Enhanced Hydrogen Storage in Mg thin Flakes with dispersed Ni Nanoparticles prepared by High Energy Ball Milling.

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Introduction | solid state storage

Solutions for H_2 storage		
Gas	Liquid (LH2 - LHCs)	Solid

Lower risk in transportation and higher gravimetric capacities.

Magnesium hydride (MgH_2)		
Lightweight, reversible and abundant on Earth's crust	Theoretical storage capacity (7.67 wt.%)	Sluggish kinetics and thermodynamic stability

Sorption / Desorption >350 °C

E_a
146 kJ/mol

Hirscher et al. Materials for hydrogen-based energy storage – past, recent progress and future outlook. *Journal of Alloys and Compounds. 2020*

Introduction | Mg modifications

Metal-oxide catalysts

They Improve kinetics or thermodynamics
But decrease storage capacity

An approach that involves various modifications is required

Nanoparticles or nanostructures

Alloying elements and additives

Hirscher et al. Materials for hydrogen-based energy storage – past, recent progress and future outlook. *Journal of Alloys and Compounds. 2020*

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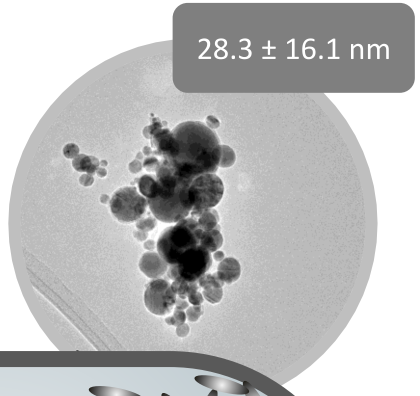
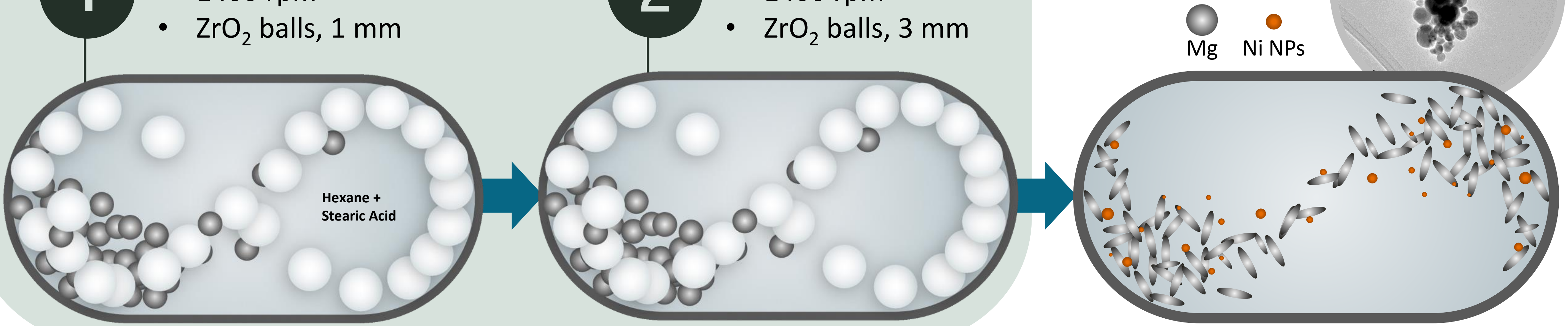
Materials and methods | Synthesis

Two step method of Surfactant Assisted – High Energy Ball Milling

1
- BPR 40:1
- 1400 rpm
- ZrO_2 balls, 1 mm

2
- BPR 60:1
- 1400 rpm
- ZrO_2 balls, 3 mm





Comminution

Deformation

Blending

5 wt.%Ni

15 wt.%Ni

Materials and Methods | Characterization

UdeA

Absorption / Desorption tests (350°C)

Differential Scanning Calorimetry

X-Ray Diffraction

SEM-EDX

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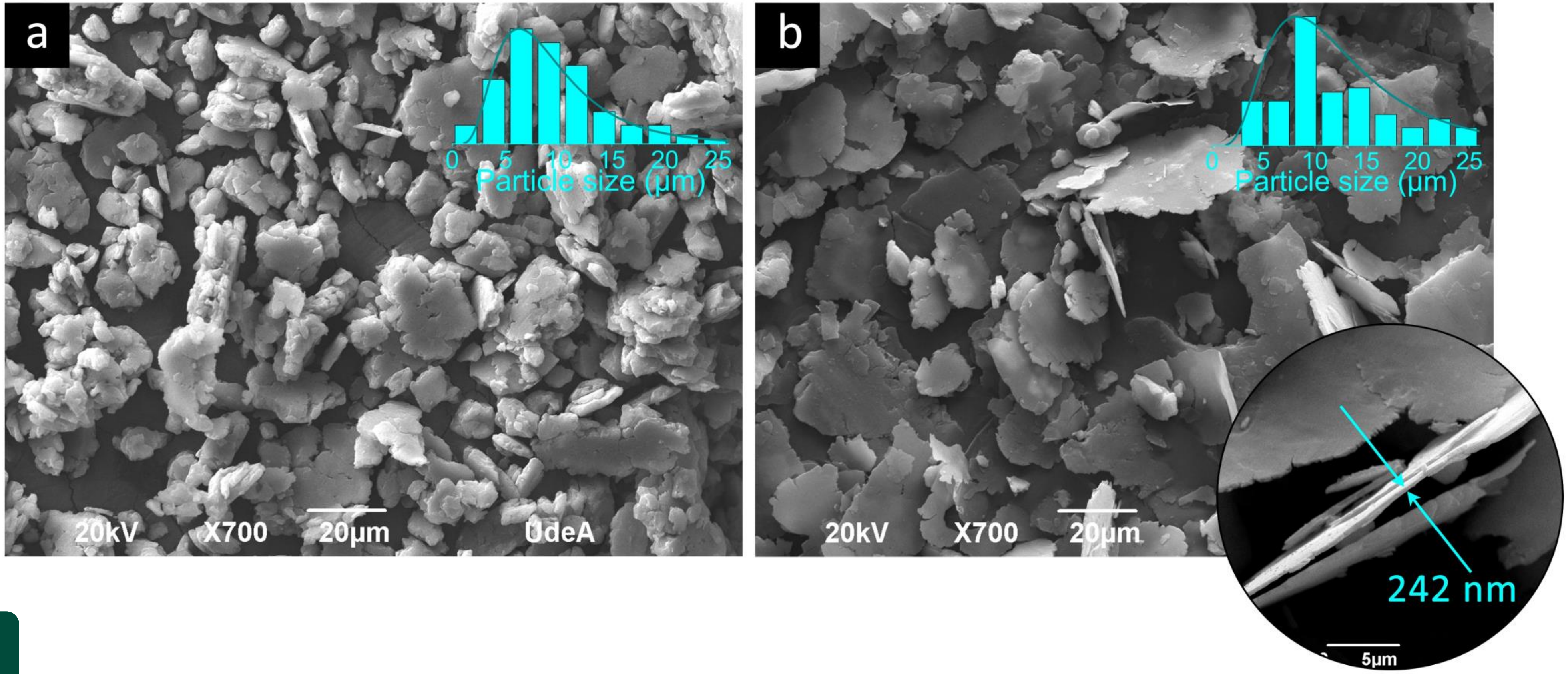
Results | Mg thin flakes

