CURRICULUM VITAE Manuel Vázquez Villalabeitia

Born in Madrid, 20 October 1952
Professor of Research, *Ad-Honorem*

Group on "*Nanomagnetism and Magnetization Processes*"

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ORCID: https://orcid.org/0000-0001-5591-0157; Scopus Author ID: 7401539793

Scientific & Technology Expertise

Scientific:
Magnetism and Magnetic Materials; Nano and Microwires; Micromagnetism; Magnetic Domains and Remagnetization; Domain Walls; Magnetic Anisotropy; Amorphous & Nanocrystalline solids, Magnetostriction

Technological:
Magnetic and Magnetoelastic Sensors; Giant Magneto-impedance; Novel Materials & Functionalization

h impact factor: 67; over 700 scientific publications with more than 19,000 citations

Languages: Spanish (mother tongue), English, French and German

Summary Scientific Carrier and Main Achievements

- *Main achievements*: overall intense and systematic *scientific and technological* activity on *Cylindrical Magnetic Micro and Nanowires*.

Microwires:
i) pioneering publications on Giant Magnetoimpedance effect
ii) magnetic bistability by single domain wall propagation and its dynamics
iii) many applications & sensing devices making use of such unique properties

Nanowires:
i) pioneering on magnetic configuration and remagnetization in isolated modulated nanowires
ii) connection to many technological applications making use of cylindrical nanowires
iii) systematic studies on magnetic behaviour of densely packed arrays of nanowires

- *Principal Investigator* of many national & international scientific & technological projects

- *Training*: supervisor of 36 PhD and 45 visiting scientists; Co-inventor of 25 filed patents

- *Invited Speaker* to more than 150 International Conferences and Schools

- *Life Senior Member IEEE, 2023*

- Visiting Professor to Zhengzhou University, China, Jul.2023 (Magnetism of Micro & Nanostructures)

- *Distinguished Lecturer Award* IEEE Magnetics Society, 2023 on "*Cylindrical Micro and Nanowires: from curvature effects on Magnetization to sensing applications*"

- *Senior Fulbright Award* at Northeastern University, Boston, Jul-Nov. 2022 (on the effect of magnetic microwires on neuronal regeneration growth)

- *Distinguished Services Award* IEEE Magnetics Society, *2021*, "*for tremendously strengthening IEEE Magnetics Society outreach worldwide and dedicated efforts to engage new people in service to the society".*

- *Editor of the Book "Magnetic Nano and Microwires: Design, Synthesis, Properties and Applications*" (Woodhead Publ., Elsevier) Editions 2015, 2020 and 2025.

- Professor Honorary of Instituto de Magnetismo Aplicado, from 2020 (on sensors technology of micro and nanowires).

- Visiting Professor (Government Brazil): Univ. Federal Pernambuco, Recife, Sept.-Oct. 2019 (on Cylindrical nano and microwires)

- *President IEEE Magnetic Society*, 2017-8. List of Presidents at https://ethw.org/IEEE_Magnetics_Society_History

- Salvador <u>Velayos Award on Magnetism</u> "*in recognition of his extensive contributions to applied magnetism, and, especially, his important role in the projection of national magnetism at an international level* (2017)

- Promotor of "*Initiative in Magnetism*" at the ICMM/CSIC (2016) and of their *Biannual Spring Meetings* on Magnetism (from 2010)

- Visiting Professor to Hubei University (China Government), Wuhan, China, March 2016 (on micro and nano magnetism)

- *International Head of the Laboratory of Magnetic Sensors*, Urals Federal University, UrFU, Yekaterinburg, Russia (2015-16) (funded by the UrFU and the Russian Federation) http://insma.urfu.ru/en/research/research-6 and Member of the International Academic Board of the Institute of Natural Sciences and Mathematics, UrFU (2017-9)

- Program Committee Chair, International Conference on Magnetism, ICM, Barcelona, 2015

- *Founder of the IEEE Magnetics Society Spain Chapter* (2006), and Chair, 2007-8. Currently with 70 members; many of them active in different MagSoc committees

- Program Committee Chair, International Conference of Magnetism, ICM, Barcelona2015

- <u>*Secretary Commission on Magnetism, International Union of Pure and Applied Physics*</u>, IUPAP, 2011-14

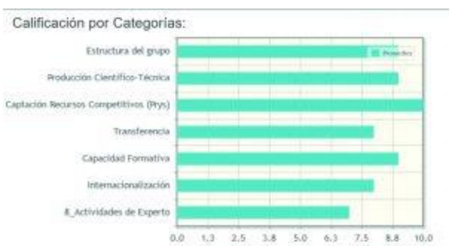
- <u>*General Chair INTERMAG'08 conference*</u>, Madrid, May 2008

- <u>*Manager of the Strategic Action on Nanoscience and Nanotechnology*</u> (Spain Ministry of Science & Technology, 2004-9); Co-manager National Plan for Materials (2001-03); Member of the NMP Commission Spanish Delegation, FM7, Brussels (2007-10)

- Co-founder (2002), and President of Spanish Club of Magnetism, CEMAG (2006-8)

- Co-founder European Magnetic Sensors and Actuators Conference, EMSA, 1996

- <u>*Founder of the Group "Nanomagnetism and Magnetization Processes*</u>" at ICMM/CSIC, 2001; In February 2019, it received the **maximum calification (A-Excellent)** in the last internal evaluation of all the CSIC groups. "The evaluators highlight the good Spanish and International funding as well as the fundings obtained from technological companies. It is also remarked the scientific and technological activity together with the high level scientific training of PhD students".



- *Director of Laboratory*, Instituto de Magnetismo Aplicado, UCM-RENFE-CSIC, 1992-2000

- *Professor of Research* at the Institute of Materials Science at Madrid, CSIC, 1996; Scientific Investigator, 1889

- Invited Visiting Researcher to Un. Santiago de Compostela, 1996

- Invited Visiting Researcher (grant Max-Planck-Gesellschaft) to Max-Planck-Institute, Stuttgart, 1989

- Invited Visiting Researcher (Sao Paulo Government) to Univ. Sao Paulo, Brazil, 1989

- *Promoter of the Company "Micromag S.L.", 1986*

- Post-doc NATO Invited Researcher at Techniske Danmark Universitat, Lyngby, 1985

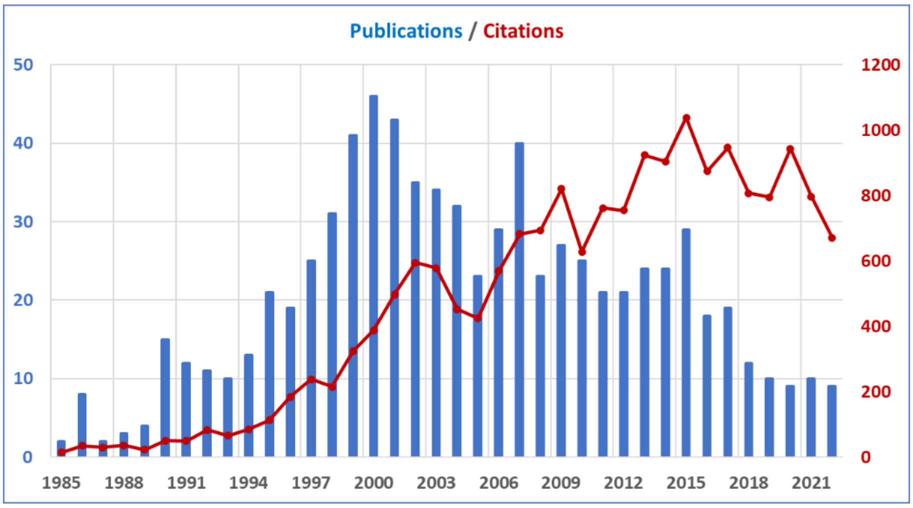
- *Alexander von Humboldt Post-doctoral Fellow* (Max-Planck-Institute, Stuttgart), 1981-3

- Associate Professor (Univ. Complutense, Madrid, 1985-89); Assistant Professor (1982-84); Post-graduate Assistant Professor (1975-80)

- Contracted Associated Professor at Univ. León, Spain, 1980-81

- Ph. D. (Physics) by Complutense University of Madrid, 1980

- IAESTE post-graduated grant at Koninklijke/Shell Lab., Amsterdam, 1974



Summary **Pag.**

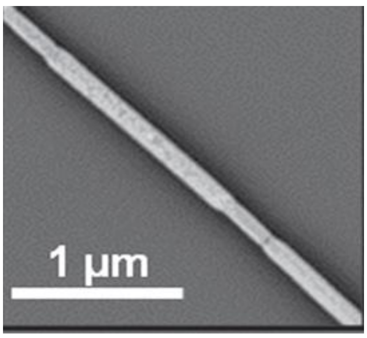
1. Research Lines and Publications

a) Magnetism of Cylindrical Nanowires

The most recent interest, along the last few years, addresses the magnetism of individual cylindrical magnetic nanowires after released from inside the template where they are electrolytically grown. The main challenges are related to the role of their intrinsic geometry curvature at the nanoscale. It focuses particularly on the local magnetic moments distribution (magnetic domain structure) and on the remagnetization process (mostly by domain wall motion).

The local domain structure is determined by the balance between cylindrical shape and magnetocrystalline anisotropies. Fe and Ni rich alloy nanowires exhibit *bcc* or *fcc* cubic structure, and shape is the predominant anisotropy (as for Py). Co and Co-rich alloy nanowires show generally *hcp* symmetry that determines an effective magnetization easy axis at a given angle with the nanowire axis.

Experimental studies are performed on nanowires especially designed with modulations in diameter (segments of different diameter, and with antinotches, see Figure 1) or in composition (FM/FM or FM/Metal multilayer) intended for the controlled remagnetization through anisotropy modulations or for domain wall pinning. The micromagnetic modelling showed that remagnetization proceeds by the formation of vortex structures at the nanowire ends, followed by depinning and propagation of Bloch-point like wall or in combination with magnetization rotations depending on the specific anisotropy. A deep knowledge of the magnetization reversal of individual nanowires is needed for full developments in logic devices, and advanced spintronics were the control over the domain wall motion is essential.



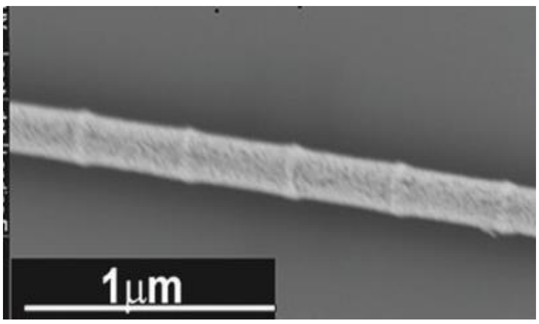


Figure 1.- Cylindrical nanowires with modulations in diameter; diameter of investigated isolated nanowires range between 80 and 160 nm

At remanence, depending on the energy balance, axial, transverse, vortex and more exotic domains, have been experimentally imaged by advanced MFM (surface), as well as by PEEM-XMCD (surface and inner), and electron holography, EH. Particularly, PEEM-XMCD technique in these cylindrical nanowires allows for the determination of the configuration of magnetic moments in the whole cross section of the nanowire. Under applied axial field, experimental measurements have been obtained (hysteresis loops) by MOKE, and domains imaging in MFM equipments in the laboratories of ICMM/CSIC, while most advanced techniques have been employed in large facilities as ALBA synchrotron (PEEM & XMCD, TXRM) or Electron Holography (CEMES, CNRS) and most recently by optically detected spin resonance in nitrogen-vacancy center in diamond magnetometry (SNVM).

Most outstanding achievements in *individual nanowires with designed modulations* are:

i) tailoring of axial, transverse, vortex and more exotic helical domain structures (Fig. 2);

ii) hysteresis loops in diameter modulated nanowires showing stepping remagnetization (Fig. 3)

iii) *magnetization ratchet* in FeCo/Cu multisegmented nanowires with designed segments length, and wall pinning at the transition regions between segments (Fig. 4).

iv) *skyrmion tubes* and corkscrew pinning in FM/M modulated diameter nanowires (Fig. 5),

vi) experimental PEEM data and micromagnetics on *stochastic & deterministic* remagnetization (Fig. 6)

v) *effect of current pulses* on the magnetization reversal in *antinotched modulated nanowires* (Fig. 7).

vi) imaging magnetic defects with optically detected spin resonance in nitrogen-vacancy center in diamond, SNVM.

