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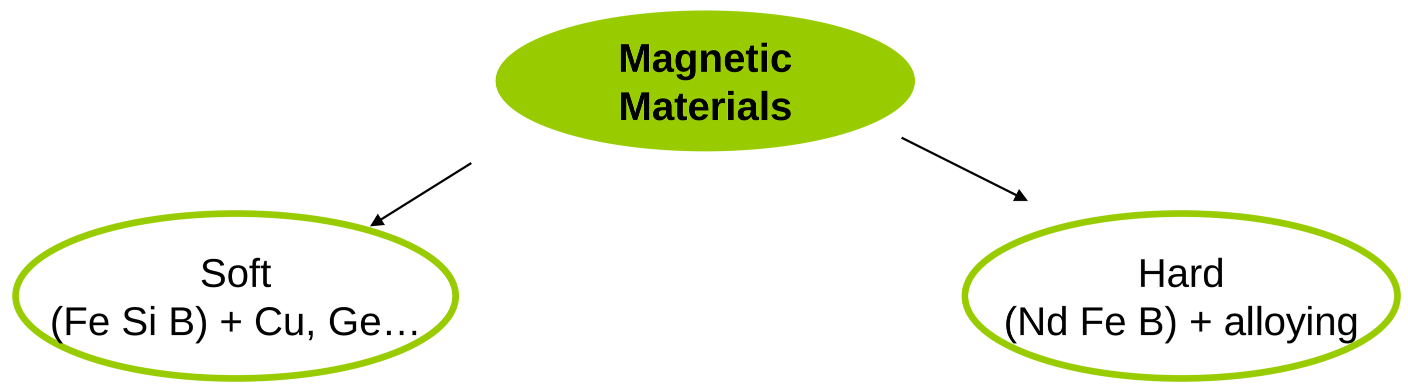
MICRO AND NANOSTRUCTURED MAGNETIC MATERIALS: Obtaining CBMS process parameters by numerical modeling and simulation

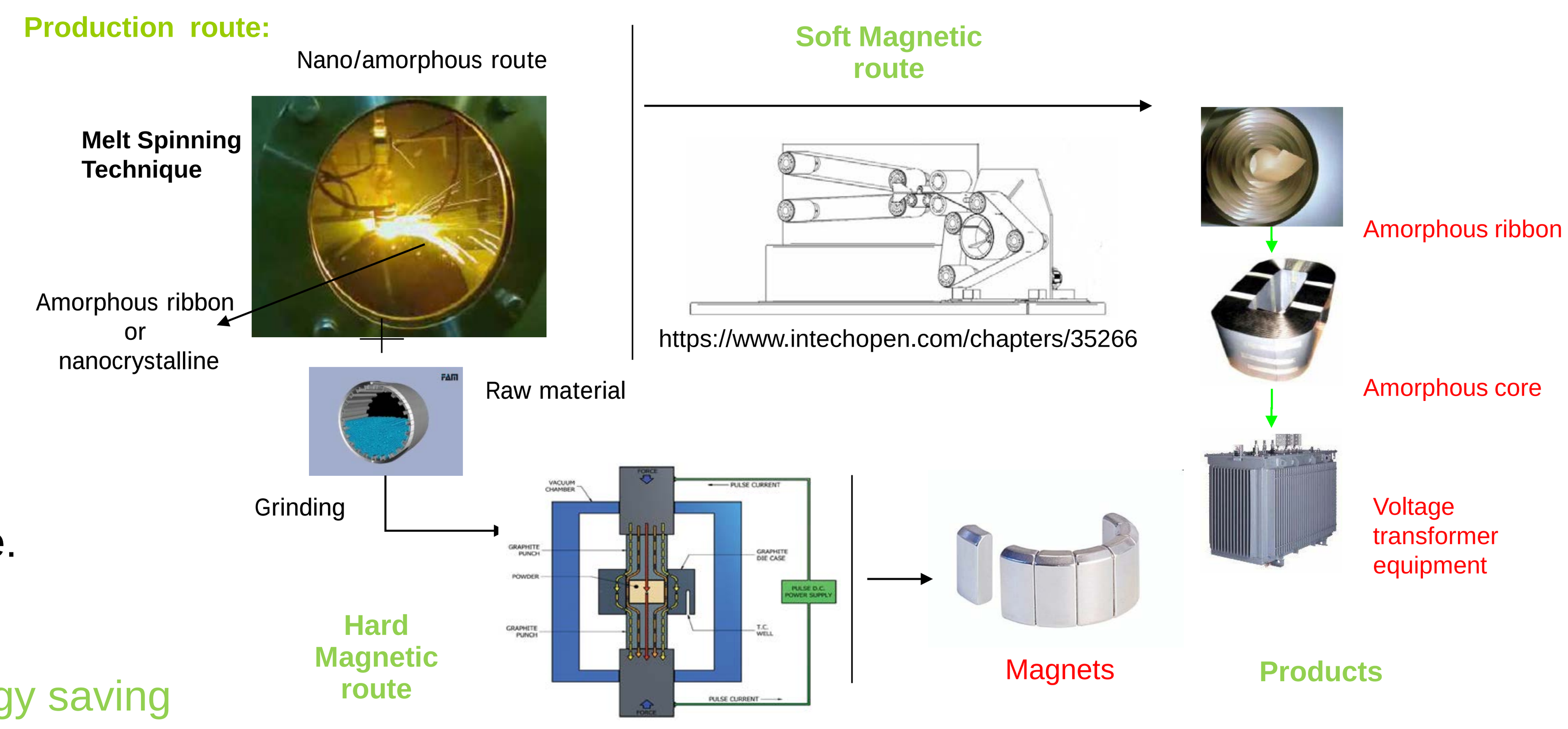
Pagnola, M.R., Barceló, F. & Useche, J.