1st step

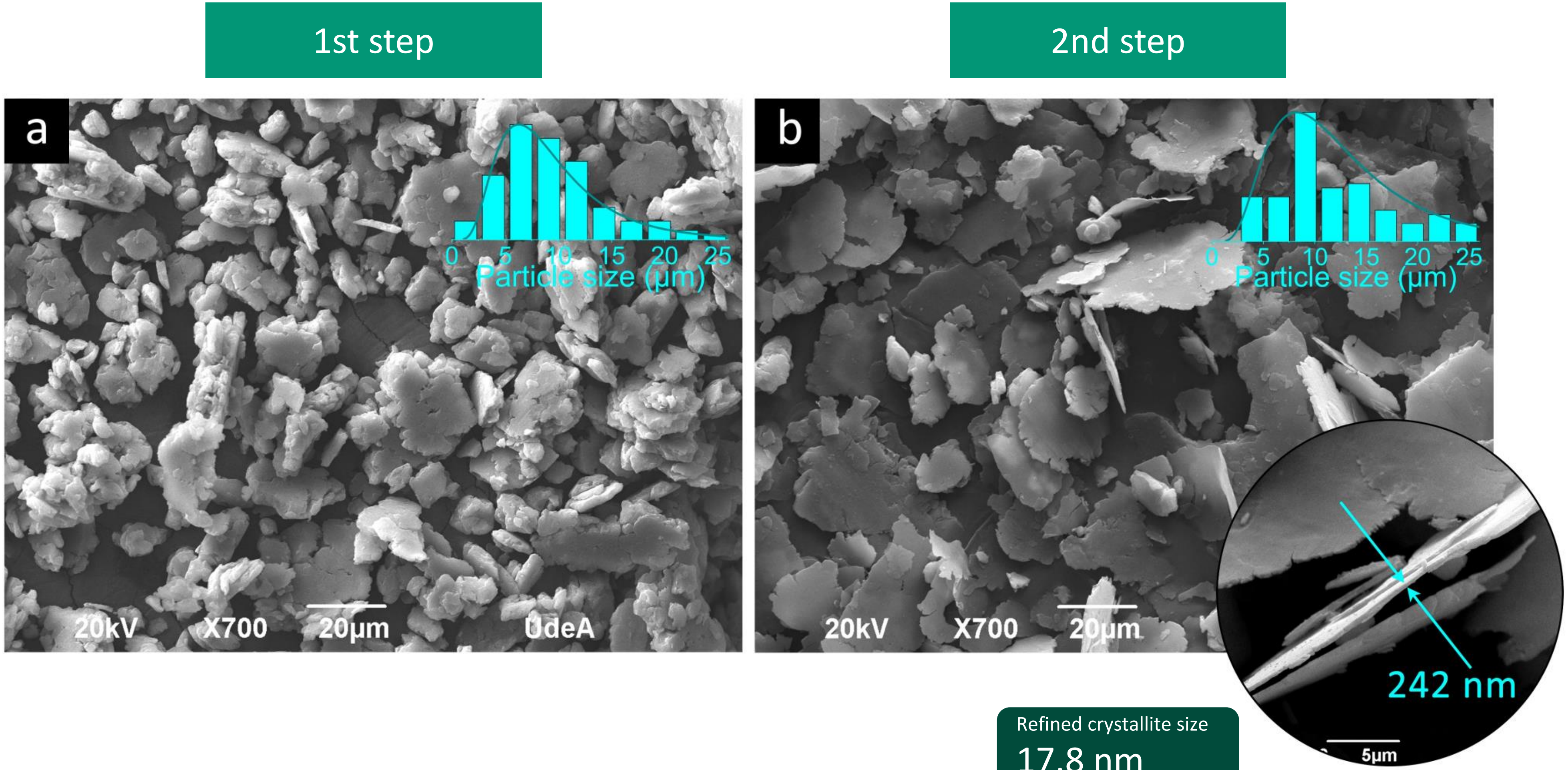
2nd step



Starting crystallite size
197.9 nm

Cortinez et al. Production of Mg Thin Flakes with Enhanced Hydrogen Storage Performance. *International Journal of Hydrogen Energy. 2024*