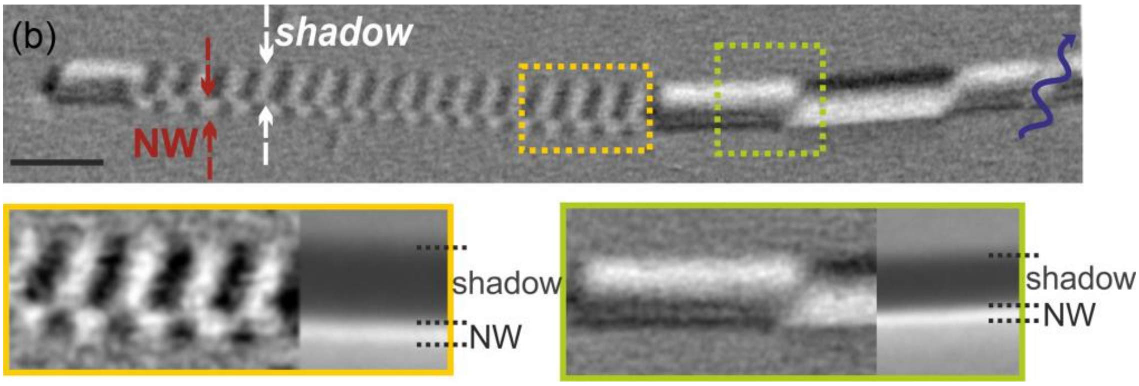


Fig. 2.- XMCD-PEEM images of Co65Ni35 nanowire. Transverse and vortex domains are clearly identified in local regions of CoNi nanowire *(C. Bran et al., 2017, Physical Review B, 96 (12), art. no. 125415)*

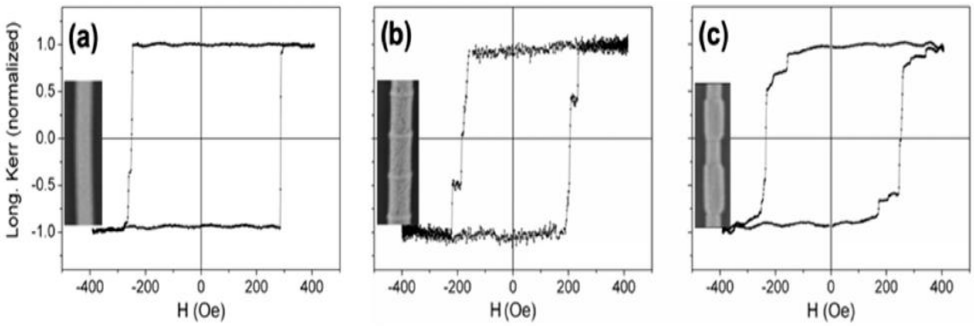


Fig. 3.- MOKE hysteresis loops of individual nanowires with homogeneous (left), antinotched (middle) and multisegmented (right) nanowires.

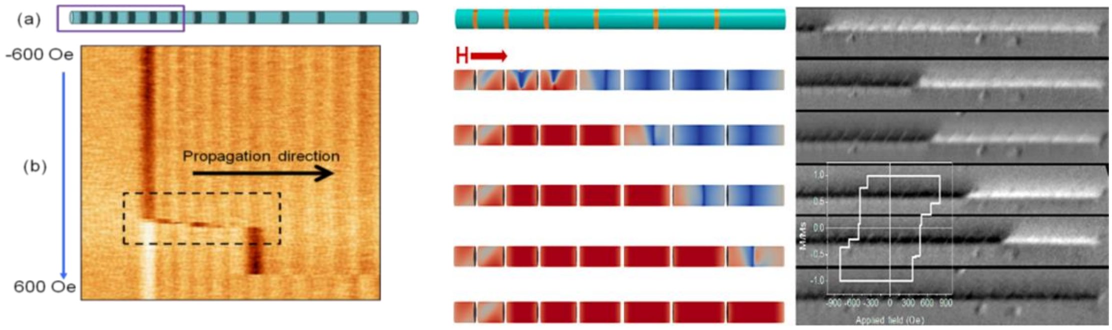


Fig. 4.- The unidirectional motion of information carriers such as domain walls in magnetic nanostrips is a key feature for many future spintronic applications based on shift registers. This magnetic ratchet effect has so far been achieved in a limited number of complex nanomagnetic structures, for example, by lithographically engineered pinning sites. This figures represent a simple remagnetization ratchet originated in the asymmetric potential from the designed increasing lengths of magnetostatically coupled ferromagnetic segments in FeCo/Cu cylindrical nanowires. The magnetization reversal in neighboring segments propagates sequentially in steps starting from the shorter segments, irrespective of the applied field direction, as observed by MFM imaging (left), micromagnetic simulations (middle) and PEEM/MXCD (right). This natural and efficient ratchet offers alternatives for the design of three-dimensional advanced storage and logic devices. (*C.Bran et al., Magnetization Ratchet in Cylindrical Nanowires, ACS Nano 2018, 12, 5932–5939)*

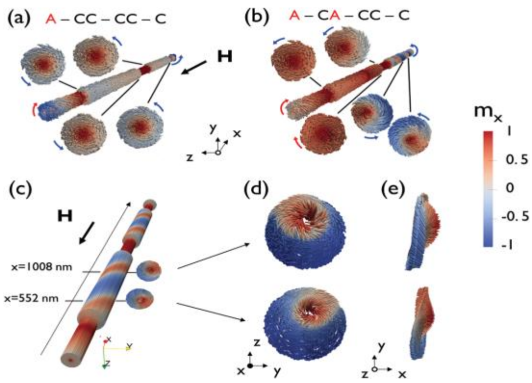


Fig. 5.- Simulated magnetization distribution in two-segment nanowires: Longitudinal magnetization component (a–b), Surface magnetization showing the magnetization spiral and the vortex/skyrmion magnetization structure (c), and views of cross sections showing the displaced skyrmion structure (d–e). (*J.A. Fernandez-Roldan et al. Nanoscale, 2018, DOI: 10.1039/c8nr00024g)*

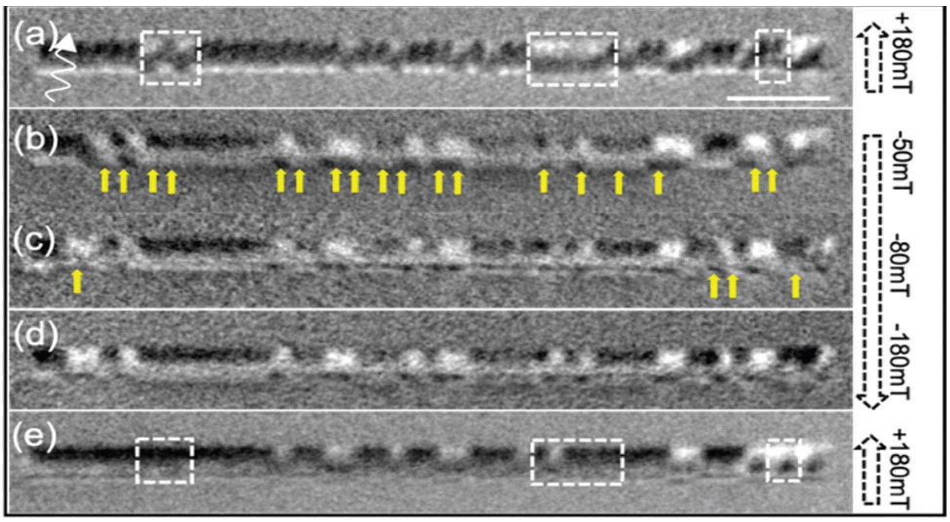


Fig. 6.- Sequence of XMCD–PEEM images measured in remanence after (a) +180 mT, (b) −50 mT, (c) −80 mT, (d) −180 mT and (e) +180 mT perpendicular magnetic fields were applied. The stochastic and deterministic remagnetization is analysed by micromagnetic simulations. *(Bran et al, Stochastic vs. deterministic magnetic coding in designed cylindrical nanowires for 3D magnetic Networks, Nanoscale, 2021, 13, 12587)*

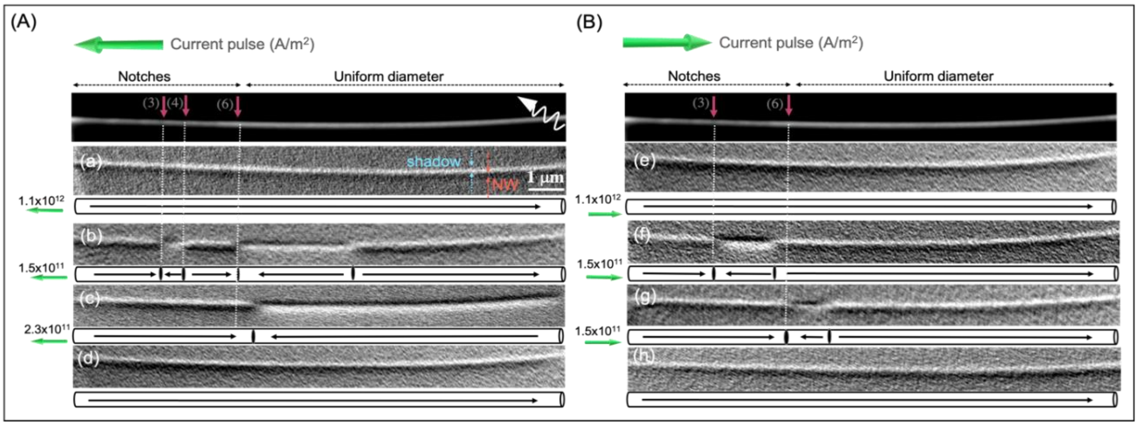


Fig. 7.- XAS images (top-panel in A and B) and a sequence of XMCD-PEEM images taken after current pulses with different intensities and polarities (indicated by the green arrows) were applied along the contacted Ni modulated nanowire. (a) and (e) XMCD-PEEM images of Ni NW presenting a single domain state. (b)-(d) and (f)-(h) XMCD-PEEM images of Ni NW taken after current pulses of 8 ns with different amplitudes and polarity, as represented by green arrows in the figure, were applied along its length. The red arrows and the white dashed line mark the different pinning centers produced by the notches. The graphical illustrations below each PEEM image represent the magnetic configurations of the NW. (*C. Bran et al, Nanoscale 2023, 15, 83)*

Publications.- (in blue more relevant ones)

- U. Celano, P. Rickhaus, C. Bran, J. Marqués-Marchán, V.J. Borràs, M. Korytov, A. Asenjo and M. Vazquez
"Probing geometry-induced magnetic defects in cylindrical modulated nanowires with optically detected spin resonance in nitrogen-vacancy center in diamond"
Nanoscale, 2024, 16, 16838

- M. Vazquez
"Cylindrical magnetic nanowires: geometry, magnetisationa and applications"
EuroPhysics News epn2023544p16 (2023) (an overview)

- C. Bran, J.A. Fernandez-Roldan, J. A. Moreno, A. Fraile Rodríguez, R. P. del Real, A. Asenjo, E. Saugar, J. Marqués-Marchán, H. Mohammed, M. Foerster, L. Aballe, J. Kosel, M. Vazquez and O. Chubykalo-Fesenko
"Domain wall propagation and pinning induced by current pulses in cylindrical modulated nanowires"
Nanoscale, 2023, 15, 8387

- M. Vazquez
"Cylindrical nanowire arrays: From advanced fabrication to static and microwave magnetic properties" Review
J. Magn. Magn. Mater. 543 (2022) 168634

- J.A. Fernandez-Roldan, C. Bran, A. Asenjo, M. Vázquez, A. Sorrentino, S. Ferrer, O. Chubykalo-Fesenko and R.P. del Real
"Spatial magnetic imaging of non-axially symmetric vortex domains in cylindrical nanowire by transmission X-ray microscopy"
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- J. Marqués-Marchán, J.A. Fernandez-Roldan, C. Bran, R. Puttock, C. Barton, J.A. Moreno, J. Kosel, M. Vazquez, O. Kazakova, O. Chubykalo-Fesenko and A. Asenjo
"Distinguishing Local Demagnetization Contribution to the Magnetization Process in Multisegmented Nanowires"
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"Magnetic Configurations in Modulated Cylindrical Nanowires" Review
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- J.A. Moreno, C. Bran, M. Vazquez, and J. Kosel
"Cylindrical Magnetic Nanowires Applications" Review
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- J. García, J.A. Fernández-Roldán, R. González, M. Méndez, C. Bran, V. Vega, S. González, M. Vázquez and V.M. Prida
"Narrow Segment Driven Multistep Magnetization Reversal Process in Sharp Diameter Modulated Fe67Co33 Nanowires"
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- I.M. Andersen, D. Wolf, L.A. Rodriguez, A. Lubk, D. Oliveros, C. Bran, T. Niermann, U.K. Rößler, M. Vazquez, C. Gatel, and E. Snoeck
"Field tunable three-dimensional magnetic nanotextures in cobalt-nickel nanowires"
Phys. Rev. Research, 033085 (2021)

- E. Berganza, J. Marqués-Marchán, C. Bran, M. Vazquez, A. Asenjo and M. Jaafar
"Evidence of Skyrmion-Tube Mediated Magnetization Reversal in Modulated Nanowires"
Materials 2021, 14, 5671

- C. Bran, E. Saugar, J.A. Fernandez-Roldan, R.P. del Real, A. Asenjo, L. Aballe, M. Foerster, A. Fraile Rodríguez, E.M. Palmero, M. Vazquez and O. Chubykalo-Fesenko
"Stochastic vs. deterministic magnetic coding in designed cylindrical nanowires for 3D magnetic Networks"
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- I.M. Andersen, L.A. Rodríguez, C. Bran, C. Marcelot, S. Joulie, T. Hungria, M. Vazquez, Ch. Gatel and E. Snoeck
"Exotic Transverse-Vortex Magnetic Configurations in CoNi Nanowires"
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"Unveiling the Origin of Multidomain Structures in Compositionally Modulated Cylindrical Magnetic Nanowires"
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- E.M. Palmero, M. Méndez, S. González, C. Bran, V. Vega, M. Vázquez, and V.M. Prida
"Stepwise magnetization reversal of geometrically tuned in diameter Ni and FeCo bi-segmented nanowire arrays"
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- J.A. Fernandez-Roldan, A. De Riz, B. Trapp, C. Thirion, M. Vazquez, J.-C. Toussaint, O. Fruchart and D. Gusakova
"Modeling magnetic-field-induced domain wall propagation in modulated-diameter cylindrical nanowires"
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- F. Nasirpouri, S.-M. Peighambari-Sattari, C. Bran, E.M. Palmero, E. Berganza, M. Vazquez, A. Patsopoulos and D. Kechrakos
"Geometrically designed domain wall trap in tri-segmented nickel magnetic nanowires for spintronics devices"
Scientific Reports (2019) 9:9010

