UPGRADE

Upscaling of a strip-cast process for heavy rare earth lean magnet grades

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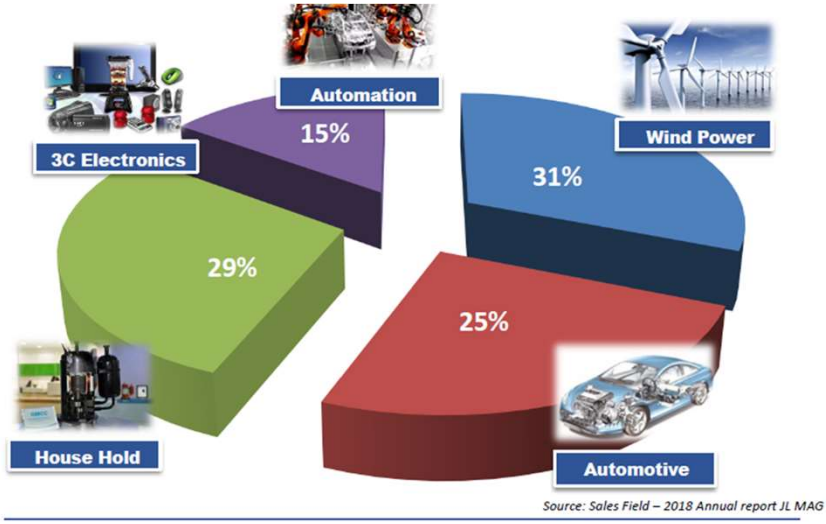
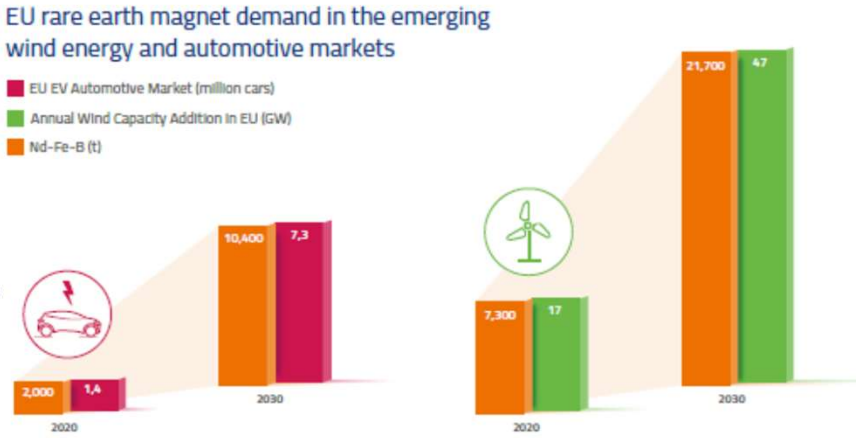
Rare Earth permanent magnets - context

- NdFeB permanent magnets = the highest energy product of any available material today
- They can be found in a variety of applications: high performances motors, magnetic separation, generators, magnetic resonance imaging ….
- The combination of the needs from the mobility sector and from the renewable energy production leads to a strong supply risk in the near future
- Most of the requirements for traction motors are targeting the highest coercivity grades still using high amount of heavy rare earth elements (Dy or Tb)



Source: Sales Field – 2018 Annual report JL MAG



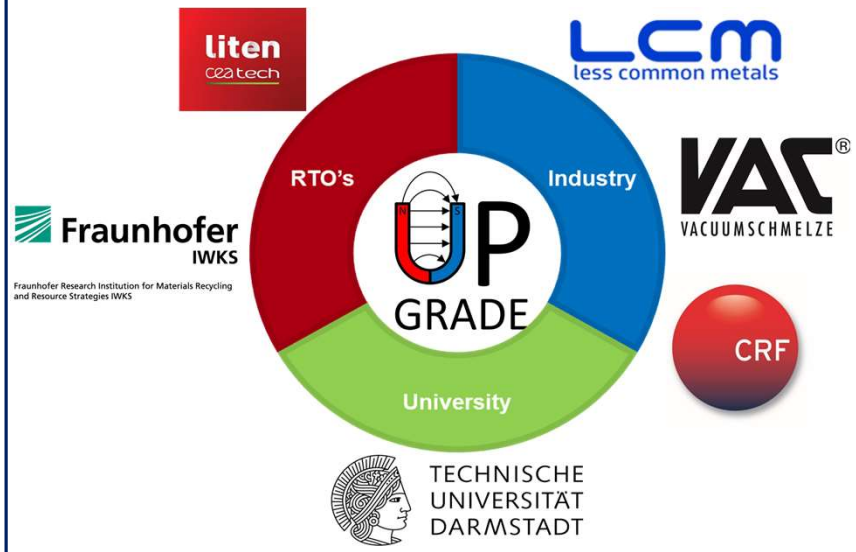
Rare Earth permanent magnets - context

Current technological challenges in permanent magnet industry:

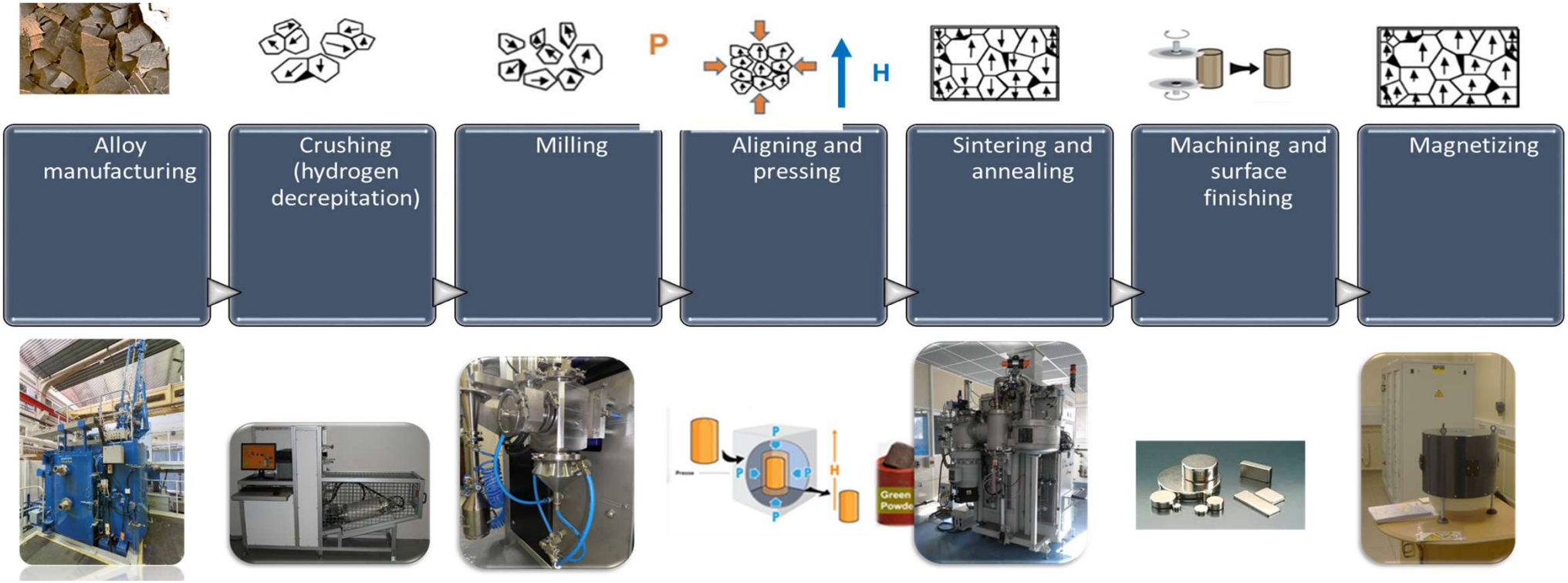
- **Heavy rare earth reduction** : grain size reduction, grain boundary engineering, grain boundary diffusion
- **Recycling** of permanent magnets
- **Substitution of rare earth elements**: rare earth – lean permanent magnets
- **Material savings** – new design

UPGRADE - Upscaling of a strip-cast-process for Heavy Rare Earth - lean magnet grades

- **Goal:**
  - the development of a strip-cast process with improved casting conditions and alloy composition for a Dy-reduction of up to 2.5 wt.% in a fine-grained magnet
  - upscaling of the strip-cast process to production volume
- **Advantage:** the results can be easily implemented at industrial scale, as the process used at pilot scale is similar to the one used at large scale in magnet industry => no need for additional equipment costs.
- Six partners covering the three corners of the knowledge triangle
- Coordinated by CEA
- Timeline: 01/2019 – 12/2021
- Bugdet: 1.9 M€

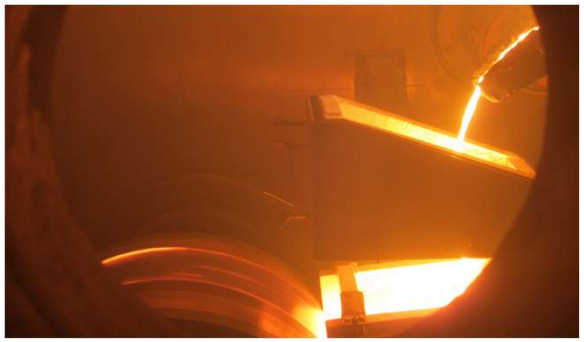


The conventional powder metallurgy process for the manufacturing of high performance NdFeB permanent magnets: CEA-LITEN's pilot plant



