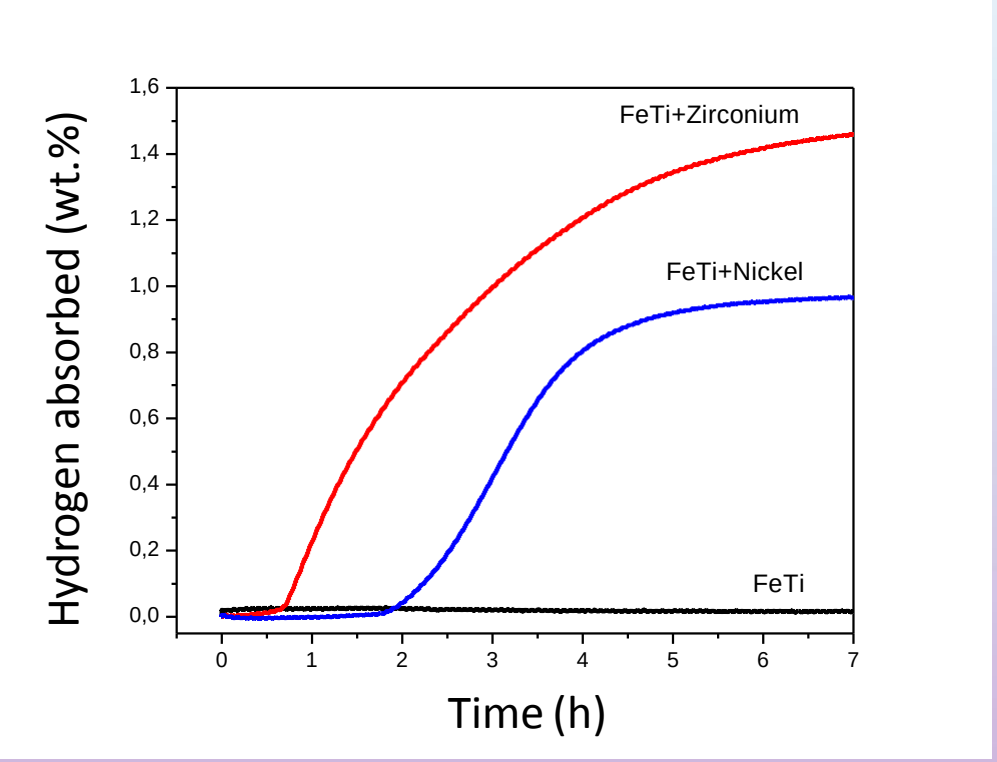
FeTi alloy


Well known as metal hydride
Reversible at RT
Low price
Low capacity (1.9 wt.%)
First hydrogenation


Fe
Ti
Space group
Pm$\bar{3}$m

Alternative process

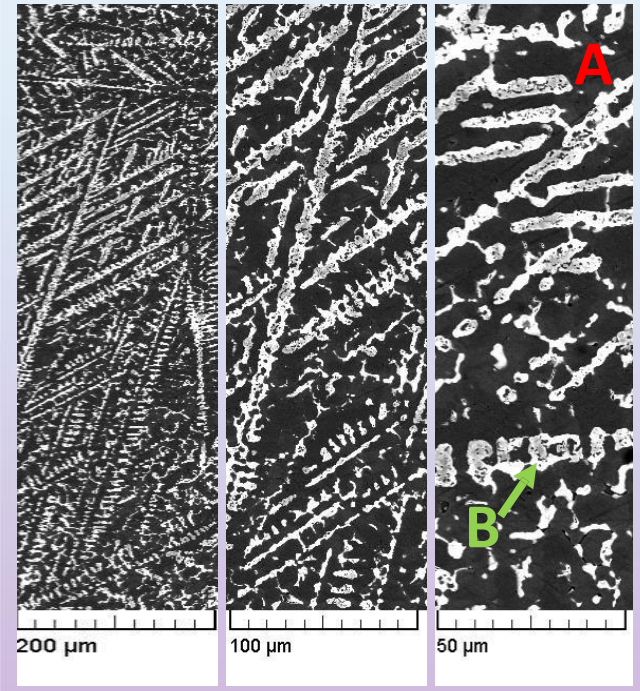
- Substitute Fe by Mn
- Add some dopants such as :
  - Zirconium (Zr),
  - Nickel (Ni),
  - Zr_7Ni_{10},
  - **Hafnium (Hf)**