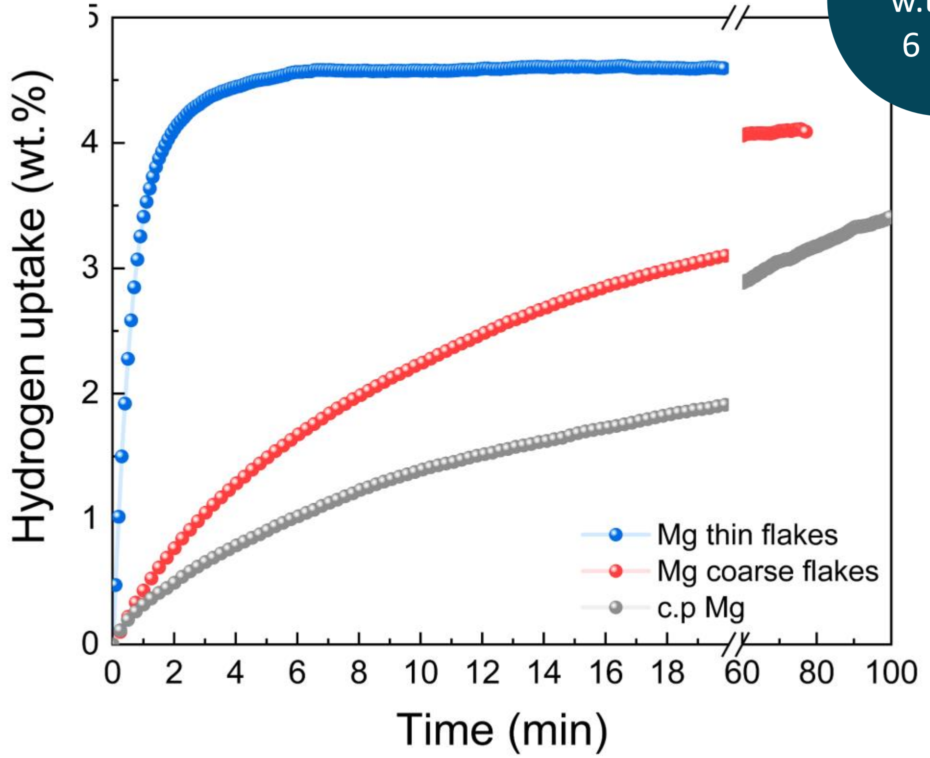
Results | Mg thin flakes



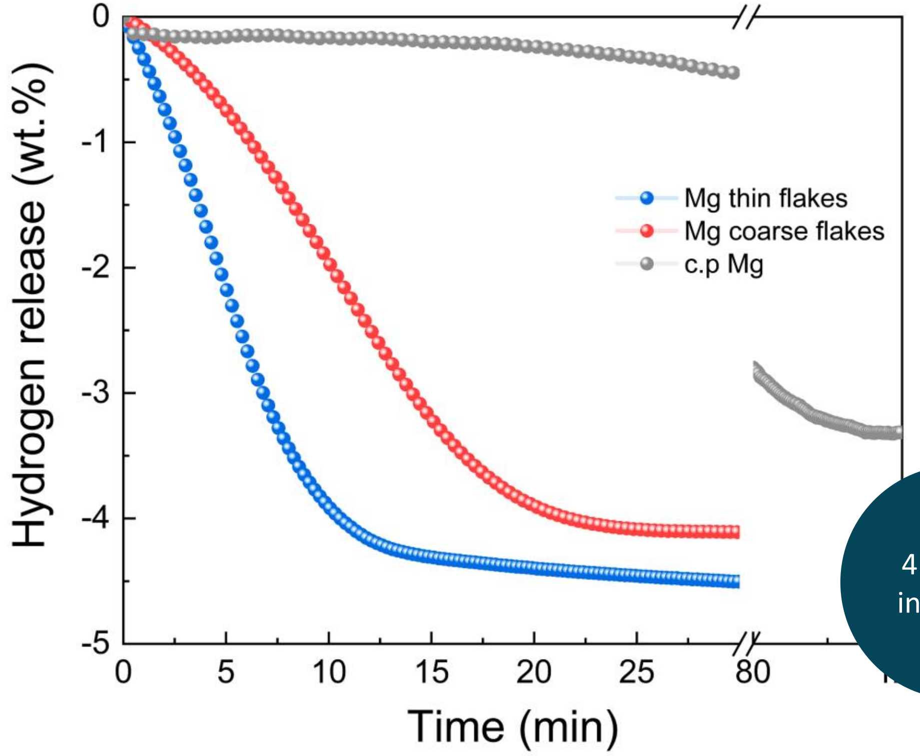
Refined crystallite size
17.8 nm

Cortinez et al. Production of Mg Thin Flakes with Enhanced Hydrogen Storage Performance. *International Journal of Hydrogen Energy. 2024*

Results | Mg thin flakes



4.6 w.t% in 6 min



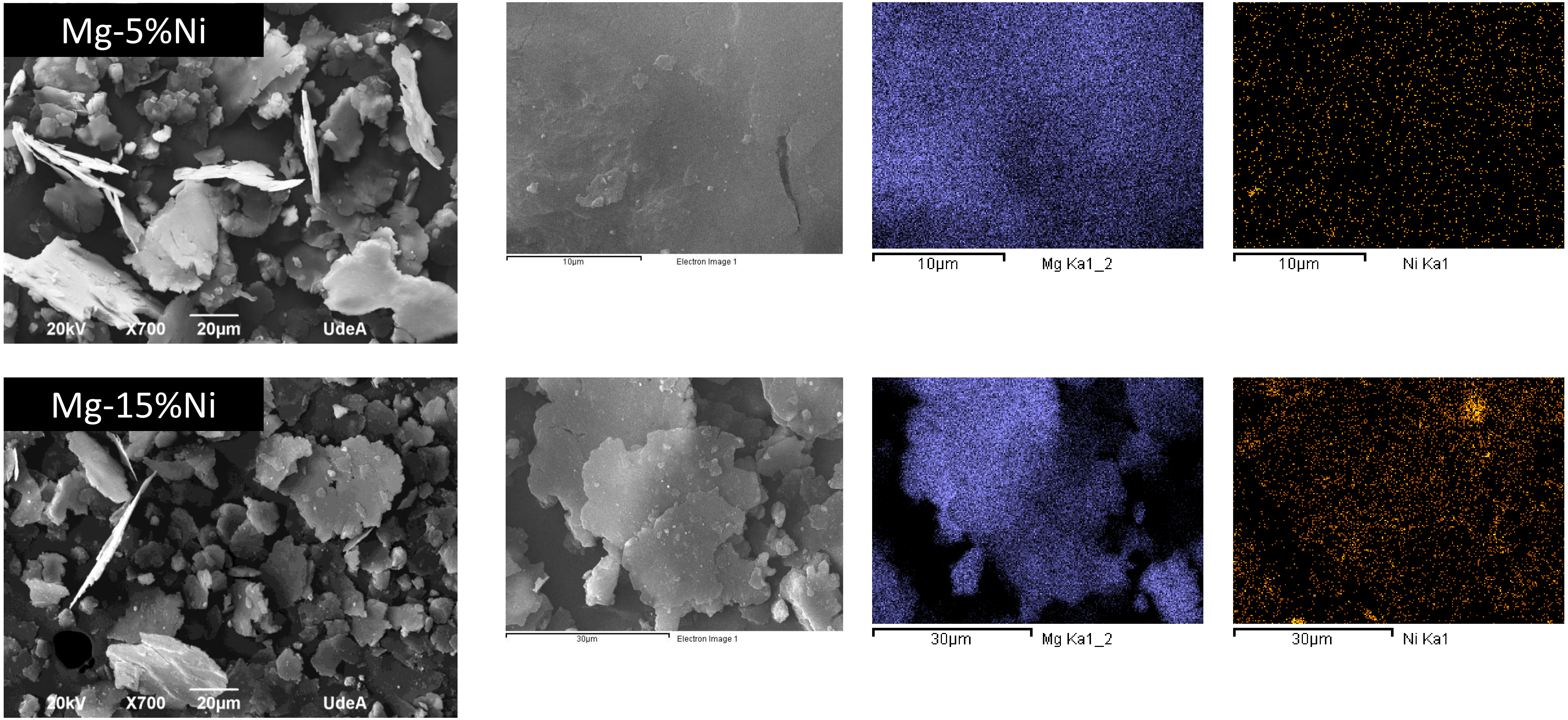
4.4 wt.% in 15 min

Improved kinetics (94% less time) and capacity (increase in 25%)