¿What are they ? They are amorphous solids materials derived (among others) used for technological applications in energy saving area.



- Easy forming by ultrafast cooling (melt spinning technique) from the liquid state.
- Are available as ribbon, powders (~ microns).
- Can be obtained in amorphous state.
- Can be heat treated (~ nanometers)

Energy saving



¿What physical properties have? Its properties vary according to their composition:

Soft Magnetic Materials:

$Fe_{78}Si_9B_{13}$

$Fe_{73.5}Si_{13.5}Ge_2B_7Nb_3Cu_1$

$Fe_{73.5}Si_{13.5}Ge_4B_5Nb_3Cu_1$

FINEMET- type alloys

Low magnetic losses
Low coercivity
High saturation

Hard Magnetic materials

$Nd_5Fe_{77}B_{18}$

$Nd_{10}Fe_{80}B_{10}$

$Nd_yFe_{(86-x-y)}B_{14}Ti_x$ (x = 0, 4; y = 7, 8)

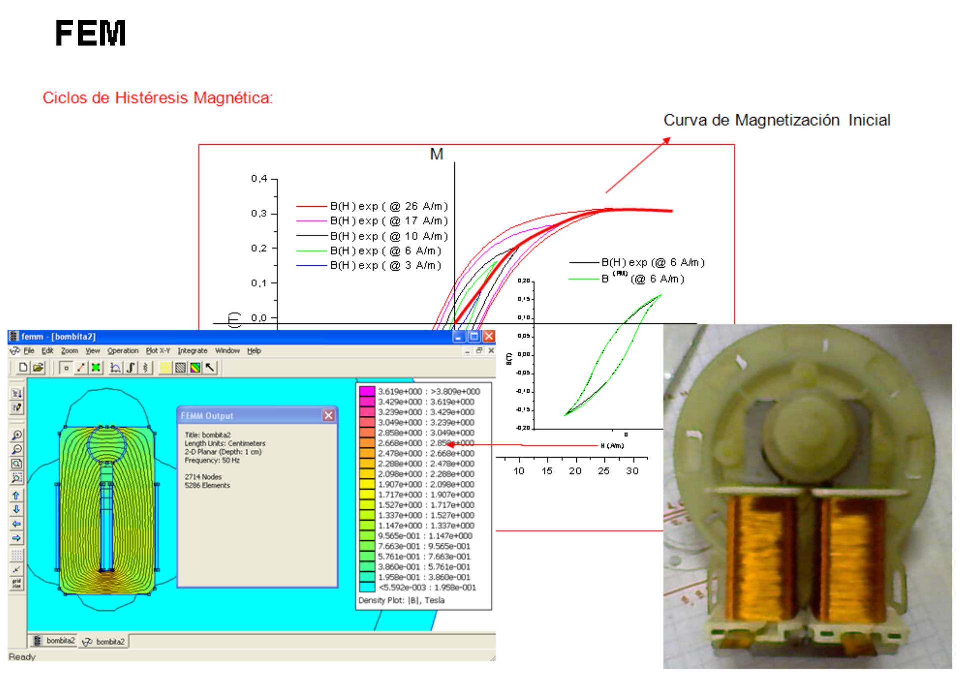
High Energy Products
High coercivity
Good saturation