- C. Bran, E. Berganza, J.A. Fernandez-Roldan, E.M. Palmero, J. Meier, E. Calle, M. Jaafar, M. Foerster, L. Aballe, A. Fraile Rodriguez,, R.P. del Real, A. Asenjo, O. Chubykalo-Fesenko, and M. Vazquez
"Magnetization Ratchet in Cylindrical Nanowires",
ACS Nano 2018, 12, 5932–5939

- J.A. Fernandez-Roldan, R. Perez del Real, C. Bran, M. Vazquez and O. Chubykalo-Fesenko
"Magnetization pinning in modulated nanowires: from topological protection to the "corkscrew" mechanism"
(2018) Nanoscale, DOI: 10.1039/c8nr00024g

- Berganza, E., Jaafar, M., Bran, C., Fernández-Roldán, J.A., Chubykalo-Fesenko, O., Vázquez, M., Asenjo, A.
"Multisegmented Nanowires: A Step towards the Control of the Domain Wall Configuration"
(2017) Scientific Reports, 7 (1), art. no. 11576. DOI: 10.1038/s41598-017-11902-w

- Bran, C., Fernandez-Roldan, J.A., Palmero, E.M., Berganza, E., Guzman, J., Del Real, R.P., Asenjo, A., Fraile Rodríguez, A., Foerster, M., Aballe, L., Chubykalo-Fesenko, O., Vazquez, M.
"Direct observation of transverse and vortex metastable magnetic domains in cylindrical nanowires"
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- Rotarescu, C., Moreno, R., Fernández-Roldan, J.A., Trabada, D.G., Nemes, N.M., Fehér, T., Bran, C., Vázquez, M., Chiriac, H., Lupu, N., Óvári, T.-A., Chubykalo-Fesenko, O.
"Effective anisotropies in magnetic nanowires using the torque method"
(2017) Journal of Magnetism and Magnetic Materials, 443, pp. 378-384. DOI: 10.1016/j.jmmm.2017.07.059

- Toscano, D., Leonel, S.A., Coura, P.Z., Sato, F., Costa, B.V., Vázquez, M.
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- Rodríguez, L.A., Bran, C., Reyes, D., Berganza, E., Vázquez, M., Gatel, C., Snoeck, E., Asenjo, A.
"Quantitative Nanoscale Magnetic Study of Isolated Diameter-Modulated FeCoCu Nanowires"
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- Berganza, E., Bran, C., Jaafar, M., Vazquez, M., Asenjo, A.
"Domain wall pinning in FeCoCu bamboo-like nanowires"
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- Bran, C., Berganza, E., Palmero, E.M., Fernandez-Roldan, J.A., Del Real, R.P., Aballe, L., Foerster, M., Asenjo, A., Fraile Rodríguez, A., Vazquez, M.
"Spin configuration of cylindrical bamboo-like magnetic nanowires"
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b) Arrays of Nanowires, Magnetism & Functionalization

Studies on nanowire arrays have been systematically performed firstly to control designed geometry, composition and anisotropy of nanowires. A main general task has been to determine the magnetization process and the bulk response of the arrays, including the essential role played by the crystalline anisotropy of nanowires and the magnetostatic interactions between nanowires. Particular achievements include:

i) *role of geometry* arrangement on magnetostatic interactions,

ii) nanowire array as *rare-earth free magnet family*;

iii) *hybrid magneto-polymers and antimicrobial activity*; nanowires for MRI contrast agent

iv) alumina templates for *functionalization of antidots, magnetoplasmonic, nanopatterning*

b1) Synthesis & Structure & Role of Geometry

The individual nanowires in the previous sections are fabricated at the ICMM/CSIC lab by electrochemical procedures. Cylindrical nanowires are grown by electrodeposition into self-assembled pores in alumina membranes as templates. These porous membranes are prepared by two-anodization process starting from Al foils or disks.

The controlled synthesis process has been addressed in the last years, firstly on the anodization processes to achieve modulations of pores diameter through the so-called hard-soft anodization under careful control of voltage/current electrolysis. Subsequent procedures include the removal of non-oxidized Al bottom resulting in pores open by both ends of the membrane and the sputtering of noble metal thin film at one end.

Arrays of nanowires are then grown under controlled electrodeposition using a bath according to the desired magnetic alloy. Typical compositions include Fe, Co, Ni and their alloys, while diameter is tailored between 15 and 200 nm and length between 100 nm and 50 μm (with up to very high aspect ratio). The nanowires are arranged into a hexagonal array with micrometric size and lattice parameter that can be tailored between 30 and 500 nm.

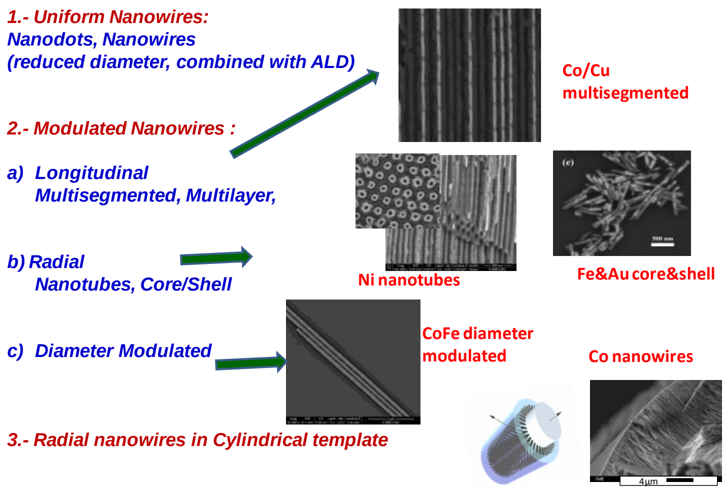

Fig. 8.- Different families of nanowires with cylindrical symmetry investigated

Different families of nanowires are depicted in Fig. 8. Of particular relevance is the case of segmented or multilayer nanowires prepared by single or double electrolites bath. In this way, FM/FM multisegmented and FM/Metal multilayer nanowire arrays are obtained.

Arrays of nanowires with radial modulation of composition were also prepared, as for example FM nanotubes with controlled tube wall. Very challenging is on the other hand the synthesis of core/shell FM/FM bimagnetic nanowires. Magnetic Metal/Magnetic oxide core/shell bimagnetic nanowires can be also grown by suitable oxidation process. We were also able to synthesize radial nanowire arrays starting in a cylindrical configuration (Al rods).

Morphology and particularly crystalline structure are characteristics determined by different techniques as HRTEM, X-ray diffraction, SEM, or AFM. See Figure 9.

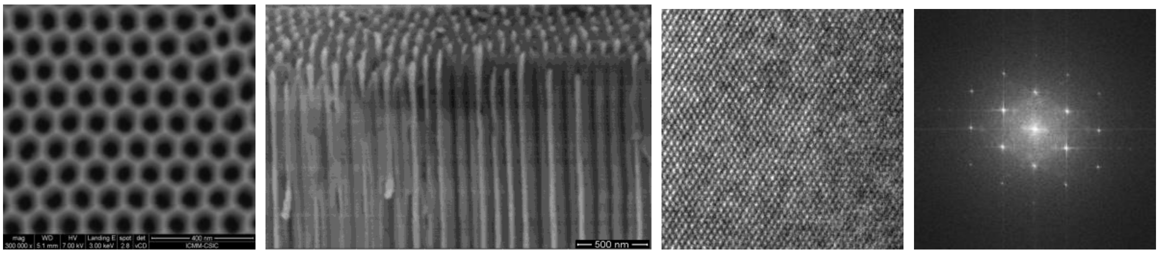

Fig. 9.- SEM images of anodic template (far left) and Co nanowire array(middle left). HRTEM image of single crystal hcp Co nanowire and its FFT

Publications

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Influence of Sulfur Incorporation into Nanoporous Anodic Alumina on the Volume Expansion and Self-Ordering Degree
(2015) J. Phys. Chem. C 119, 27392−27400 DOI: 10.1021/acs.jpcc.5b06928

- *I. Mínguez-Bacho, S. Rodríguez-Lopez, A. Climent-Font, D. Fichou, M. Vazquez, M. Hernandez-Velez*
Variation of the refractive index by means of sulfate anion incorporation into nanoporous anodic aluminum oxide films
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Compositionally graded Fe(1−x)-Pt(x) nanowires produced by alternating current electrodeposition into alumina templates
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b2) Magnetization Process, Anisotropy, Interactions

Figure 10 shows a MFM image at remanence of Ni nanowire array where the magnetostatic interactions are demonstrated, where where the nanowires ends show white or dark contrast denoting their dipolar character.

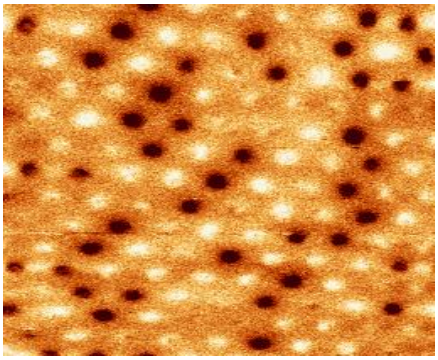

Fig. 10.- Magnetic Force Microsciopy image of an arrays of Ni nanowires at remanence whose different (white/black) contrast denotes the opposite magnetization direction of individual nanowires (*A. Asenjo in Escrig et al. Phys. Rev. B75 (18), art. no. 184429 (2007)*)

A particular objective in an EU project was to reach nanowire arrays with magnetically hard character. In this regard, CoFe alloys with the highest saturation magnetization (2.25 T) were considered. The inclusion of small amounts of other elements (i.e., Cu) resulted in very modest reduction of magnetization while increasing significantly their coercivity (0.5 T) and remanence (c. 0.9Ms) after suitable thermal treatments. Reasonable energy product values are still measured at high temperatures of about 500ºC. Most recent studies are focused towards the growth of ferri/antiferro magnetic caps at the ends of nanowires in order to magnetically couple with the main nanowire and enharden the remagnetization process.

The role of anisotropy was also clearly manifested in Co-rich nanowire arrays where the length and the diameter of nanowires determine the bulk magnetic response as a consequence of the different crystal symmetry of the transient initial and steady growing processes (*fcc* and *hcp*, respectively). Interestingly, 3D nanopillar vortex array was determined for short (45nm diam, 55 nm lenght) Co nanopillars (see Fig. 11).

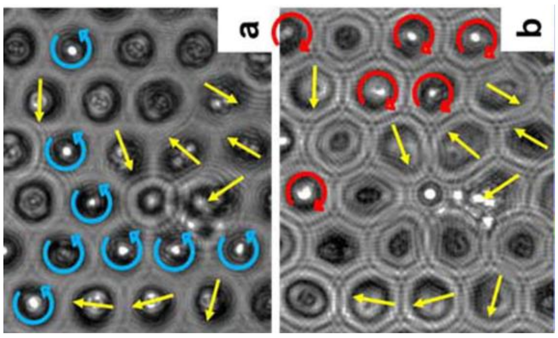

Fig. 11.- Lorentz TEM images in over- (**a**) and under-focused (**b**) conditions of an array of Co nanowires 45 nm in diameter and 55-nm long at remanence. The arrows show the transverse direction and the clockwise (red) and anticlockwise (blue) rotation of NW magnetization *(Y.P. Ivanov, Y.P., Chuvilin et al. Scientific Reports, 6, art. no. 23844(2016))*

From the angular dependence of coercivity and remanence it is possible to determine through analythical calculations the preferred reversal mode, by propagation of either by vortex-like or transverse like mechanism of domain wall. The magnetostatic interactions have been also investigated making use of the First Order Reversal Curves, FORC (Fig. 12).

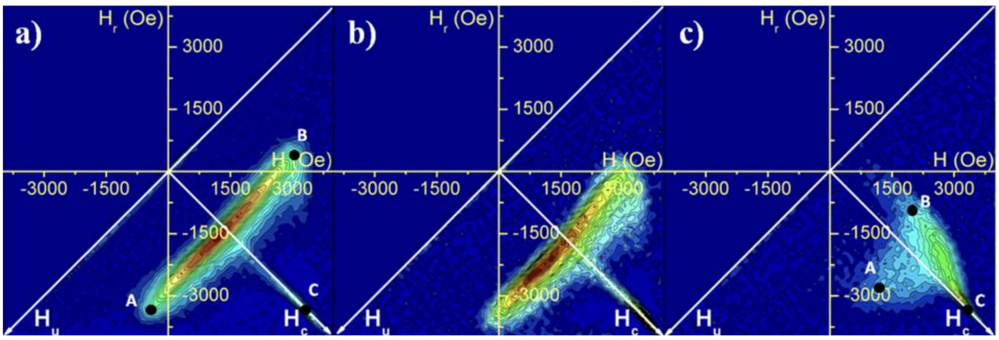

Fig. 12.- FORC distributions for FeCo/Cu multilayer nanowire arrays as afunction of the Cu layer thicknesses for the same FeCo segment thickness ($[FeCoCu (300 nm) / Cu(x)]_{10}$): (a) x=7 nm, (b) x=15 nm and (c) x=40 nm (*E. Palmero et al. Nanotechnology 27 (2016) 435705*).