Cortinez et al. Production of Mg Thin Flakes with Enhanced Hydrogen Storage Performance. *International Journal of Hydrogen Energy. 2024*

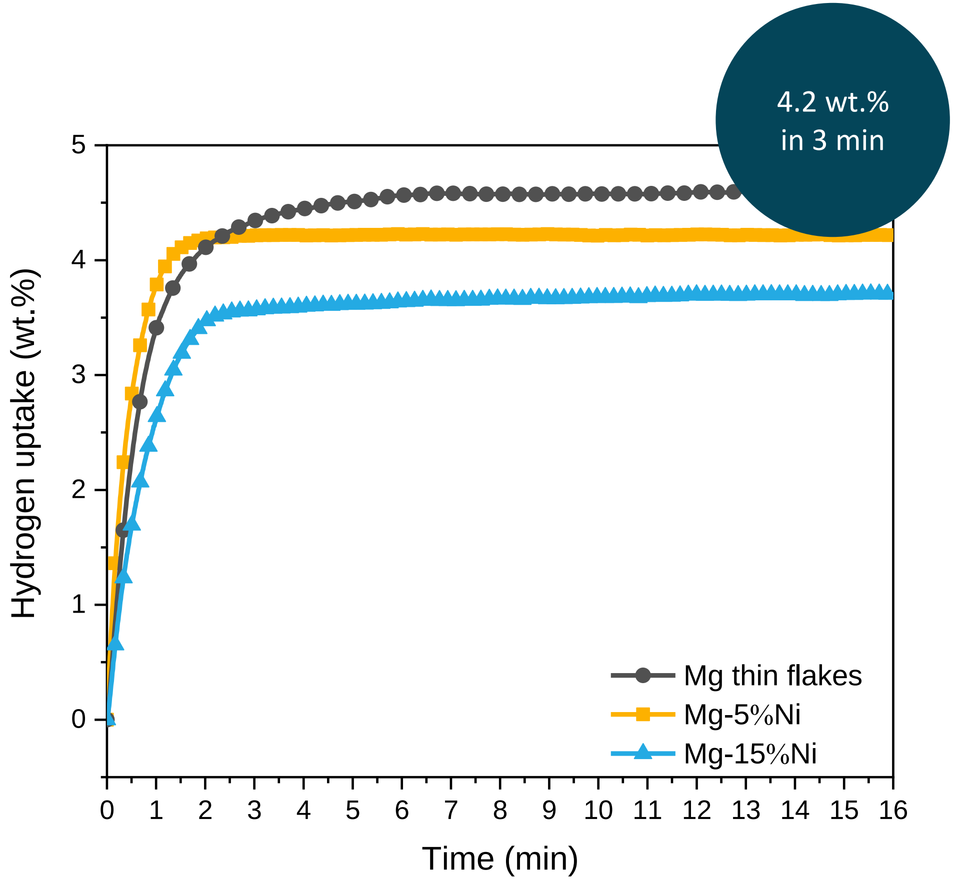
Results | Mg with Ni decoration

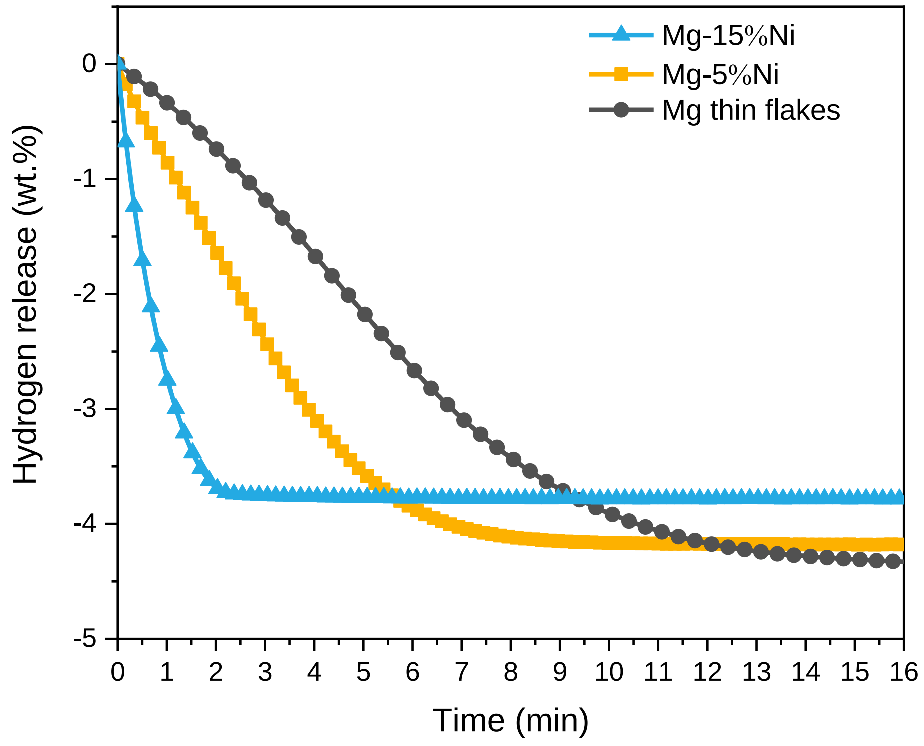
