Influence of ball milled pyrex free magnetic microwires on strontium ferrite, BH_{max}

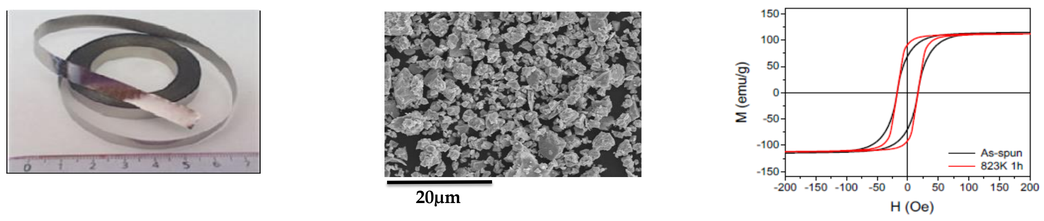
P. G. B. Gueye, M. Gonzales Barrio, P. Marín ,

[1]Instituto Magnetismo Aplicado IMA ,UCM, Las Rosas (Madrid), Spain. Tel: 913007173

[2] Departamento de Física de Materiales ,UCM, Madrid

Background –Permanent magnets with Ribbons

•Hybrid permanent magnets were fabricated with a high energy ball milling of hard and soft magnetic phases. Previous works developped in this field using ribbons, show an increment of BHmax for cryomilled powder of nanocrystallized ribbons. In our case we propose the use of magnetic microwires with uniaxial anisotropy presenting a biestable hysteresis loops..



a) $Fe_{73.5}Si_{13.5}B_9Nb_3Cu_1$ ribbons fabricated at IMA (b), SEM image of ribbons annealed at 823K -1h and wet ball milled for 3h and (c) Hysteresis loops of ribbons as-cast and annealed at 823K

Introduction

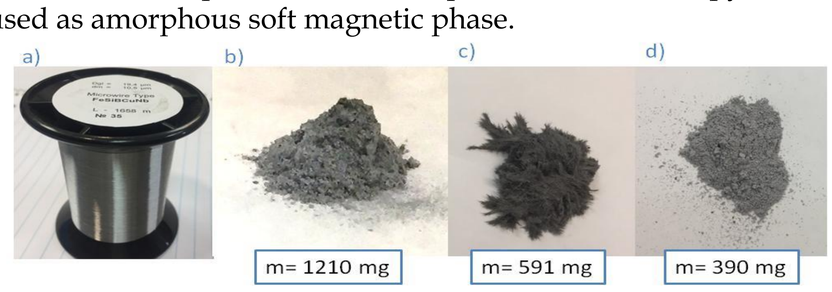
•Fe-Si-B-Cu-Nb amorphous microwires have been ball-milled for times between 6 and 30 min. Pyrex has been removed by a magnetic method, and pyrex-free microwires 10 μm length have been ball milled with ferrite. Wire morphology and the influence on the ferrite's energy products BH_{max} was studied by SEM and hysteresis loops.

•The aim of this work is to improve the BHmax (energy product) of hybrid permanent magnets in comparison with pure strontium ferrite.