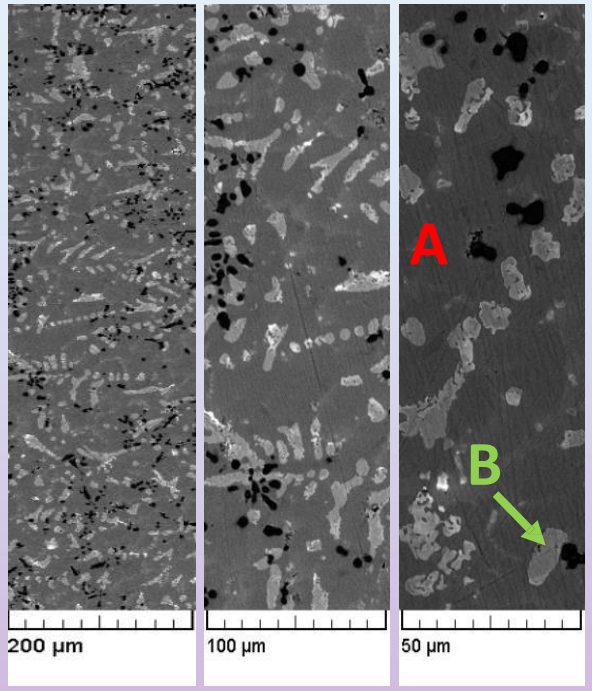
Activation curves of FeTi and FeTi doped with Zr and Ni, at 25°C under 45 bar of H_2.