UdeA



Homogeneous distribution through the dry blending method

Results | Kinetics test at 350°C, 20 bar

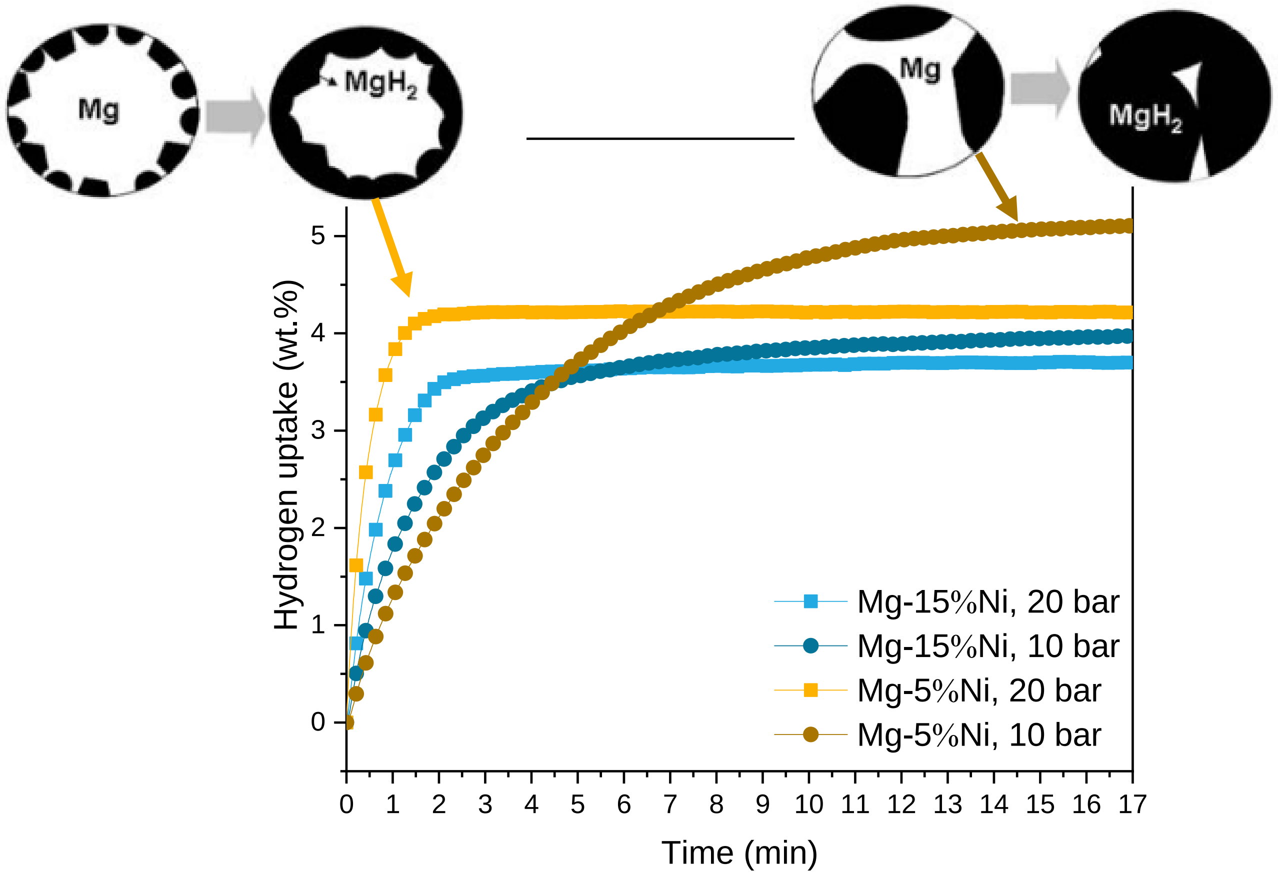


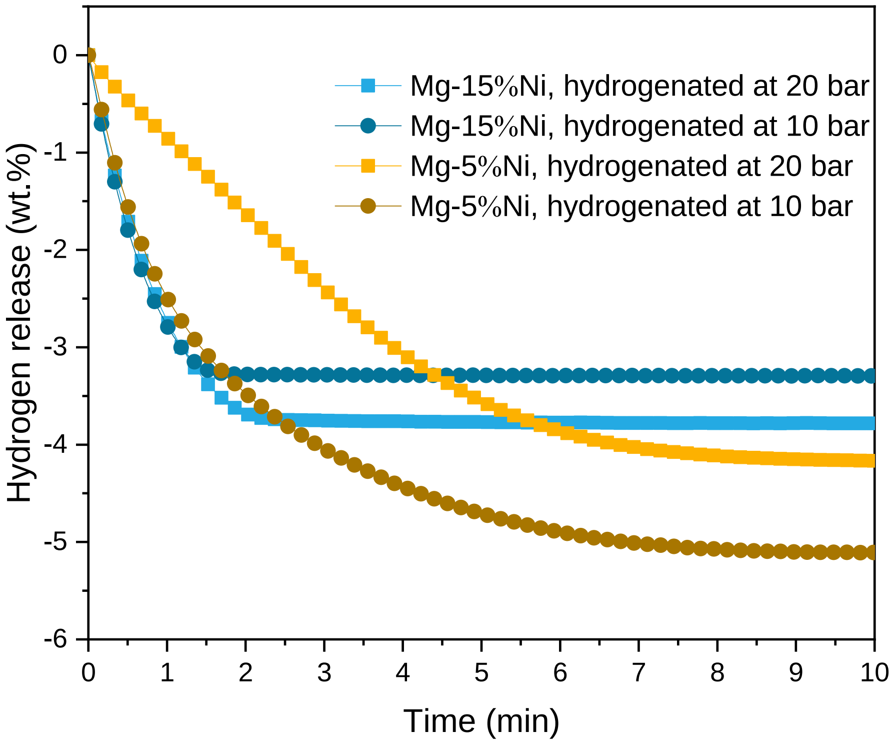


Improved kinetics (50% of the time) but decreased capacity (9%)