Recent studies have focused on the temperature dependence of magnetic behavior in the range above room temperature and up to 900 Kelvin making use of advanced SQUID magnetometer. There it has been evidenced the role played by the microstructural changes together with the ferro/paramagnetic phase transition.

Fundamental studies were also performed in collaboration with other groups on spin waves modes. Configurational spin reorientation phase transition, or Ferromagnetic Resonance, as well as magneto-optical properties of Ni nanowire arrays.

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b3) Magnetopolymers & nanoparticles & magneto-opticals

Several kinds of functionalization of the nanowire arrays have been developed particularly looking for the combination of magnetic and polymeric behavior. One of them has been to use the template ordering to grow magneto-polymers (i.e., magnetic nanowire in PPMA composites) by replica-antireplica processes, or by magnetic nanoparticles into ordered polymers (Figure 13).

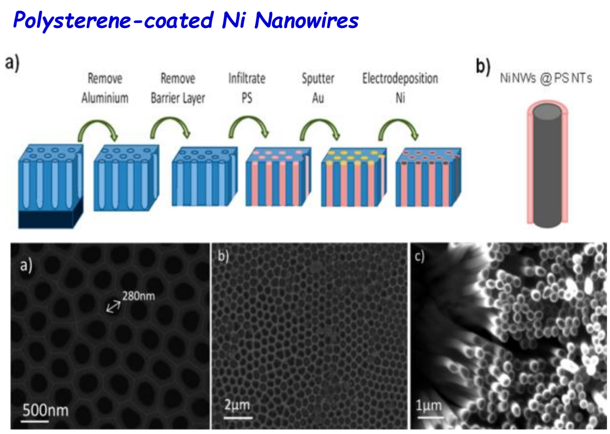

Fig. 13.- Top view SEM images of AAO membrane with average pore diameter of 280 nm and interdistance between pores of 420 nm (a), polystyrene nanotubes embedded into AAO membrane (b), and polystyrene nanotubes out of AAO membrane (c).

Other studies making use of anodic templates were related to: i) filling the magnetic porous membranes with nanoparticles; ii) investigating the magneto-optical properties of nanowire arrays.

Publications

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ACS Appl. Bio Mater. 2021, 4, 559−570

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b4) Organic & chemical & functionalization

As another example, studies have been reported for Ni/Cu multilayer nanowires, where Ni short segments were isolated and employed as contrast agents in MRI (Figure 14). Fe/FeO core/shell nanowires were found of interest for biomedical and harsh environmental applications

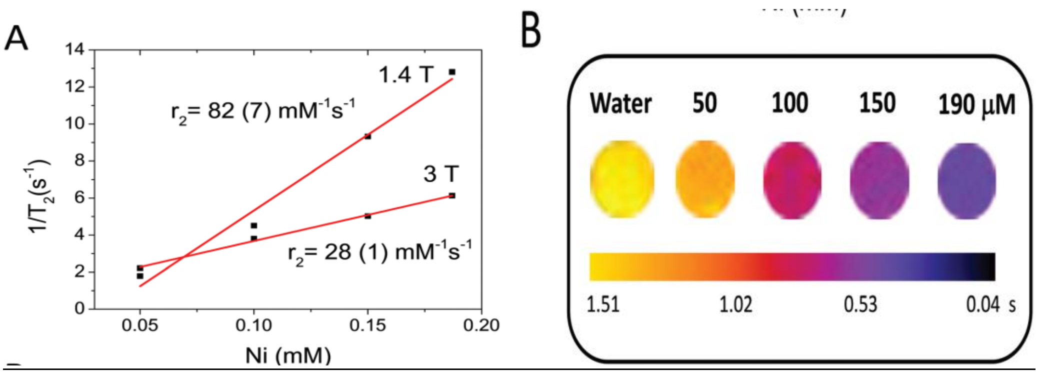

Fig. 14.- Individual Ni segments out of Ni/Cu nanowires grown inside AAO template as contrast agents for MRI imaging: Transversal relaxivity (r_2) of a water solution of PAA-coated Ni nanowires at 1.41 T and 3 T at 37 1C (A); and T_2 map of PAA-coated Ni nanowires acquired at 3 T and 37 1C (*M. Bañobre-López et al., Journal of Materials Chemistry B, 5 (18) (2017) pp. 3338-3347*)

Interestingly, nanowires have been recently employed hybrid Magnetoelectric Polymer-Based Nanocomposites with Magnetically Controlled Antimicrobial Activity (see Fig. 15)

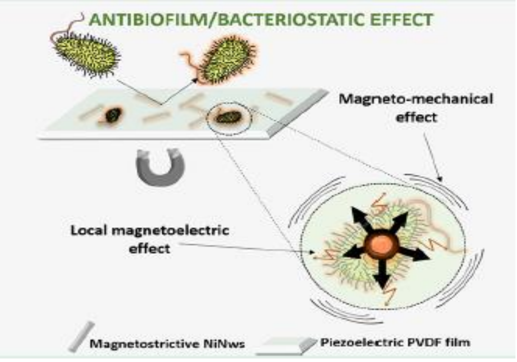

Fig. 15.- Magneto-Electric Polymer-Nanowire Hybrids with Antimicrobial Activity (*M. Fernandes et al. ACS Appl. Bio Mater. 4, 559*)

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b5) Alumina templates for functionalization: antidots, nanopatterning

On another hand, particularly interesting functionalization employing ordered porous Alumina templates is the growth of antidot thin films by sputtering onto the upper surface of the membrane (Fig. 16). Several studies were performed, including MOKE and PEEM, to determine the formation of domains during the remagnetization. Single and bilayer antidot films were thus characterized.

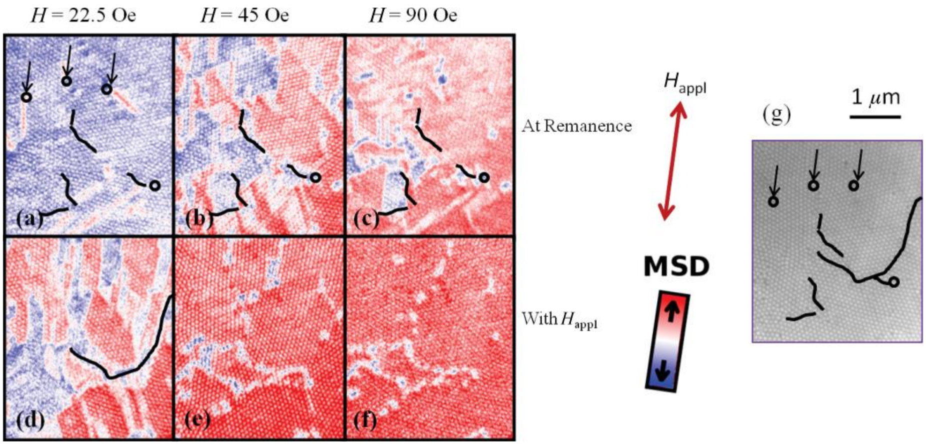

Fig. 16.- XMCD images of the magnetic domain structure of a Py antidot thin film grown on alumina template (a)–(c) at remanence and (d)–(f) under the applied field, and (g) XPEEM image denoting the geometric domains, with indication of some dislocations and punctual defects (*K.J. Merazzo et al. Phys. Rev B 85, 184427 (2012)*)

Anodic alumina templates have been also employed as templates for the assembling of highly ordered Ga nanoparticles for magnetoplasmonics applications (Fig. 17)

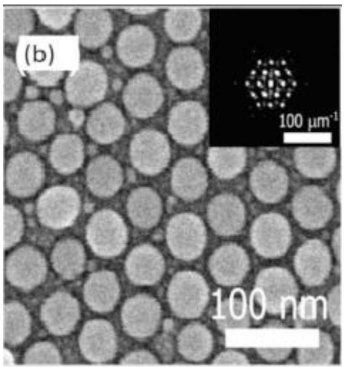

Fig. 17.- Highly ordered plasmonic Ga nanoparticles in AAO (*S. Gomez-Catalan et al. NanoFuture 2 (2018) 041001*)

A representative additional functionalization can be considered the combination of anodization with soft imprint and electrodeposition for nanopatterning of areas with designed pattern geometry (Fig. 18)

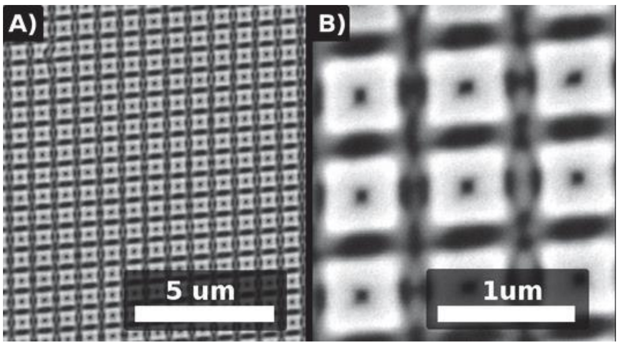

Fig. 18.- Nanopatterning with Soft Lithographic Imprint & Electrodeposition (*Vazquez et al., Patent 2016*)

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c) Magnetic Microwires

Amorphous metallic alloys are prepared by rapid solidification techniques. At the ICMM/CSIC laboratories we have three casting units operational for ribbons (50 μm thick), in-rotating-water quenching (120 μm diameter wires) and glass-coating quenching (glass-coated microwires, 1 to 30 μm diameter for the metallic core and 5-10 μm glass thickness). Amorphous structure, and its characteristics soft magnetic behaviour, is ensured by the rapid solidification process, so that, magnetic response is mainly determined by the strong mechanical stresses coupled to magnetostriction. General composition is FeCoSiB where the relative content Fe/Co determines the sign of magnetostriction (positive for Fe, and negative for Co).

Most relevant achievements are:

i) Pioneering studies on *Magnetic bistability* (remagnetization between two stable remanent states showing a squared hysteresis loop); outstanding studies on domain wall dynamics.

ii) Pioneering studies on *Giant Magnetoimpedance* (large change of impedance of a metallic conductor at the presence of a given static field): pioneering studies on this effect and sensor applications based on that

iii) *Introducing Bimagnetic microwires*, a novel family of microwires with two magnetic phases incorporated that has been employed as sensing elements in various devices;

iv) Novel alloys microwires for *advanced applications particularly as sensing elements*

v) Previous systematic research on Magnetostriction & Induced Anisotropies & Nanocrystalline Alloys.

c1) Magnetic Bistability & Single Domain Wall Remagnetization in Microwires and sensing applications

Magnetostrictive microwires show a squared hysteresis loop when axially magnetized. Such bistable behaviour, with a single giant Barkhausen jump, is originated by the propagation of a single domain wall, and it appears spontaneously in Fe rich microwires with large positive magnetostriction (30 ppm) where its coupling with strong mechanical (quenching, drawing and glass-induced) stresses of fabrication determine an axial magnetization easy direction.

Most relevant studies along have been devoted to the reversal by motion of a single DW that represents an ideal case for fundamental static and dynamic studies see Fig. 19). As it has been demonstrated years ago, at remanence there is a nearly single axial domain with closure structures at both ends. Reduced local net magnetization is observed by MOKE at both ends. Under the application of a homogeneous axial field, at a critical value (0.1 to 5 Oe) a domain wall depins from one of the ends and propagates along the whole microwire to reach the opposite end. The position, motion direction and the speed of the wall is experimentally determined with the help of few tiny pick coils to be in the range 0.5 to few km/s. In a series of articles we investigated the motion equation of the wall considering the damping from structural defects and the interaction with amorphous relaxation effects. The temperature dependence of switching field allowed additional information about structure defects (Fig. 20).