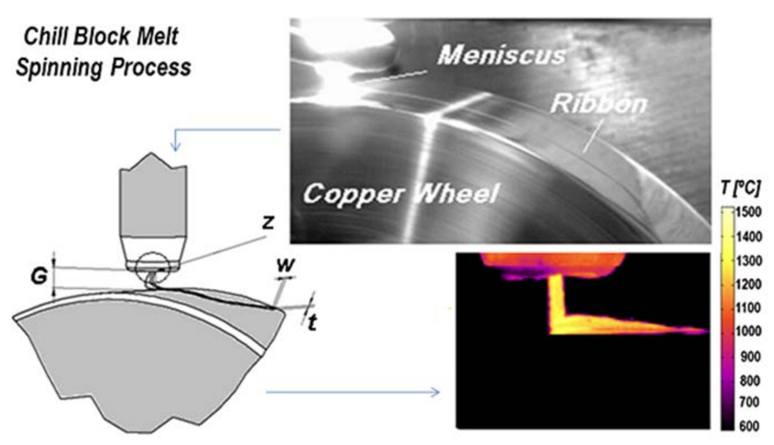
Due to its physical properties and its ease to be formed as thin films (~ 20 - 40 microns), these materials can be heat treated and crystallize in the nanometers arranged order structures, which makes applications having impact on Nano -Technologies. Then, this films may be ground to provide powder particles to generate complex 3D structures by powder metallurgic methods.

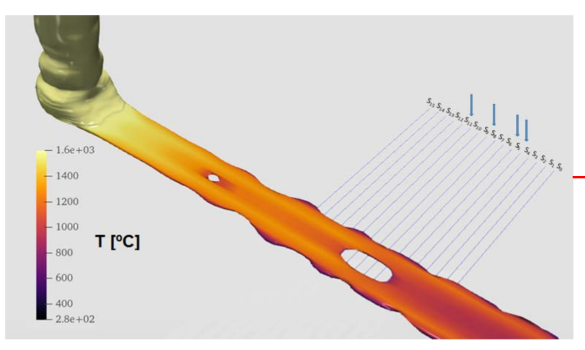
¿What applications are interesting?

• Soft Magnetic Materials

These materials are obtained by ultrafast cooling, and also in powder form by centrifugal atomization for applications in engine components. They can be controlled in its surface by means of organic or inorganic coatings to effect control of its magnetic properties.-