Results | Kinetics at 350°C, 10 bar

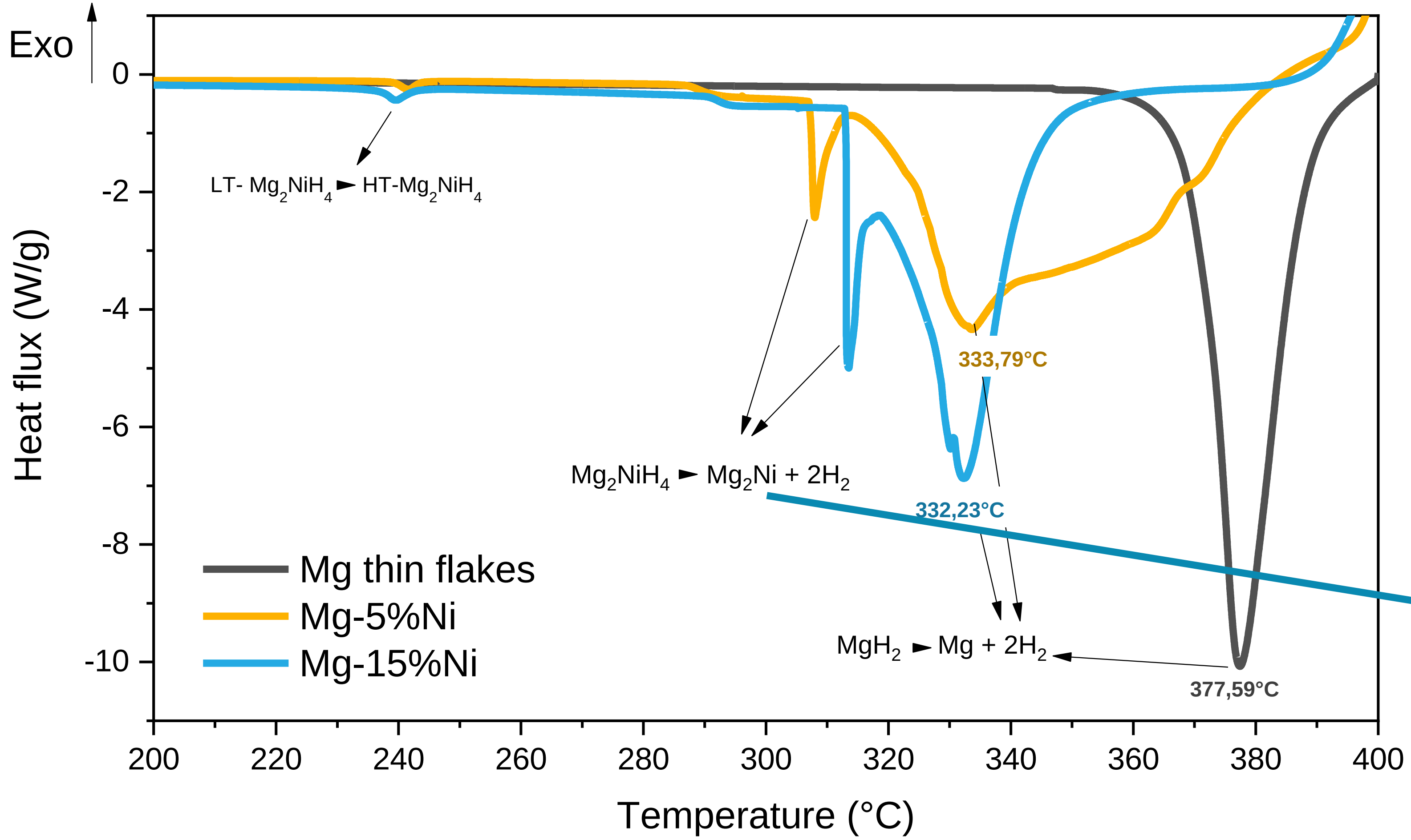
Lower pressures resulted in higher capacities but slower kinetics due a to a change in sorption mechanism.





Tien et al. Mechanism of hydrogen capacity dependence on the hydrogenation temperature. Scr Mater. 2010