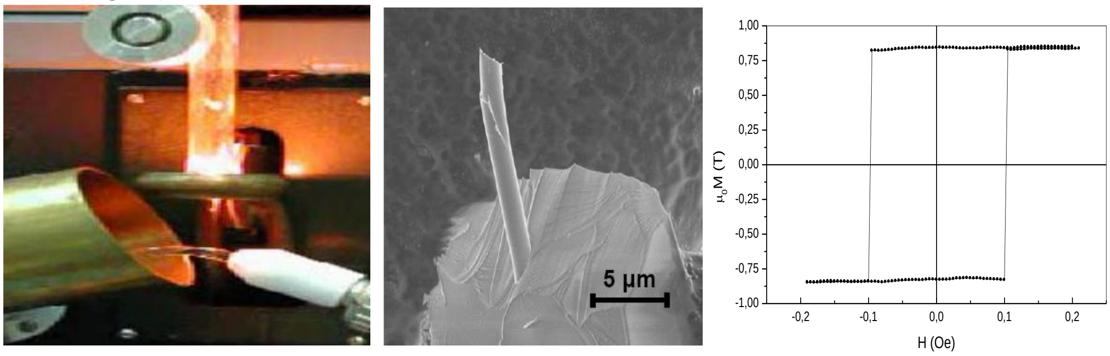

Fig. 19.- Glass-coating cast unit during the quenching fabrication (left); FeSiB glass-coated (center) and its bistable loop (right)

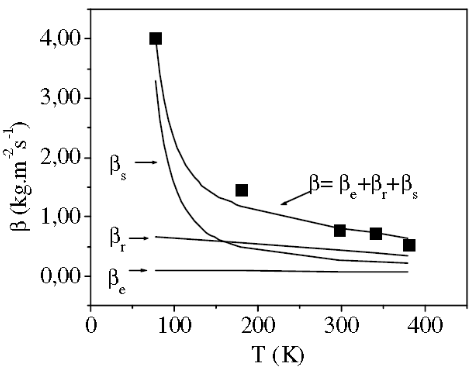

Fig. 20.- Temperature dependence of the domain wall damping β: experimental (square points) and calculated. Eddy current contribution, β_e, spin-relaxation damping coefficient, β_r, and structural relaxation wall damping β_s (R. *Varga et al., Phys. Rev. Letters, 94 (1), art. no. 017201, (2005).*

More recently we focused towards the controlled motion of the DW. The DW nucleates at the largest "defect" which is the end of the microwire, however, it can be nucleated somewhere else under the action of local reverse magnetic field supplied by a tiny coil. In this way, it was possible to move and to stop at will the position and the velocity by applying local field parallel/antiparallel to the main homogeneous exciting field (Fig. 21 left).

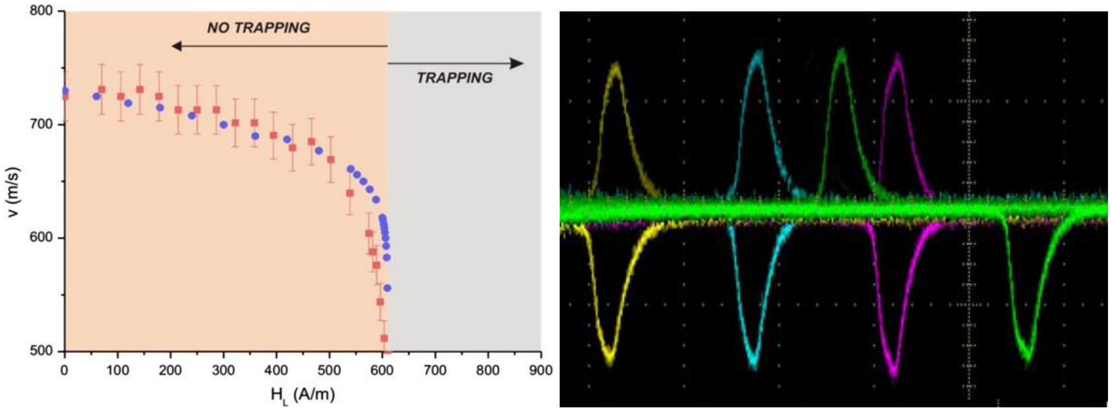

Fig. 21.- Left.- Domain wall velocity in a FeSiB microwire is tuned in with a local field, H_L, antiparallel to the homogeneous drive field originating the wall motion. For a given local field, 610 A/m, it gets trapped. Experimental and calculated data of DWSt speed are included *(M. Vazquez et al. Phys. Rev. Letters, 108 (3), art. no. 037201 (2012)*)
Right.- Sequences of induced signals at the pickup coils numbered (yellow, blue, pink, green), under rightward (bottom peaks) and leftward (upper peaks) applied field of amplitude 392 A/m. Note the presence of two domain walls moving in opposite directions (*A. Jimenez et al. European Phys. Journal B, 86 (3), art. no. 113 (2013)*)

Moreover, several domain walls can be nucleated and move (when in opposition, they collapse and annihilate). Current challenge is the generation of a train of domain walls moving at unison. Further, the electromotive force induced at the ends of the microwire upon the flowing of a small ac current through the wire gives us an additional hint of the shape and motion conditions for the wall. Such control of the DW motion is thought to be much relevant for the development of magnetic sensors and particularly for logic devices (Fig. 21 right).

Very interestingly, we have shown experimentally and qualitatively interpreted the fact that the unidirectional propagating domain wall in bistable microwire depends on the direction of the applied field. We conclude that the Head-Head and Tail-Tail domain walls propagate at different velocities (see Fig. 22).

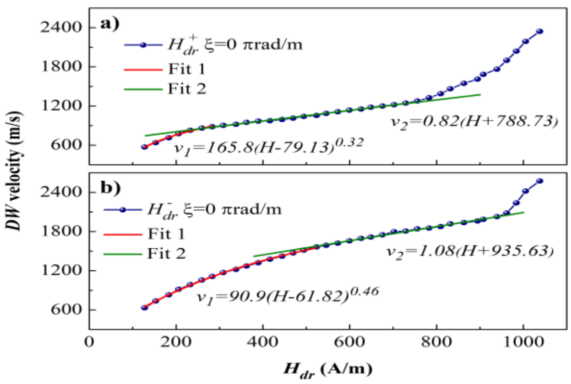

Fig. 22.- Domain wall velocity as a function of the driving field for parallel and antiparallel directions of the field (*Jimenez et al. Phys. Status Solidi A 2021, 2100284*).

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c2) Giant Magnetoimpedance, GMI, and High-frequency absorption, FMR, for sensing devices

The giant magnetoimpedance was rediscovered in 1994 in soft amorphous alloys (i.e., in-water-quenched microwires) and consists of the very large change of impedance, both real and imaginary parts, of a metallic conductor at the presence of static magnetic field. In fact, to measure the impedance, a small AC current of high frequency flows along the conductor (Fig. 23). If the frequency is high enough, the current flows just near the surface down to the skin-effect depth. The real advantage is provided by ultra-soft conductors like the amorphous alloys where the static field changes the permeability of the sample and consequently the skin depth and the impedance finally. In ultrasoft microwires changes of permeability occur at small field and consequently they can be used as field sensors in the low-field region. It is particularly large effect in near vanishing magnetostriction alloys (i.e., CoFe based) (see Fig. 24).

Most original work was performed along the 90’s decade to determine the full understanding of GMI and the optimal parameters like amplitude and frequency of AC current, the most suitable susceptibility characteristics of various materials (i.e, optimal response is obtained in amorphous wires and ribbons while amorphous thin films somehow gives a more limited response). For example, microwires with axial magnetization easy axis (Fe-base) show so-labelled single-peak GMI with a maximum at zero applied field. In turn, alloys with perpendicular easy axis (Co-base) exhibit two-peak behaviour with maximum GMI at the transverse anisotropy field.

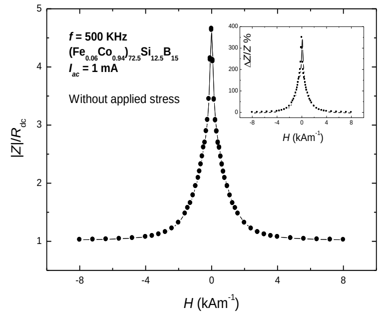

Fig. 23.- GMI in FeCoSiB microwire with vanishing magnetostriction (*Velazquez et al. Phys. Rev. B, 50 (1994) 16737)*

Quite recent result on the magnetostriction has been obtained showing high sensitivity measurements (see Fig. 24).

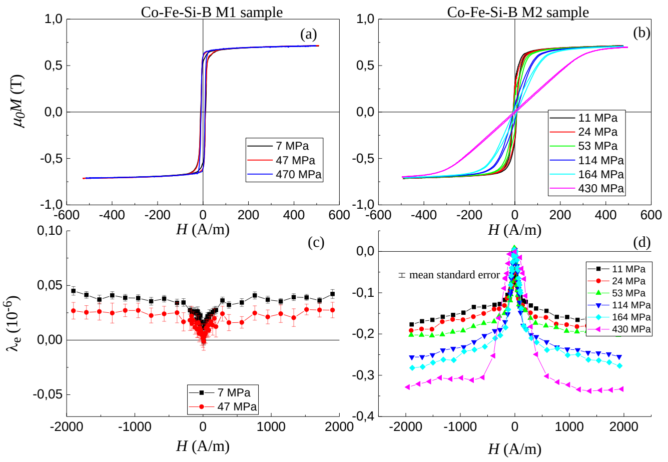

Fig. 24.- Direct measurement of magnetostriction and hysteresis loops as a function of the applied field in $(Co_xFe_{(1-x)})_{75}Si_{15}B_{10}$ (x = 0.94,left, and x= 0.95, right) alloy microwires with very similar composition *(Moya & Vazquez, to be published)*

The maximum GMI response is in the radio frequency range and up to few GHz depending on the composition and geometry. However, quite interesting is the response in the microwave frequency range (few GHz) where resonant absorption and FMR phenomena take place. That behaviour was originally exploited in the former USSR for the development of antiradar screens by embedding small microwire pieces in polymeric films and paintings.

GMI effect has been the base of several applications namely as magnetic field sensing, temperature or stress sensing. In Fig. 25 it is depicted a GMI based magnetoelastic sensor for signature identification where the stress-magnetoimpedance is used as the working principle.

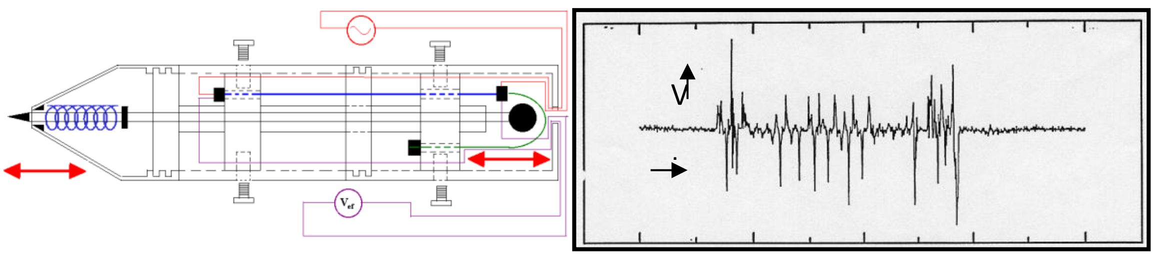

Fig. 25.- Magnetoelastic Signature device (pen) for signature identification and authentication and magnetoelastic signature (right) using GMI effect glass-coated microwire as sensing element (Patent).

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c3) Bimagnetic microwires and sensor applications

The group introduced by the beginning of 2000’s the so-called bimagnetic of biphase microwires employing combined rapid solidification-sputtering-electrodeposition. In this way it was possible to grow an external magnetic micro or nanotube with different magnetic character as compared to the core of the precursor glass-coated microwire (Fig. 26 left). Original work was performed in soft/soft, soft/hard and hard/soft bimagnetic wires (Fig. 26 middle). Particular emphasis was made to determine the extent of magnetoelastic and magnetostatic interactions between phases. Important is the case of soft/hard microwire after magnetic saturation followed by low-field magnetization since the soft core undergoes a magnetostatic shift similar to exchange bias.

Microwave absorption and FMR determination has been systematically performed in these bimagnetic wires where specific absorption phenomena are identified specially in soft/soft microwires (Fig. 26 right).

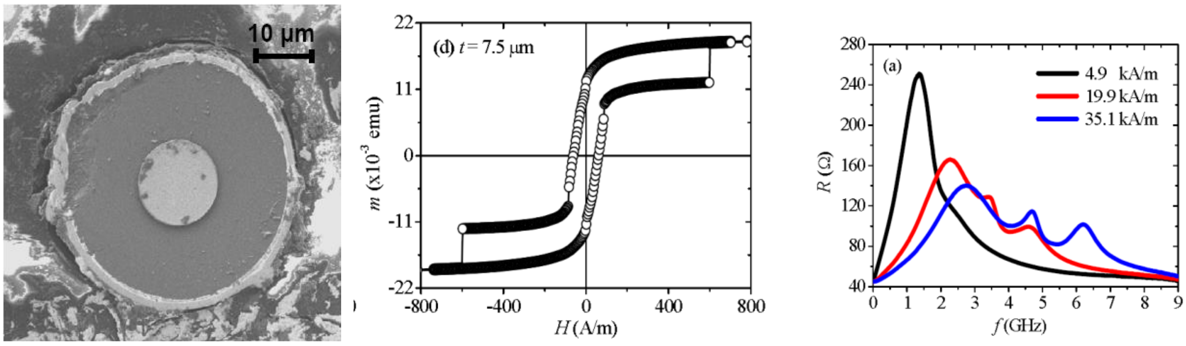

Fig. 26.- FeSiB/CoNi bimagnetic microwire (left); hysteresis loop of a soft/ultrasoft FeSiB/NiFe bimagnetic wire (center) and the impedance spectrum with static field as the parameter for a CoFeSiB/NiFe microwire (right) (*G. Infante PhD, 2010*)

Several applications have been developed based on bimagnetic microwires. Fig. 27 shows several bimagnetic microwires that bend different angle as a function of the applied field that has been proposed as microactuator.