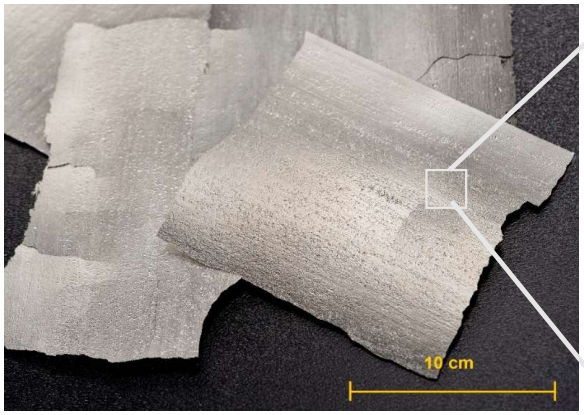
STRIP CAST FACILITIES – PILOT SCALE

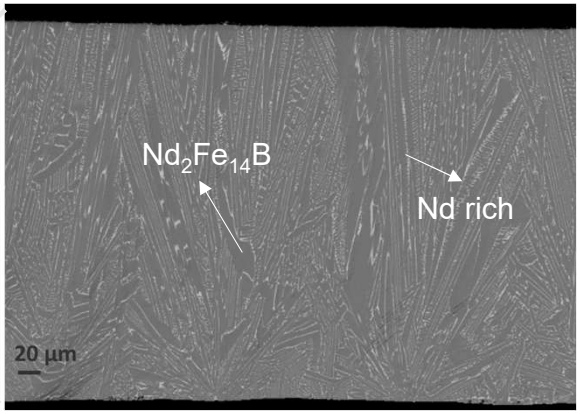
Strip cast equipment installed in CEA – pilot scale



Stripcasting of Nd-Fe-B alloys. The alloys are cast onto a rotating copper wheel to achieve rapid cooling rates which enables the creation of fine grained microstructure.

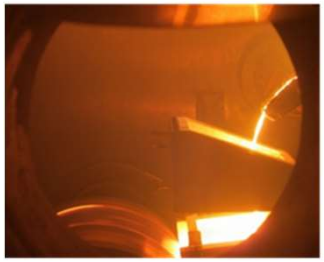
Flakes and flake's microstructure obtained by SC





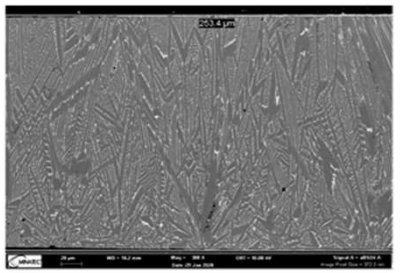
UPGRADE's key results

CEA/LITEN SC - 10-50 Kg per batch



Role of crucible rotation speed

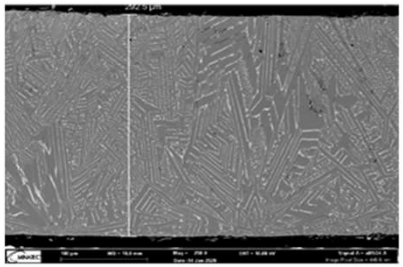
Std SC conditions



Nd Rich spacing= 3.2 µm

HcJ @ 150°C (avg) = 630 kA/m

Crucible tilting speed x 2



Nd Rich spacing= 4.5 µm

HcJ @ 150°C (avg) = 680 kA/m

Role of alloying elements (under IP protection)

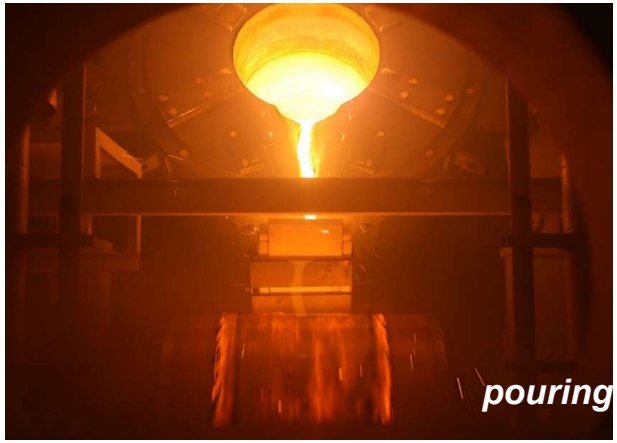
Add. elts	A	B	A + B
Coercivity @ 150°C (avg)	608 kA/m	656 kA/m	**671 kA/m**

- **Key results:**
  - ✓ Two Nd-Fe-B alloys at pilot scale (15 kg/batch) allowed to achieve the target (reduction of 2.5 wt.% of Dy)
  - ✓ Two batches of Nd-Fe-B alloys at industrial scale (600 kg/batch) have been produced within the project timeline

SUCCESSFUL TRANSFER TO PRODUCTION VOLUME

Strip cast equipment installed in LCM

crucible



pouring

flakes

CONCLUSION

- The **PM** are in the heart of the **energy transition**
- UPGRADE project have demonstrated the possibility to reduce the heavy rare earth content in NdFeB high performance permanent magnets by an optimization of the alloys microstructure and composition
- The **pilot lines** play an important role to establish innovative technologies, easily implementable in industry

Thank you for your attention

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