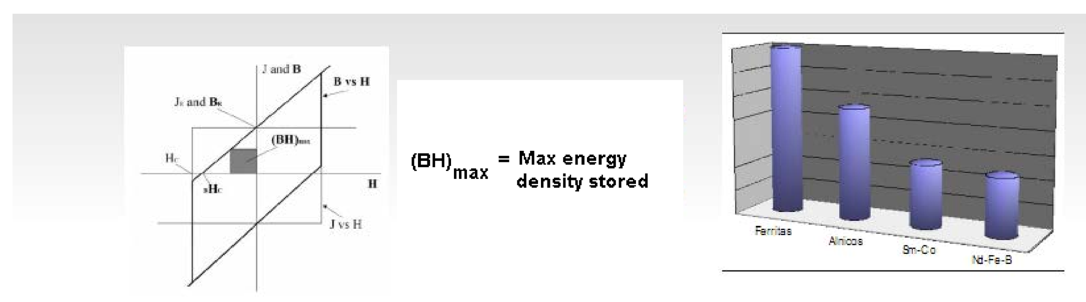


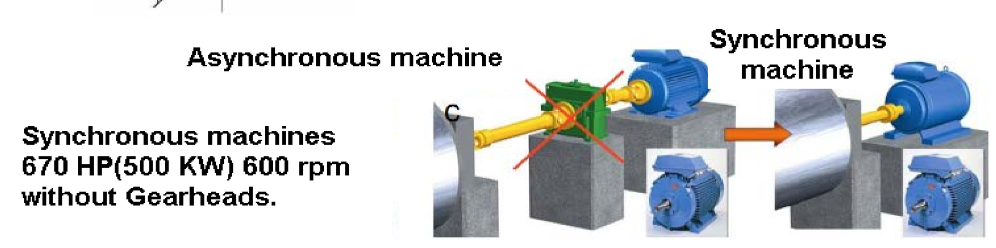
• Hard Magnetic Materials

In the electronics industry it has been a permanent objective the development of ever more efficient and lighter components for typical applications. The most common uses are permanent magnets to eliminate gearheads used in elevators, wind turbines and their applications in automotive engines.

Increased energy density stored is due to obtaining structures nanoscale that enhance the production to power.

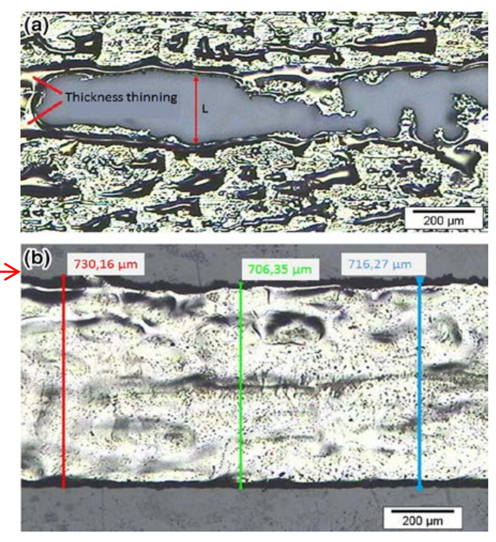
Use of Nd as an integral the permanent magnet must be careful to prevent corrosive effects.