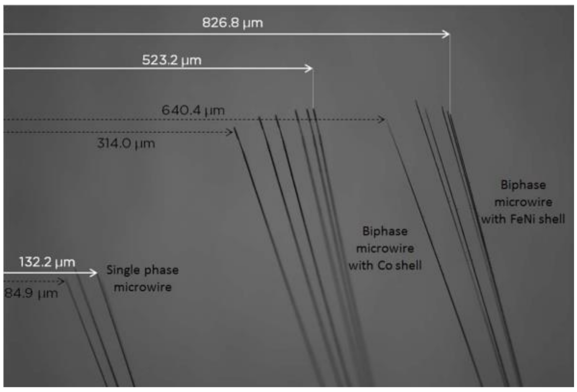

Fig. 27.- Micro-actuator based on bimagnetic core/shell microwires with asymmetric external shell (Patented, 2017). Image showing the bending under increasing applied field of the single-phase FeSiB (left), and biphase microwires with Co (middle) and FeNi (right) external shell, (Vazquez et al. Patent EU/Ru, 2017)

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c4) Novel materials and applications with microwires

In the last years, novel materials and applications with microwires have been developed. Interestingly, NiMnGa alloy microwires with shape memory and superelasticity phenomenon were fabricated as glass-coated microwire (Fig. 28). Also, glass coated microwire with MnBi composition as emerging novel family of alloys for alternative permanent magnets (Fig. 29) showing interesting increase of coercivity with temperature.

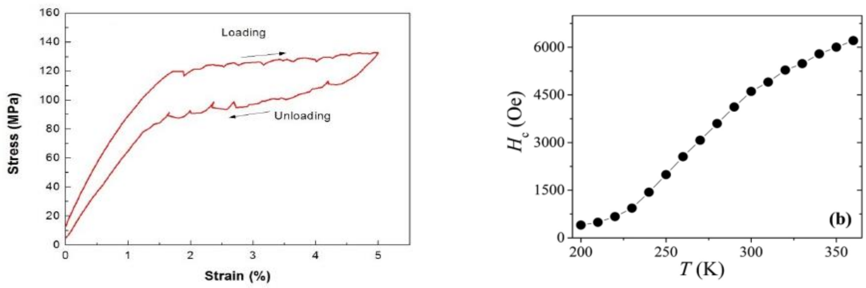

Fig. 28.- (Left) Superelasticity and shape memory effect in NiMnGa microwire (*Y. Zhao et al Scripta Materialia 162 (2019) 397*)
(Right) Temperature dependence of coercivity in MnBi glass coated microwire (*I. Betancourt et al. Scripta Metallurgica 153 (2018) 40*)

A wide spectrum of applications are developed very recently, as for example using microwire as part of hybrid magnetoelectric composite for invisible electronics (see Fig. 29).

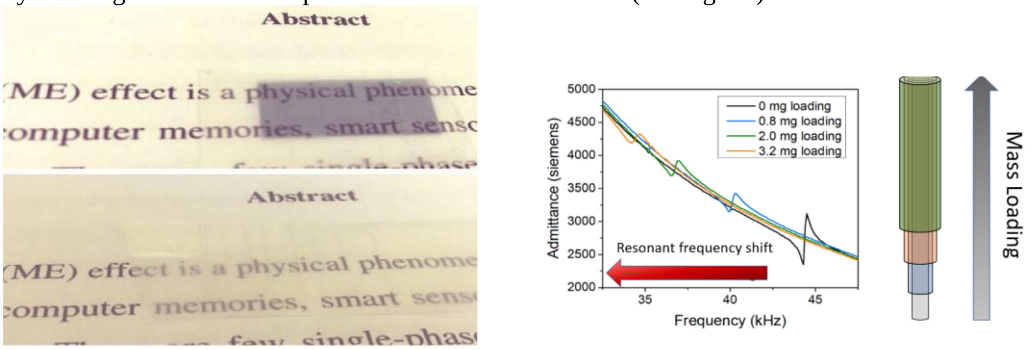

Fig. 29.- (left) Magnetoelectric composite with microwire for invisibility electronics (*Policia et al, Adv. Electron. Mater. 2019, 1900280*) (Right) Microwire for wireless high-frequency sensing *(Lejeune et al. IEEE Sensors 23, 2023, 1099*)

The very last application of magnetic amorphous microwires has been related to the influence of the presence of a piece of microwire in contact with a neurite on its growth. As has been experimentally demonstrated (Fig. 30), the local stray field of the microwire together with the geometrical topology promotes largely the growth. The origin for such influence is to be clarified by further investigations.

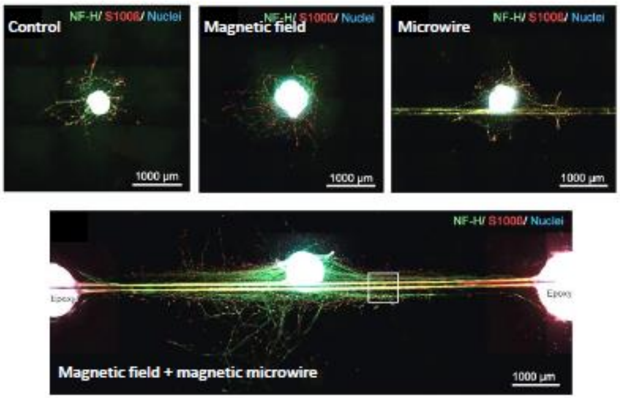

Fig. 30.- Dorsal root ganglia, DRG, (neuron clusters) cultured under various conditions. White spheres: clusters of neuron bodies, green lines: neurites extending outward, size/shape reflecting neuroregeneration effectiveness (*Neuman et al. Adv. Healthcare Mater. 2024, 2403956).*

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c5) Magnetostriction & Induced Anisotropies & Nanocrystalline Alloys

Investigations on amorphous alloys started during the 80's and continued later in the 90's not only on amorphous wires but also on amorphous ribbons. Interest at the time was focused on intrinsic stress distribution and on magnetostriction. Very fine magnetostriction measurements were performed (modified small-angle-magnetization-rotation method) in vanishing-magnetostriction ribbons (CoFe-based) as a function of the measuring temperature. It was found particularly the crossing zero-magnetostriction in CoFe- based alloys at given temperature below the Curie point. That was interpreted as originated from the different temperature dependence of single-ion and two-ion anisotropy mechanisms. Also, the critical exponent for the magnetostriction was introduced and correlated with the other critical exponents for magnetization and susceptibility.

An important aspect was the induction of magnetic anisotropies by free thermal treatments or at the presence of magnetic field or mechanical stresses. That way enabled the induction of axial, transverse and helical anisotropies. Quite interestingly, studies on the nanocrystallization process in FeSiBCuNb alloys were performed. The microstructural changes of the amorphous state were correlated to the magnetic response so that, ultrasoft character was observed before the nucleation of small hard grains.

A recent study focused on the role of thermal treatments to the devitrification process reaching nanocrystallization without the need of alloying.

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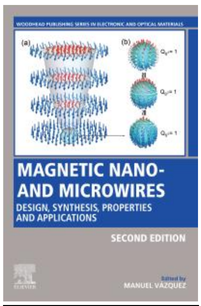
2. Books & Chapters



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(1993) Chap. 12: in "Propiedades Magneticas de los Materiales", Ed. J.M.Albella, A.M.Cintas, T.Miranda and J.M.Serratosa (CSIC) pp. 303-332

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-M. Vazquez
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3. Leadership of Scientific Projects (only responsible)

a) EU funded projects

- "Rare Earth Free Permanent Magnets (REFREEPERMAG)", FP7NMP.2011. 2.2-4; European Union, 2012-2016, IPs: D. Niarchos (NCRS, Athens), M. Vázquez (ICMM/CSIC), Univ. Duisburg-Essen (M. Farle), Techn. Un. Vienna (J. Fidler), Uppsala Uni. (O. Erikson), RuhrUniversitaet Bochum, Leibniz-Institut für Festkoerper-und Werkstofforschung Dresden (S. Fähler), Comm. Energie Atomique (F. Ott), Un. Toulouse (G. Viau), Magnetfabrik Bonn, Wittenstein Cyber Motor, Un Delaware, USA (G. Hadjipanayis). The achievement of the ICMM group was the growth of CoFe nanowire arrays with functionalized ends of the nanowires to enlarge their coercivity. They presented good high-temperature behavior relevant for some specific applications, and apart from several publications a patent was filed for position and tachometer sensor.

- "Magnetic nanoparticles combined with submicron bubbles for oncologing imaging (NANOMAGDYE)", FP7-NMP-2007-SMALL-1; European Union; IPs: G. Pourroy (CNRS, Grenoble), M. Vázquez (ICMM), I. Bernhard (Saarland Univ.), P. Chirco (Softech Techn & Res. Italy), P. Vertesy (Hungarian Ac. Sc.) (2008- 2012). Here, the objective was the fabrication and characterization of magnetite nanoparticles with specific size and behavior for their employment in oncology applications. The participation was mainly focused on the magnetic characterization as function of temperature, functionalization and size. It gave rise to a significant publication on the magnetic response of nanoparticles at low temperature.

- "Magnetostrictive bi-layers for multifunctional sensor families" EU-Growth GRD1-2001-40725 (2004-2008); H. Pfützner (Techn. Un. Vienna), M Vazquez (CSIC), Cardiff Un. (T. Moses), Fiat (J.Chiricco), ELCAT (Germany). Our relevant achievement in this project was the growth of bimagnetic microwires, a new family of magnetic microwires where onto the glass-coated microwire an Au microtube was sputtered and on that a microtube with desired magnetic behavior was electrodeposited. These microwires having tailored soft/hard, soft/soft and hard/hard behavior that resulted in several relevant publications but particularly in several patents related to their own fabrication and as sensing elements in temperature sensor and in microactuator depending on the characteristics of the external magnetic layer.

- "Integrated Lab-On-Chip Platforms for Medical Diagnostics" EUI2008-00120; Program of Internacionalization of research Spain/Portugal; 2008- 2011; IPs: P. Freitas, R. Ibarra, M. Vázquez (ICMM). Here, prospective studies on the application of nanowire arrays were developed. The collaboration between Portuguese colleagues was very successful and several PhD students were shared between the groups.

- "Electrical and Magnetic properties of materials" EU (Programa ALFA Europeo-Latinoamericano). PI: J.Irvine (Coordinador, Univ. St. Andrews), G. Pourroy (Univ. Strassbourg), M.Vázquez (IMA), R.Valenzuela (UNAM), J. Gonzalez (Univ. P. Vasco), A. Guimaraes (Univ. R. Janeiro), Univ. Aveiro and Univ. Monterrey. 1998-1999.

b) Spain Ministry of Science and Education & Regional Government of Madrid & CSIC

- "Solutions from Nanomagnetism to the Society Challenges (NANOMAGCOST)", Autonomous Goverment of Madrid (P2018/NMT-4321); 2019-2023, IPs: Rodolfo Miranda, Manuel Vázquez (ICMM)

- *"Design of magnetic nanowires for green technologies" MAT2016-76824-C3-1-R, MINEC (2017-19), IPs: A. Asenjo, R.Perez, M. Vazquez*

- "Magnetic Nanowires and their 3D arrays for advanced technologies", MAT2013-48054-C2-1; MINECO; 2014-2016; IPs: Manuel Vázquez and Agustina Asenjo

- *"Ordered arrays of nanodots and antidots: magnetization and transport", MAT2010-20798-C05-01; MCINN; 2011- 2014; IP: Manuel Vázquez*

- "New Frontiers in fundamental and applied nanomagnetism". NANOFRONTMAG-CM (S2013/MIT-2850) CAM: 2014-2018; IPs: R. Miranda (IMDEA), M. Vazquez (ICMM/CSIC)

- *"Magnetotransport in micro and nanowires" MAT2007-65420-C02-01; MCINN, 2008- 2011; IP: M. Vázquez;*

- "Magnetic Nanoparticles and Nanostructures: from spintronics to biomedicine" NANOBIOMAGNET(S2009/MAT-1726); CAM; 2009-2012; IPs: R. Miranda, IMDEA, ICMM, M. Vázquez;

- *"Magnetotransport properties in micro and nanowires", Min Ed. Sc. MAT2007-6542-C2-01 IP MVazquez, 2007-2010*

- "Ordered magnetic nanostructures for applications in optomagnetic biosensors" PIE CSIC project. ICMM/IMM/IIQA/ICMAB, IP: (ICMM) M Vazquez, G. Armelles, P. Marco, 2005-07.

- *"Template assisted gowth of magnetic nanostructures from chemical solutions" PIE CSIC project ICMAB/CNM/ICMM, IP (ICMM) M Vazquez, X. Obradors, X. Borrisé, 2005-07.*

- "Ferromagnetic nanowire arrays" Funded by Regional Government of Madrid GRMAT/0423-2004, IP: MVazquez, 2005

- *"Uni and bidimensional self-assembled magnetic nanosystems" Min. Educ. and Science, MAT2004-00150, IP MVazquez, 2005-07.*

- "New sensing elements for magnetic recording: Nanowires and characterization by MFM" Regional Governm. Madrid, CAM (07N/0033/1998). Diciembre 1998 / Diciembre 2000

- *"Artificial Magnetic Nanoestructures design, preparation, magnetic characterization and applications" CICYT MAT98-0965-C04-C01. PI: M. Vázquez (Coordinator, ICMM), J.J. de Miguel (UAM), P. Crespo (IMA), y F. Cebollada (UPM). Octubre 1998 / Octubre 2001*

- "Magnetic Force Microscopy" Reg. Governm. Madrid. Infraestructure CAM. 1996.