Results | Mg with Ni decoration



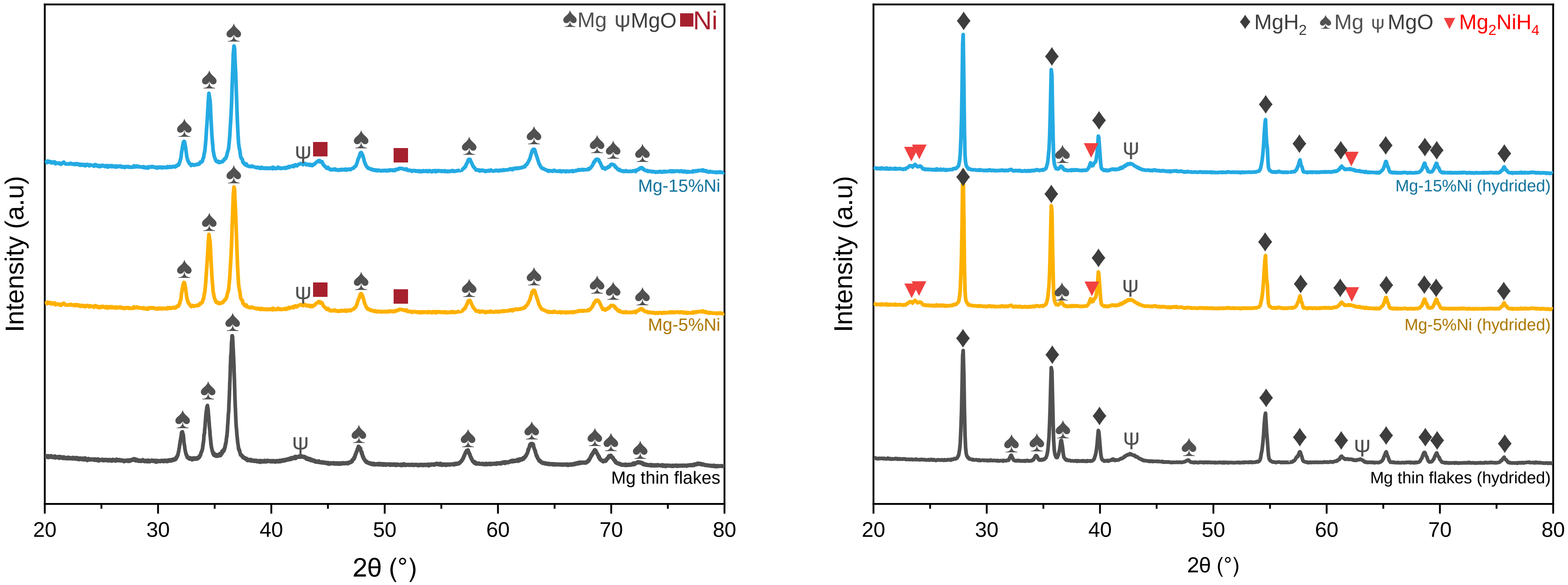
Decrease in operation temperature

Mg_2Ni promotes desorption reaction

This was later confirmed by XRD analysis

Results | Mg with Ni decoration

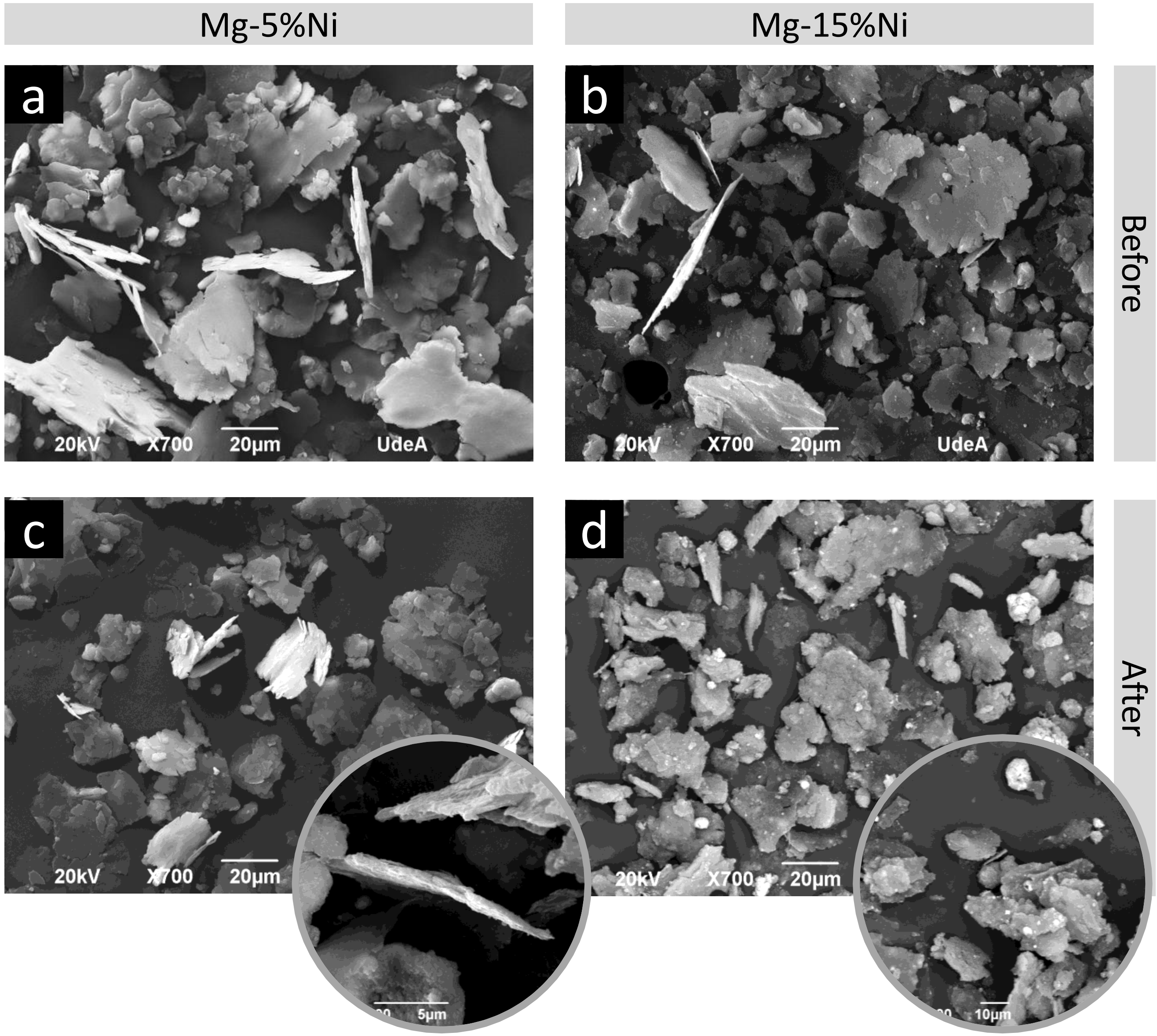
Oxygen content (EDX) below 5 wt.%



Hydrogen sorption at 350°C promotes Mg – Ni reaction to form the complex hydride

Results | Mg with Ni decoration

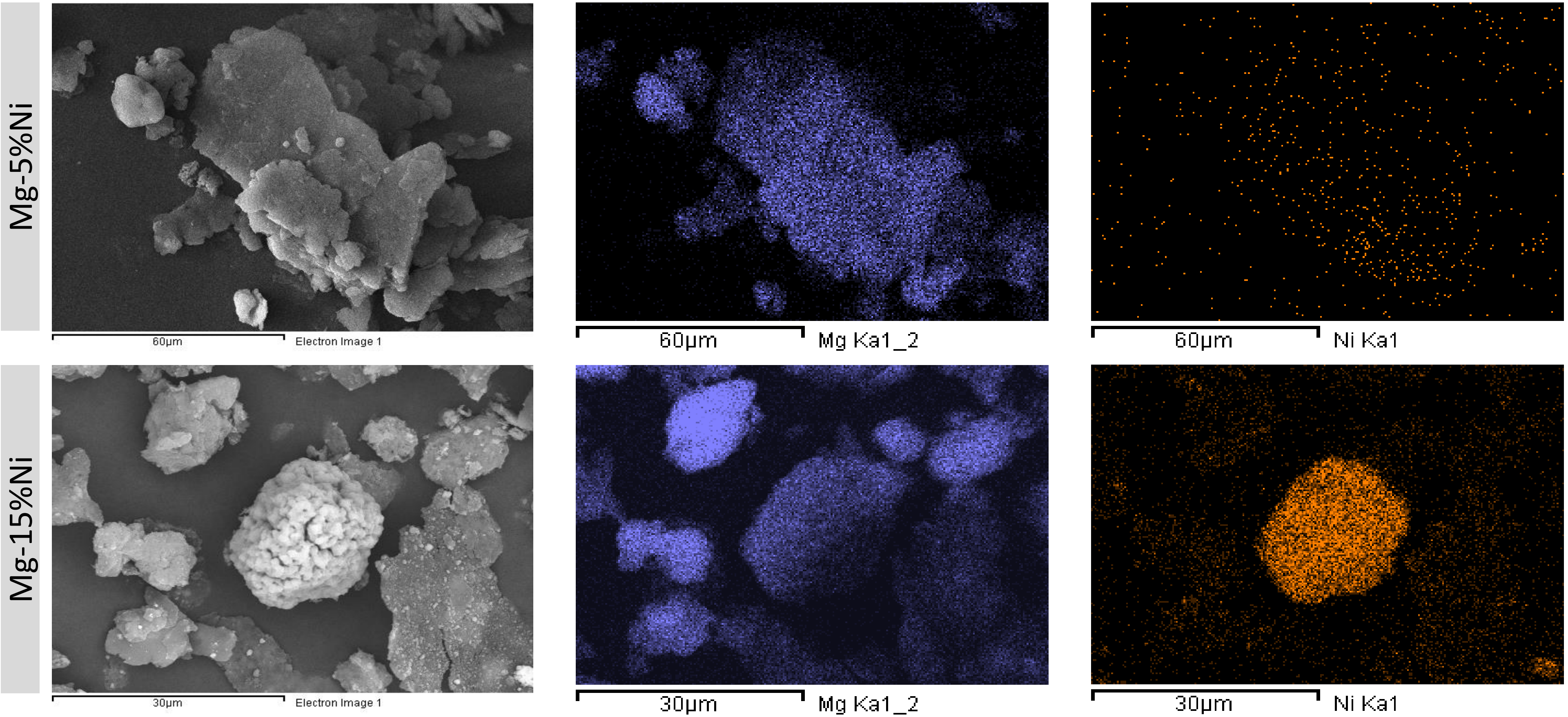
UdeA



Preserved morphology after 5 cycles

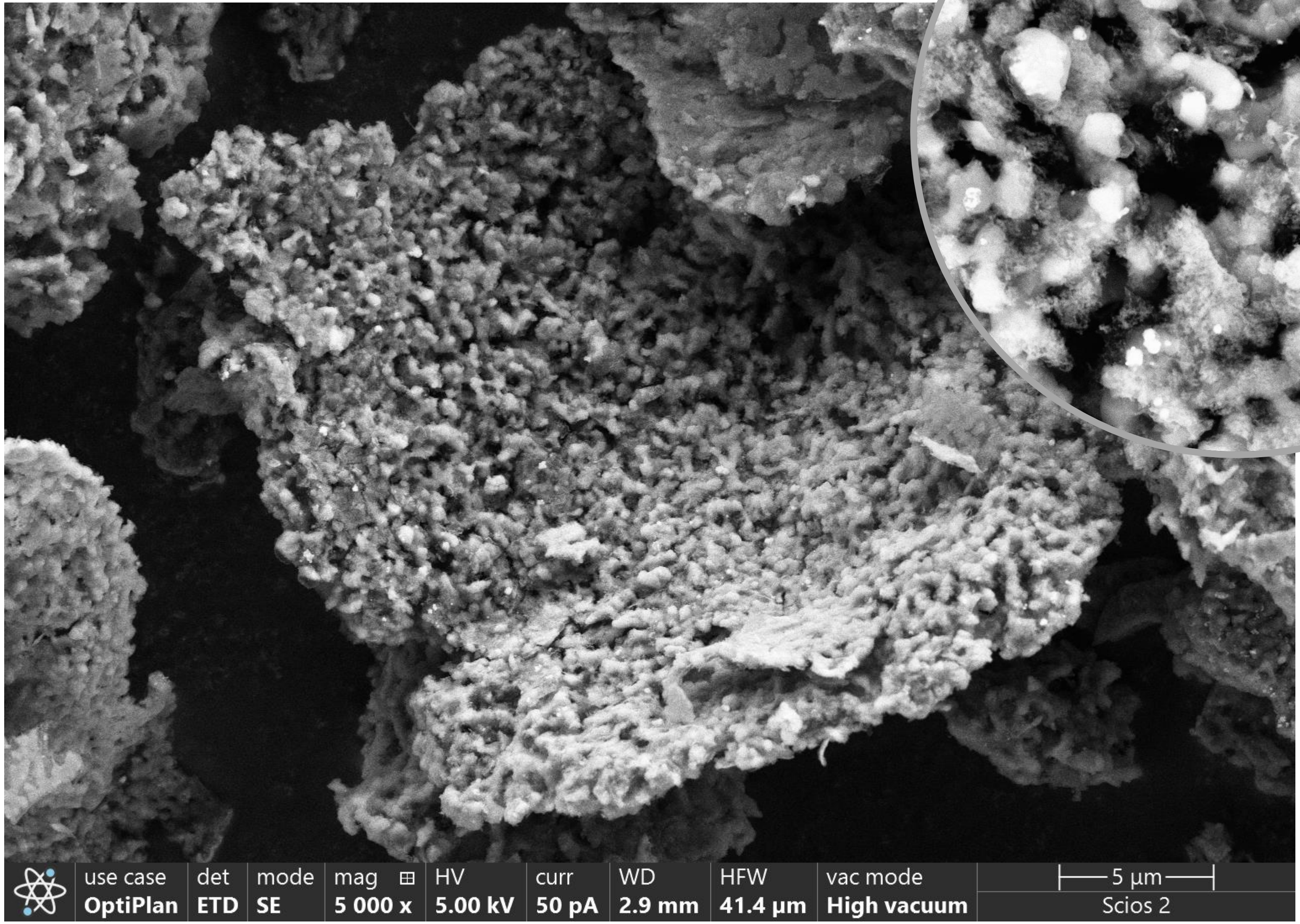
Results | Mg with Ni decoration

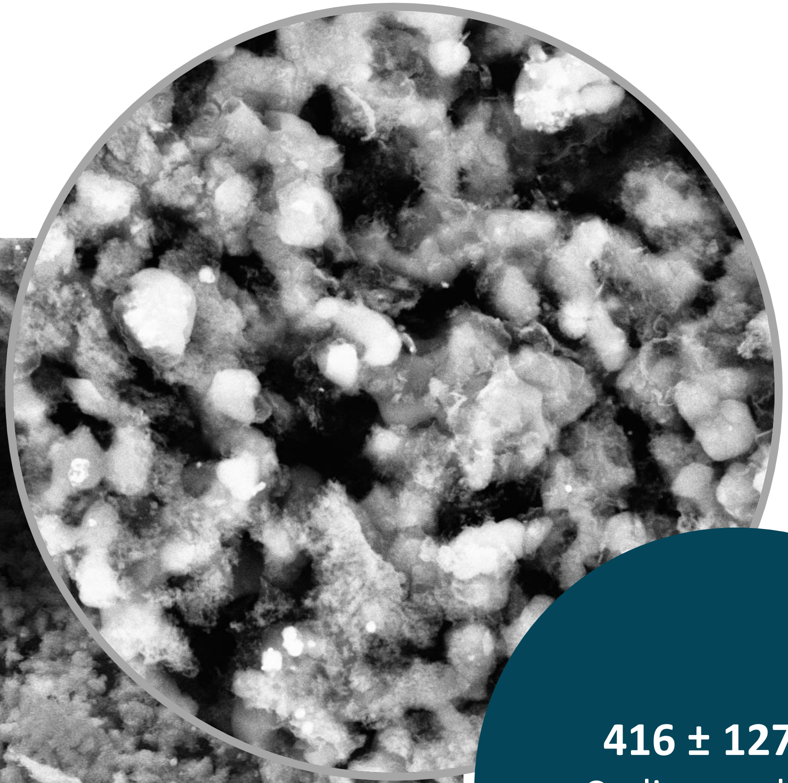
UdeA



Higher Ni content agglomerated after sorption/desorption tests

Results | Mg with Ni decoration





416 ± 127 nm
Cycling could lead to finer particles

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Conclusions

1. A two step ball milling method led to Mg thin flakes (thickness <300 nm) and improved hydrogen storage capacity

2. 5 wt.%Nickel decoration improved sorption/desorption process in 50% of the time with a decrease of 9% in capacity

3. The formation of Mg_2NiH_4 after activation process led to improved dehydrogenation kinetics

Thanks *for* your attention

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