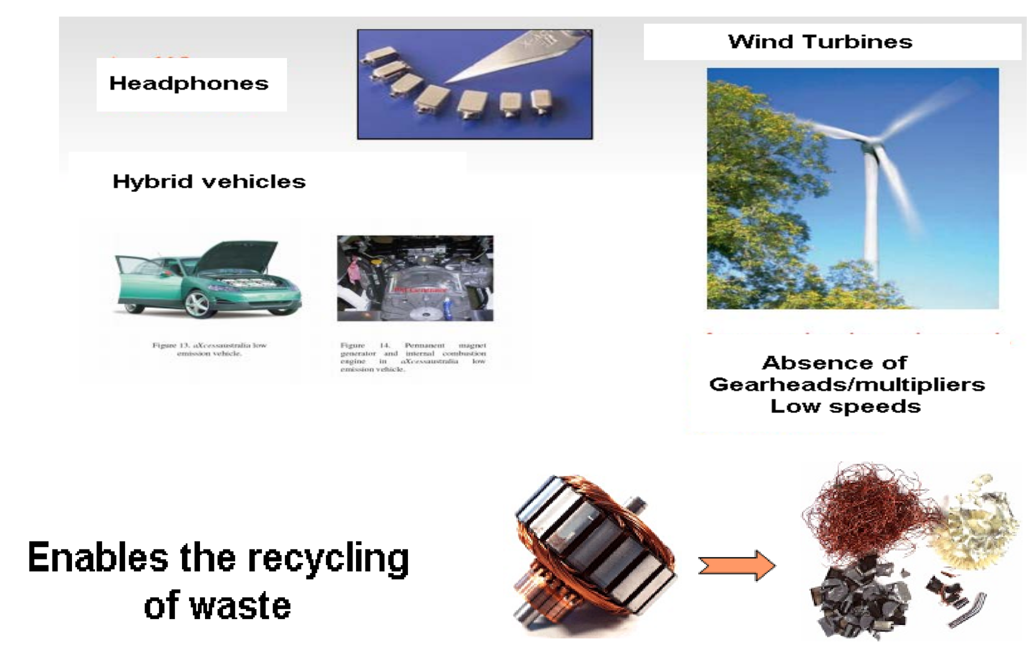


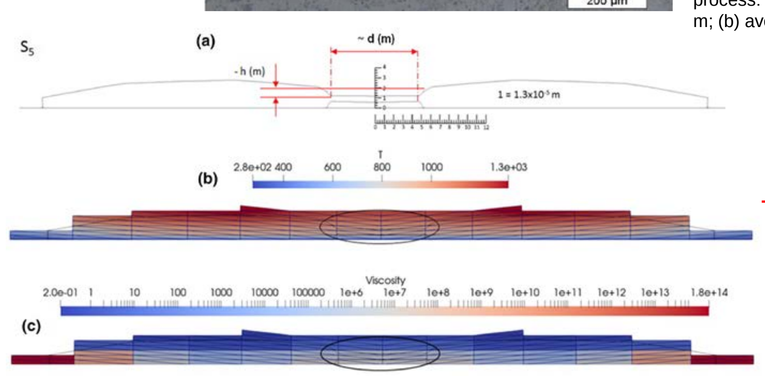
Crack Formation in Chill Block Melt Spinning Solidification Process: A Comparative Analysis Using Open FOAM

https://doi.org/10.1007/s11837-021-05105-y



Optical microscopy of rifts on Fe78Si9B13 ribbon (at.%) obtained in the melt spinning process: (a) width (L): $1.7x10^{-4}$ m – $2.5x10^{-4}$ m; (b) average width (W): $0.717x10^{-3}$ m.





Sectioning plane S5 with: (a) thicknesses obtained in the profile with details of depression (h) and width (L) of thinning (scale: 1 = 1.3 9 105 m). (b) Temperatures obtained in the profile with details of thinning (scale in C). (c) Dynamic viscosities obtained in profile with details of thinning and solidification at the ends (scale in Pa s).

Conclusion:

Through a ***VOF*** model implemented in ***OPENFOAM®*** for two non-isothermal, immiscible, and compressible fluids using ***compressibleInterFoam*** to solve the mathematical model with a hyperbolic tangent type (***HTE***) viscosity function previously assigned to the solver, has been recreated the necessary turbulence condition to explain the bubble formation in ***CBMS*** process of $Fe_{78}Si_9B_{13}$ (% at.). Ejected ribbon with a 2 ***mm*** of gap over the rotating copper wheel. The dimensionality of modeled crack (~ $1.24x10^{-4}$ - 3.1 $x10^{-4}$ ***m***) has been verified by contrasting it with a real cracking obtained in an experimental laboratory process (~ 1.7 $x10^{-4}$ - $2.5x10^{-4}$ ***m***). It was also established that the effects of the viscous forces are appreciable at 1200***ºC***. In this temperature, the surface tension effects almost triple, and temperatures above 1300***ºC***, the effects of both forces tend to balance out. Above that temperature, the surface tension begins to prevail over the viscous stresses. This fine balance of forces, in the range of 1000-1350***ºC*** (together with the vorticity in the liquid contact zone- solid) manifest the narrowing formation mechanism, which gives rise to cracking from a trapped bubble in ***FeSiB*** ribbon. Then, this bubble collapses by inertial forces action (***We*** ~ 2700). The transverse profiles solidification at cooling rates such as those described in laboratory tests of this work (~ 9.3x106 ***$K.s^{-1}$***) and the trapped gas pockets that influence in profile roughness are consistent with those obtained by other authors [14], [10], [12], [7]. This effect reinforces the proposed hypothesis in the present work after of the molten material pool formation.

Magnetic Materials Pilot Plant

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