- *"Magnetism of multiphase systems" Spain Minst. Science and Education CICYT (MAT95-0273). Jul.95-Jun.98.*

- "Low temperature behavior of magnetic multiphases systems" Fundación D. Martinez Award. Ene. – Dic.1995.

- *"Vibrating Sample Magnetometry" Infraestructure Min. Ed. Science, CICYT. 1994.*

- "Temperature dependence of amorphous and nanocrystalline alloys". Fundación D. Martínez Award. Enero - Diciembre 1993.

- *"Optimized soft magnetic materials: microwires and nanocrystalline alloys" Spain. Min. Sc. Educ. C.I.C.Y.T (MAT/ 92-0156). Jun 1992-May 1995).*

- "Fabrication, magnetic characterization and microstructure modifications in amorphous alloys of technological relevance" Sp. Misn. Sc. Educ. CICYT (MAT89-0508). Nov. 1989- Oct.1992.

c) International Bilateral Projects

- "Magnetic Nanostructures, from fabrication to magnetic characterization", bilateral cooperation between Zhengzhou University, Hunan, China and ICMM/CSIC; supervisors Prof. R.H. Wei and M. Vazquez (2024- 2026)

- *"Monitoring magnetostimulated neuroregeneration with amorphous microwires" Fulbright Senior Mobility, IP:M.Vazquez & L.Lewis (Northeastern University, Boston) (2022)*

- "Nanorobots and sensors based on magnetic nanowires" i-LINKA20052 (CSIC), Coordinated by Manuel Vázquez, and partners from Institute of Robotics and Intelligent Systems at ETH, Zurich (Dr. S. Pané), Sensing, Magnetism and Microsystems group at KAUST, Thuwal, Saudi Arabia (Ass. Prof. J. Kosel), Functional Materials group at University of Vienna (Dr. Ch. Vogler), Nanomagnetism team of Quantum Detection Group at National Physical Laboratory NPL; Teddington, UK (Dr. O. Kazakova) and SuessCo Sensors GmbH, Herzogenburg, Austria (Eng. R. Windl). 2020-21

- *"Electrochemical techniques for the growth of magnetic nanowires and development of a MOKE device for their magnetic characterization" Project I-COOP 2017 (CSIC); Universidad de Cordoba (Argentina) and ICMM/CSIC: IPs. M.vazquez and P. Bercoff, 2018-19*

- "Research on magnetic microwires", Projects to fund the stay of Prof. Laura H. Lewis at ICMM/CSIC funded by Spain Fulbrigth and Northeastern University. Summertime 2016, 2018 and 2019.

- *"Ordered arrays of nanowires, nanotubes and antidots" 2010CL0018; Bilateral Project ICMM/CSIC and Univ. Santiago, Chile; 2011-2012; IPs: D. Altbir and M. Vázquez*

- "Magnetic Nanostructures for Data Storage"; MISTI Global Seed Fund, MIT-Spain; 2009- 2011; IPs: C. Ross (MIT); M. Vázquez (ICMM/CSIC)/F. Castaño (UPV)

- *"FMR studies in magnetic wires"; Bilateral Spanish-Czech action; 2009- 2011; IPs: M. Vazquez and L. Kraus.*

- "The study of high frequency behavior of magnetic nanostructures" PCI2006-A7-0694; ICMM/CSIC- Un. Tangier, Marocco; 2008- 2011; IPs: M. Vazquez and M.R. Brittel

- *"Magnetic domain analysis and magnetization process of micro and nanowires" Spain-Germany Bilateral agreement IP: R. Schaefer (IFW, Dresden) and M Vazquez (ICMM), 2005-06.*

- "High frequency behavior of arrays of micro and nanowires" Japan-Span bilateral program, Tohoku Un. (M. Yamaguchi) and CSIC (M Vazquez), 2005

- *"Evaluation of magnetic properties of nanocrystalline magnetic materials" Bilateral Spain-Poland program, Cestochowa Inst Power Engeenering (J. Sczyglowsky) ICMM (MVazquez), 2004-05.*

- "Giant Magnetoimpedance in magnetic microwires" Funded by CSIC-CONACYTAgreement, UNAM-Mexico (R. Valenzuela) and ICMM-CSIC (MVazquez) 2004-5

- *"Magnetism in low dimensions, relaxation and anisotropy" Funded by FONDECYT 2002 (Chile). IP: P. Vargas (Un. F. Sta. María, Valparaiso), M. Vázquez (ICMM/CSIC), M. Knobel (Un. Campinas, Brasil). 2002-2003.*

- "Nanohilos magnéticos" Funded by AECI/CONACYT. IP: M. Vázquez (ICMM), M. Tovar (CA. Bariloche, Argentina). 2001-2002.

- *"The nature of disperse (second) phase and the dynamic properties in ultrasoft magnetic alloys" Foreign Affairs Minst. PI: M. Vázquez & A. Lovas (Hungary Ac. Sciences) 2001-2003.*

- "Magnetoimpedance and absorption in soft ferrites and amorphous alloys" Agreement CSIC/CONACYT. PI: Vázquez (CSIC) and R. Valenzuela (CONACYT, UNAM-Mexico). 1999-2000

- *"Preparation, Magnetic Properties and Applications of amorphous microwires" Spain-Romania Bilateral agreement, PI.: M. Vázquez (CSIC) and H. Chiriac (Inst. Phys. Iasi, Romania). 1996-1997, 1999-2001*

- "Magnetic Nanowires" British-Spanish Integrated. PI: M. Vázquez (IMA) and M. Gibbs (Univ. Sheffield). Abril-96- Marzo-97.

- *"Amorphous and nanocrystalline alloys" Programa de Cooperación Iberoamericana (ICI). PI: M.Vázquez (IMA) and H.Sirkin (Univ. Buenos Aires). Ene.1995-Dic. 1996.*

- "Multiphase Magnetic systems" Spain-Germany Integrated Action. PI: H.Kronmüller (MPI, Stuttgart) and M.Vázquez (ICMM, Madrid). Enero 1995- Diciembre 1997.

- *"Preparation and structural and magnetic characterisation of amorphous wires". British-Spanish Integrated Actions. PI: H.A. Davies (Univ. de Sheffield) and M. Vázquez (ICMM). Abril 1992- Marzo 1993.*

- "Correlation between microstructure and magnetization processes in soft/hard magnetic materials" Germany-Spain Integrated Actions. PI: H. Kronmüller (M.P.I. Stuttgart) and M. Vázquez (I.C.M.M.). En. 1991- Dic. 1993.

4. PhD Supervision

- Soledad Aprea "Magnetism of Fe-based nanowire arrays, temperatura dependence" Universidad de Cordoba, Argentina, supervised by Paula Bercoff and Manuel Vazquez, (to be defended in 2025)

- *Zengxin Wei "Influence of layer thickness on exchange coupled ferromagnetic bilayers separated by non-magnetic layer" Universidad Autónoma de Madrid, supervised by David Navas and Manuel Vazquez, 2024*

- Esther Calle "Dinámica resuelta en tiempo de una única pared de dominio y procesos de imanación en microhilos magnéticos", Universidad Autónoma de Madrid, supervised by Rafael Perez del Real and Manuel Vazquez, 2021

- Nikita A. Kulesh, "Continuous and nanopatterned bCo-based heterostructures with in-plane and perpendicular anisotropy", Autonomous University of Madrid co-supervised by Manuel Vázquez and Vladimir O. Vaskovskii, 2019

- Jose Angel Fernandez Roldán "Micromagnetism of cylindrical nanowires with compositional and geometric modulations" Autonomous University of Madrid, supervised by Rafael Perez del Real, Oksana Chubykalo-Fesenko and M. Vazquez, 2019

- David González "Plantillas nanostructuradas por impresión y anodización para el crecimiento de redes ordenadas de nanohilos y nanotiras de Co" Univ. Autónoma de Madrid, co-Supervisors: M. Vazquez and D. Navas, 2017

- Alejandro Jimenez "Movimiento controlado de paredes magnéticas en microhilos biestables" Univ Autónoma de Madrid, Supervisor: M Vazquez, 2017

- Ester M. Palmero "Magnetization processes of magnetic modulated nanowires" Autonomous Univ. Madrid, Co-supervisors: M. Vazquez, R. Perez and C. Bran, 2016

- Rhimou El Kammouni "Single and biphase magnetic microwires: Microwave behavior and temperature dependence" Uni. Autónoma Madrid, Supervisor: MVazquez, 2014

- Mariana P. Proença, "Magnetism at the Nanoscale: Nanoparticles, Nanowires, Nanotubes and their Ordered Arrays "Porto University, Co-supervisors: J. P. E. de Araújo,, M. Vázquez and J. O. Ventura, 2013

- Karla J. Merazzo "Ordered magnetic antidot arrays" Autonomous Univ. Madrid, Supervisor: M. Vazquez, 2012

- Diana P. Leitao "On the magnetic and structural properties of Co and Co-based nanowire arrays" Porto University, Portugal, Co-supervising: JP Araujo and M Vazquez, 2012

- Ignacio Minguez "Nanostructures fabrication: Porous anodic alumina and ZnO nanorods" Autonomous Univ. Madrid, co-Supervisors: M. Hernandez-Velez and M. Vazquez, 2012

- Laura G. Vivas "On the magnetic and structural properties of Co and Co-based nanowire arrays" Autonomous Univ. Madrid, Supervisor: M. Vazquez, 2012

- German Infante "Propiedades magnéticas y de Transporte en nuevos microhilos mono y bifásicos" Autonomous Univ. Madrid, Supervisor: M Vazquez, 2010

- Wagner O. da Rosa "Nanostructuras magnéticas ordenadas sobre alúmina anodizada" Universidad Autónoma de Madrid, Co- Superviors: M Vazquez and A. Asenjo, 2009

- Ruy Sanz "Nanostructuras ordenadas basadas en TiO2 y ZnO obtenidas mediante irradiación iónica" Universidad Autónoma de Madrid, Co-Supervisors: M. Hernandez-Velez and M. Vazquez, 2009.

- Jacob Torrejon "Estudio del acoplamiento magnetoelastico y magnetoestático en microsistemas magnéticos multifásicos" Universidad Autónoma de Madrid, Supervisor: M Vazquez, 2009

- Pedro Mendoza de Zelis "Mecanismos de inversion de imanacion en aleaciones amorfas", University of La Plata, Argentina. Co-supervisor Q. Sánchez, M. Vazquez. 2007

- Davas Navas "Preparación y Propiedades Magneticas de arrays de nanohilos magnéticos en membranas porosas", Autonomous Univ. Madrid, Supervisor M Vazquez, 2006

- Karin García "Proceso de inversion de la imanación, y su dinámica en microhilos magneticos biestables", Universidad Complutense de Madrid. Supervisor M Vazquez. 2006.

- Carlos Luna "Preparación y Propiedades Magneticas de nanopartículas de CoNi", Universidad Autónoma de Madrid. Co-supervisors: J.C. Serna and M. Vazquez, 2006.

- Pedro Agudo "Influencia de pequeños contenidos de Ni y Cr en el comportamiento magnético y propiedades de corrosión de aleaciones nanocristalinas", Universidad Complutense. Supervisor: M Vazquez, 2005

- Yin-Feng Li "Propiedades dinámicas de imanación y efecto de magnetoimpedancia gigante en hilos magnéticos", Universidad Complutense. Supervisor: M. Vazquez, 2003.

- Leonor Pascual "Propiedades magnéticas lineales y circulares de los hilos amorfos", Universidad Complutense, co-Supervisors: D.X Chen and M Vazquez, 2003

- David García "Anisotropías magnéticas en películas delgadas y multicapas ferromagnético/ferromagnético fabricadas por pulverización catódica", Universidad Complutense de Madrid, Supervisor: M Vazquez, 2000

- Juan Manuel García Beneytez "Magnetismo y propiedades de transporte en Microhilos Metálicos", Universidad Complutense de Madrid, Supervisor M Vazquez, 2.000

- José Miguel García "Nanohilos Magéticos preparados por electrodeposición y caracterizado mediante Microscopía de Fuerzas Magnéticas", Universidad Complutense de Madrid, Supervisor M Vazquez, 1999

- Hector García Miquel"Caracterización de las propiedades magnéticas de vidrios metálicos en forma de microhilos, de composición FeCoSiB" Universidad Politécnica de Valencia, co-Supervising: M Vazquez and J.M. Andrés, 1999

- Javier Moya "Aleaciones nanocristalinas: propiedades magneticas blandas, propiedades mecanicas, y aplicaciones" Universidad de Buenos Aires, co-Supervising: H. Sirkin and M. Vazquez, 1999

- Julián Velázquez Cano "Anisotropia Magnetoelástica en hilos amorfos inducida durante su proceso de Fabricación" Universidad Complutense, co-Supervising: A. Hernando and M. Vazquez, 1995

- Pilar Marín Palacios "Evolución de las propiedades magnéticas durante el proceso de nanocristalización de hilos amorfos de composición FeSiBCuNb" Universidad Complutense, Supervisor: M. Vazquez, 1995.

- Cristina Gomez Polo "Magnetismo de hilos amorfos: comportamiento biestable y relajación estructural" Universidad Complutense, Supervisor: M Vazquez, 1992.