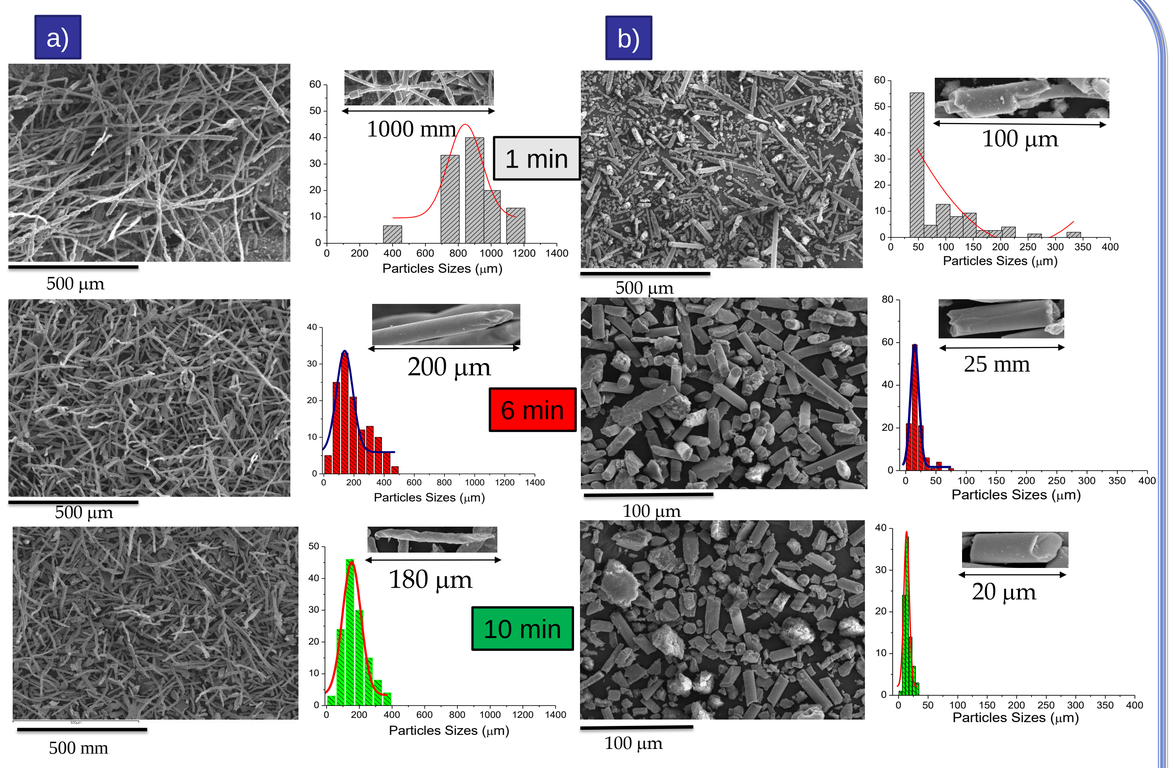
Technique and Characterization

➢ Pyrex-free amorphous microwires using a magnetic method

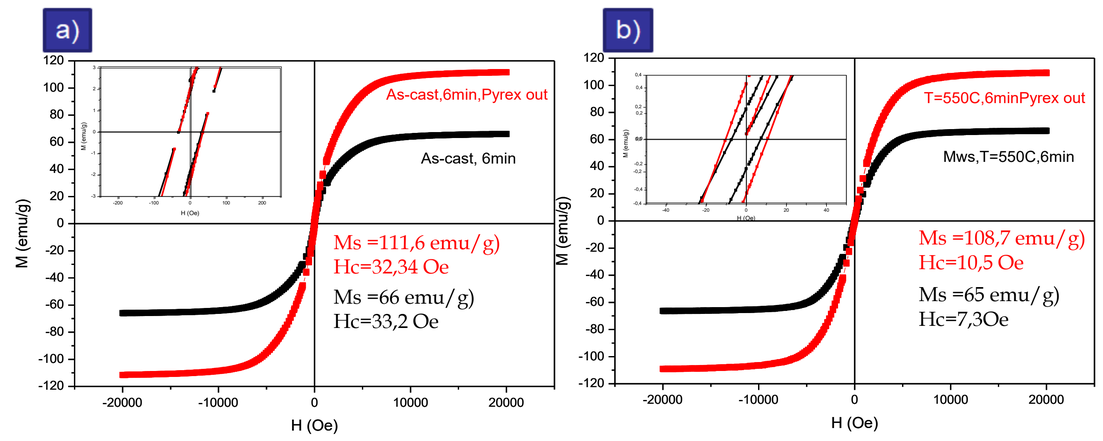
We report results of an experimental technique to remove the pyrex coating from microwires used as amorphous soft magnetic phase.



- Microwires (a) , MWs ball-milled (6 min) (b), metallic nucleus (c) and Pyrex residuals (d)



- SEM images of (a) as-cast and (b) annealed at 823K-1h microwire powders and their particle size distributions