Microstructure

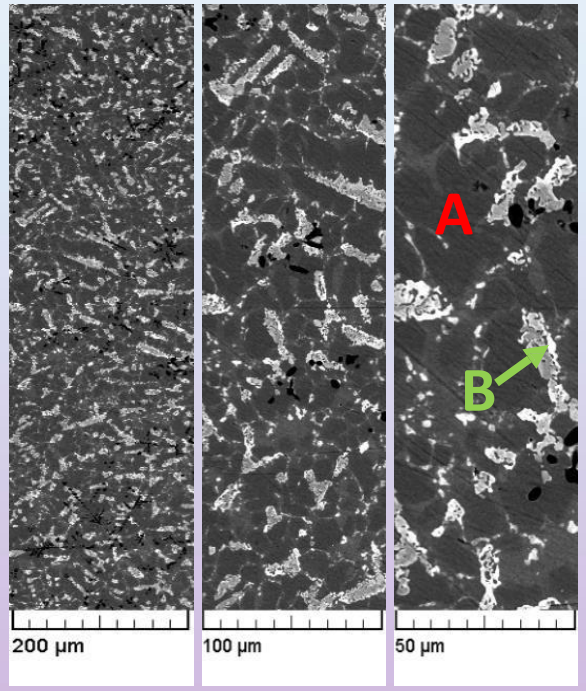
FeTi + 4wt.%Hf



FeTi + 8wt.%Hf



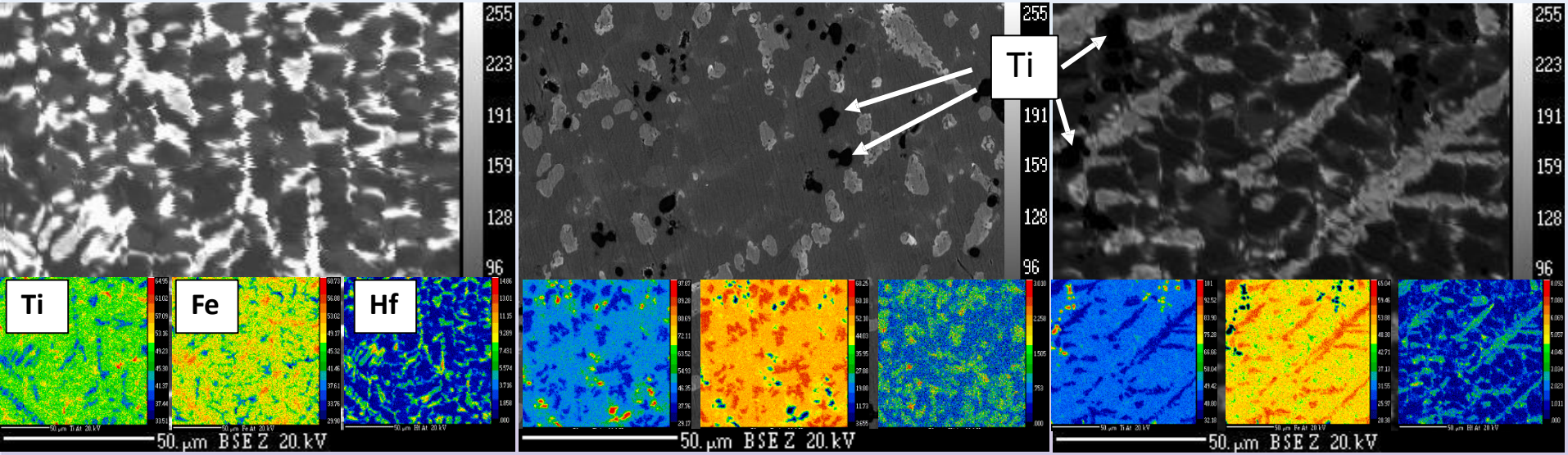
FeTi + 12wt.%Hf



- Matrix (**A**) + secondary phase (**B**)
- Presence of dendritic phase

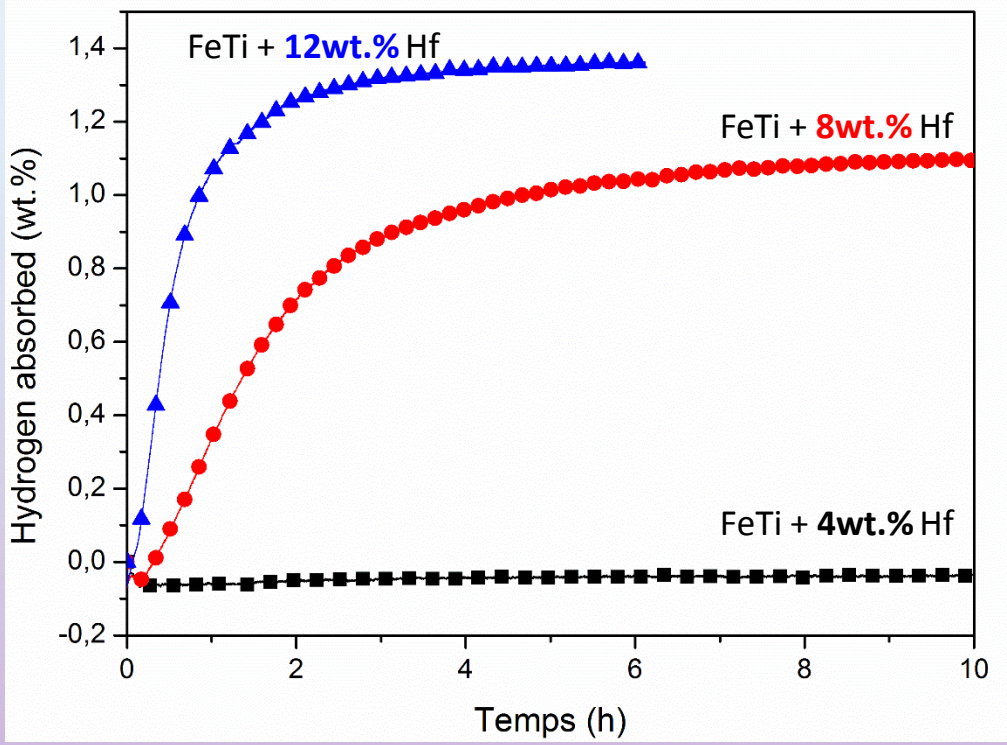
Element mapping by EPMA

FeTi + 4wt.%Hf **FeTi + 8wt.%Hf** **FeTi + 12wt.%Hf**



Phase Composition	FeTi + 4wt.%Hf	FeTi + 8wt.%Hf	FeTi + 12wt.%Hf
Matrix	48.9Fe – 49.0Ti – 1,9Hf	49,7Fe – 49,5Ti – 0,7Hf	49.3Fe – 49.7Ti – 1.0Hf
2nd phase (1)	53,2Fe – 40.3Ti – 6,4Hf	58,5Fe – 39,9Ti – 1,6Hf	56.7Fe – 40.4Ti – 2.8Hf
2nd phase (2)	34.5Fe – 59.8Ti – 4.7Hf	-	-

Activation properties



Activation curves of FeTi + x wt.%Hf (x = 4, 8 and 12), at 25°C under 20 bar of H_2.

- Need a minimum of 8wt.% of Hf to activate FeTi
- No incubation time
- Kinetic increases with wt.% Hf

% Hf	4	8	12
% H abs.	0	1.1	1.4

Resume

- FeTi needs a minimum of **8wt.% Hf** to be activated
  - Role of the Ti rich phase

- FeTi alloy doped with hafnium has a good industrial base
  - Low cost
  - First hydrogenation at room temperature
  - Fast kinetic

Perspective

- Identify the 2nd phase by neutron diffraction

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CAP Congress organizers
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Region Aquitaine
My colleagues

Thank you for your attention

Questions ?

placamat

IRH

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