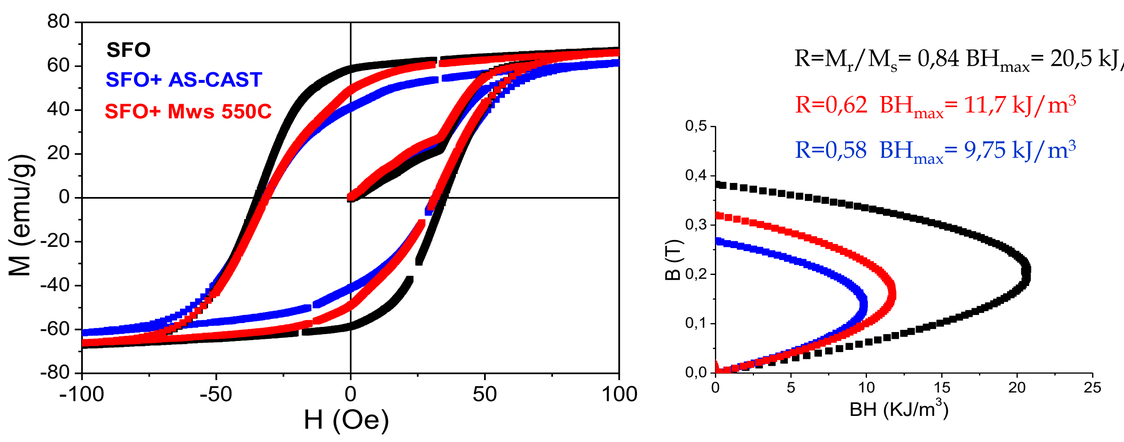


•Hysteresis loops of microwire powders after 6 min of ball milling and pyrex removal (a) as-cast and (b) microwires annealed at 823K-1h,

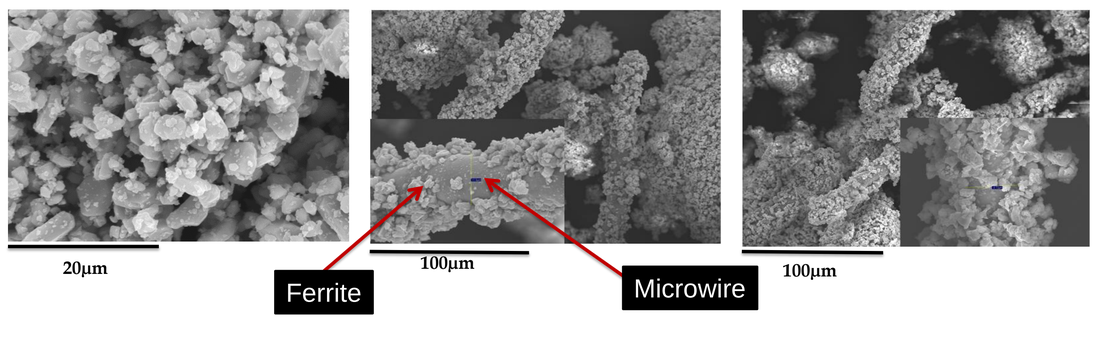
➢Permanent magnets with Microwires

•Energy product BH_{max} of several composites are compared with that of pure ferrite (SFO).

- Magnetic characterization by Vibrating Sample Magnetometer (VSM)



- Hysteresis loops of pure ferrite and their composites (left) and B=f(BH_{max}) curves (right)



- SEM images of composites of hard- and soft-phase hybrid magnets after 30 seconds of wet ball milling. (a) Ferrite powder; (b) as-cast microwires; and (c) microwires annealed at 823 K.

References

- [1] Spanish patent WO2017137640A1, Aragon, A.; Marín, P.; Hernando Grande, A. *Material microcompuesto magnético permanente sin tierras raras y su metodo de obtención* (2017).
- [2] B. Balamurugan et. al. *Scripta Materialia* **67,** 542–547 (2012).
- [3] Hao Zeng et. al. *Nature* **420**, 395–398 (2002).
- [4] Chuanbing Rong et. al. *J. Appl. Phys.* **109**, 07A735 (2011).

Conclusions

- To remove 90% of pyrex coating and keeping the cylindrical shape, we have chosen a dry ball milling and an optimal milling time of 6 minutes for annealed microwires at 550ºC where we have get more small particles size.
- A good microwires orientation (all parallel to each other) and a compaction of the sample result in an increase of the coercive field and the remanent magnetization observed in hysteresis loops.
- Our next work will consist in separating powders of the amorphous soft magnetic microwires.
- With several particles sizes, we will study how to improve the soft-hard phase exchange to get a better energy product.

Acknowledgements

- Financial support from AMPHIBIAN EU project.
- Instituto of Magnetismo Aplicado, Las Rozas.
- Universidad Complutense de Madrid.

* E-mail: pagueye@ucm.es