- Julián González Estévez "Anisotropías magnéticas inducidas en vidrios metálicos recocidos por corrientes eléctricas" Universidad del Pais Vasco, co-Supervising: JM Barandiarán and M Vazquez, 1987

- Cristina Nuñez de Villavicencio "Medida directa de la magnetostricción en aleaciones amorfas ricas en Co: Variación con la temperatura y exponente crítico" Universidad Complutense, Supervisor: M Vazquez, 1987.

5. Technological Projects

- "Magnetic Microwire Research", contract with the company Bartington Instrument Ltd., United Kingdom, to develop technologically advanced magnetic microwires for flux-gate sensors, PIs: M. Vaquez and Nigel Roffe, 2021-2022.

- "Microhilos Magnéticos para Sensores Magnetoelásticos", contract of Technological Support concerning the development of magnetic microwires as sensing elements for magnetoelastic sensors with Universidad Pública de Navarra. PIs: Manuel Vazquez and J.I. Pérez de Landazábal, 2021.

- "Research on the electromagnetic sensing adaptability to different clinical parameters", OrthoBaltic, Lithuania; microwires as sensing elements for intracraneal temperature detection. PIs: M. Vazquez and Osvaldas Grubys. 2020-21

- "Microwires for orthogonal flux-gates" Czech Technical University, Prague and ICMM/CSIC; stay of Ass. Prof. M. Buttha to ICMM. 2019, Supervised: M. Vazquez

- "Development of a new technology for the application in wireless battery charging in the range of 20-150 kHz" MINECO (RTC-2016-4820-4), Consortium: PREMO-ANDALTEC-CSIC-UPM, PI. (CSIC) R. Perez, M. Vazquez

- “Consulting Services Agreement” Boston Sci. Corporation, Marlborough, MA, 01752 USA; M. Vazquez, 2016

- *“EM protection of electrical bundles to fast EM transients”; EADS France; 2013-2016; IP: D. Garcia & R. Pérez, M.Vazquez (ICMM/CSIC)*

- “Magnetic microwires for various sensor devices” Universidad Publica de Navarra, 2013-2014; IPs: M. Vazquez (CSIC) & C. Gomez-Polo (UnPub Navarra)

- *“Displacement and Position sensing using magnetic microwires materials” Micro-Epsilon Messtechnik GmbH, Ortenburg, Germany; 2011; IPs: M. Vazquez and T. Wisspeittner;*

- “Dynamics of domain wall motion in micro and nanowires”; ICMM/CSIC and IBM, Almaden Research Centre; 2010-2014; IPs: S.S.K. Parkin and M. Vazquez.

- *“Hilos submicrometricos para generador eléctrico, purificación de aguas y sensor medioambiental” PLE2009-0057; MICINN; 2009-2012; IPs: M. Vazquez (CSIC), K. Mohri (Nagoya Industrial Research Inst., NISRI)*

- “Magnetic microwires rapidly solidified for sensing applications” Contract Publ. Univ. Navarra (C. Gomez-Polo) and ICMM/CSIC (M Vazquez), 2008-2011

- *“Microwires as sensing elements for low-noise sensors in mineralogy prospection”, contract Quantec Geotech (Montreal, Canada) R. Bazinet and ICMM/CSIC, M. Vazquez, 2007-08*

- “Fabrication and development of micron-size glass-coated microwires as sensing elements for magneto-impedance devices” contract Aichi-Toyota Japan (Y. Honkura) and ICMM/CSIC (M Vazquez) 2005-06.

- *“Magnetoelastic signature: Development of magnetoelastic sensos for identification and authentification of signature employing magnetic microwires as sensing elements” Min. Ed. Science, Project PETRI 95-0594-OP Company Micromag and ICMM/CSIC IP ICMM: M. Vázquez. 2002-2003.*

- “Magnetic wires for absorption screens”, Spain Space Agency INTA/IMA. IP: M. Vazquez, 1998- 1999.

- *“Antiradar absorption screens” Spain. Min. Sc. Educ., PETRI 95-0339-OP IMA/ Minist. Defense, TPYCEA., IP (IMA): M. Vazquez, 1999 –2001*

- "Magnetic fields by high voltage power lines" General Attorney Justice Ministry of Madrid. IP: M. Vazquez, 1997.

- *"Battery charge by magnetic induction” Tutoring J.M. Garcia grant VOLKSWAGEN-CSIC. 1996-8*

- Magnetic properties of soft ferrites” Hispafer (Philips Components), IMA and Pharmacy Fac., UCM. IP(IMA): M.Vazquez, 1996.

- *“Soft magnetic materials by metallurgical techniques" IMA & Barcelona Univ. PI: M.Vazquez (IMA) and N. Clavaguera, 1995*

- "Amorphous microwires as absorption materials of electromagnetic radiation” Spain Minst. Defense, program: COINCIDENTE, IMA and TPYCEA. IP(IMA): M. Vazquez, 1995.

- *“Magnetic integrated circuits MAGIC”, GAME program PI: IMA, Alcatel-Sesa, Philips, Univ. Politécnica de Madrid & Universidad de Oviedo. IP(IMA): M.Vazquez, 1994-1996.*

- Spin-off promotor of company "Vidrios Metálicos S.A." for the development of prototypes based in magnetic properties of amorphous alloys. Jan. 1987.

Supplier of Microwires to

- Donghua University, Shanghai, 2024

- University of Stanford 2022, 2023
- Xi'an Huashun Measuring Equipments Co. Ltd, China, 2022,
- Leibniz-Inst. f. Festkörper u. Werkstoffeforschung, Dresden, 2019, 2017
- Czech Technical University, 2017
- St. Just Medical Hospital, Plymouth, MN, USA, 2016
- Univ. of Tel Aviv, 2015
- Public University of Navarra, 2015, 2022

6. Patents

- L.H. Lewis, R. Perez del Real, M. Vazquez and A. Koppes,
"Magnetic microwires for ebnergy transporting biomedical applications"
Co-ownership Northeastern University, Boston / ICMM-CSIC; patent US 2021/0101016 A1

- M. Vazquez, D.G. Trabadas and D. Navas
"Method for nanostructured materials fabrication combining soft lithoigraphic imprint, aluminium anodization and metal sputtering"
Co-ownershio CSIC/Porto Un.; PCT/EP2020/066600 PCT16411475

- M. Vazquez, R. ElKammouni, V. Rodionova, N. Perov, K. Chichay, I. Baraban
"Microactuator based on bimagnetic coated core/shell microwires with asymmetric external shell and the use of it"
Co-ownership CSIC/Fed.Un. Baltic, Europe/Russia patent EP17382418.6

- M. Vazquez and V. Kolesar
"Procedure & apparatus to measure DC-field based on magnetostrictive effect in magnetic wires.
Co-owbership CSIC/Slovak Techn. Bratislava Uni. EP15195921

- M. Vazquez and V. Kolesar
"Temperature sensor for electromechanical systems and its fabrication procedure"
Co-ownership CSIC/Slovak Techn. Bratislava Uni., Sp. Patent P2014/31530. (PCT1641.1023)

- R. Perez, M. Vazquez, E. Palmero, A. Asenjo and C. Bran
"Sensors based on disks with magnetic nanowires"
CSIC, Sp.Patent P2014/31005

- M. Vazquez, G. Badini-Confalonieri, G. Infante, M. Butta and P. Ripka
"Bimetallic magnetic wires with helical anisotropy",
Co-ownership CSIC/Czech Techn. Prag Un., Sp. Patent PES2009/070417.

- M. Vazquez, G. Badini-Confalonieri, C. Gomez-Polo, J. Perez de Landazabal, J. Recarte, V. Sanchez
"Ferromagnetic wires with shape memory",
Co-owbership CSIC/Un. Publica Navarra, PCT/ES2008/070034.

- M. Vazquez, K. Pirota, G. Badini-Confalonieri, J. Torrejon and H. Pfüztner
"Multifunctional sensor based on magnetic microwires"
Co-ownership CSIC/Techn Un. Vienna, Patent PCT/ES2006/070173

- V. Larin, A. Torkunov, L. Panina, D. Mapps, A. Zhukov, J. Gonzalez, M. Vázquez, A. Hernando
"Micro wires and a process for their preparation"

- C. Tyren, A. Hernando, M. Vázquez and C. Quiñones
"Wireless Stress Antenna"
UK Patent

- F. Castaño, M. Vázquez, A. Hernando
"Viscosimetro basado en la rotación macroscópica de hilos inducida por campo magnético"

- A. Hernando, M. Vázquez, P. Marín, E. Fraga, P. Agudo, D.X. Chen and J. Llorente
"Dispositivo magnético electrónico para control de sistemas de proteccion perimetral"

P9901732

- M. Vázquez, A. Hernando, J.J. Freijo, C. Gómez-Polo and J.M. Barandiarán
"Dispositivo para la deteccion de la posicion de un piston neumático"
P9900237

- M. Vázquez, A. Hernando, P. Marín, A. Zhukov, V. Larin, A. Torkunov and A. Antonenko
"Producción de microhilos magnéticos de elevada susceptibilidad"

- M. Vázquez, A. Hernando, J. Arcas y C. Gómez
"Sensor de corriente crítica basado en el efecto Matteucci"
P9602271

- A. Hernando, A. Zhukov, M. Vázquez, V. Larin, A. Torkunov and A. Antonenko
" Método de codificación y marcado magnético de objetos"
P9601993

- M. Vázquez, J.M. Garcia Beneytez y A.Zhukov
" Dispositivo magnetoelastico para la identificacion y autentificación de firmas",
P 9600172

- M. Vázquez, A. Hernando and R. Valenzuela
"Dispositivo para la medida de corrientes continuas",
P 9502081

- M. Vázquez, A. Hernando and R. Valenzuela
"Dispositivo magnético de detección y control de elementos móviles",
P 9501232

- E. Fraga, G. Rivero, J.M. Barandiarán, M. Vázquez and A.Hernando
"Dispositivo eléctrico y electrónico de seguridad para vallas" ,
P 9302583

- M. Vázquez, G. Rivero, J. M. Barandiarán and A. Hernando
"Sensor de detección de ejes móviles en vias de ferrocarril"
P9001345

- M. Vázquez, G. Rivero, J. M. Barandiarán and A. Hernando
"Sensor de campo magnético",
P9001344

- M. Vázquez, G. Rivero, J. M. Barandiarán and A. Hernando
"Sensor de campos magnéticos que utiliza como sensor un hilo amorfo ferromagnético con anisotropia helicoidal"
P 9001343

- M.Vázquez, G. Rivero, J. M. Barandiarán and A. Hernando
"Sistemas de seguridad para vallas alámbricas",
P 8903270 (Commercialized).

- A. Mitra, M. Vázquez, G. Rivero, J.M. Barandiarán and A. Hernando
"Sensor de fuerza o tensión mecánica",
P 8903269

7. Conferences

7a) Chairing/organization

- Program Chair, ICM'2015, Barcelona
- Chair INTERMAG Europe 2008, Madrid

- Co-chair Symposium “Soft Magnetic Materials”. JEMS, Grenoble, 2001.
- *Chair International Workshop on Magnetic Wires. San Sebastian, Spain 2001.*
- *Co-chair Symposium “Ferromagnetic Materials”. Spring Meeting MRS. San Francisco, 2001.*
- *Co-Promotor (Athens 1994) & Steering Com. European Magnetic Sensors & Applications, EMSA, 1995-2022*
- Secretary "Soft Magnetic Materials'9" Conf. El Escorial, 1989.
- Secretary "Intern. Symp. on Magnetic Properties of Amorphous Metals" Benalmádena, Spain, 1987

7b) Selected Invited Talks to Conferences and Schools

- 4 additional DL talks in 2024
- 52 Talks on all over the world as Distinguished Lecturer of the IEEE MagSoc (2023)
- *Summer School, CEMAG & MagSoc, Llanes, 2022*
- Real Academia de Ciencia de Zaragoza, 2022
- *Centro Atómico de Bariloche, virtual, 2021*
- Czech Technical University, 2020
- *XI Workshop Chile-Mexico, plenary, 2019*
- Universidade Federal de Pernanbuco, Recife, 2019
- *Summer School on Magnetismo y Materiales Magneticos, Morelia, Mexico, 2019*
- Comarruga workshop on magnetism, 2019
- *MML 2019, Madrid*
- NANOCOLD, Santiago de Compostela, 2019
- *M2ZART workshop on Nanomagnetism, Zaragoza, 2019*
- Universidade do Minho, Porto, 2019
- *13 Symposio Ciencia Materiales Avanzados y Nanotecnologia, San Jose Costa Rica, 2018*
- Baltic Federal University, Kaliningrad, 2018
- *Urals Federal University, Yekaterinburg, 2018*
- Nanyang Technical University, Singapore, 2018
- *Intermag2018, Singapore*
- Cali School on Magnetism, Colombia, 2018
- *Advances in Magnetics, AIM 2018, La Thuile, Italy*
- Carnegie Mellon Uni., Pittsburgh, 2017
- *18th Int. Symposium on Electromagnetics, ISEM 2017, Chamonix, France*
- Intern. Baltic Conf. on Magnetism, IBCM 2017, Kaliningrad, Russia
- *Annual Meeting, Italy Chapter, Messina*
- VI Euro-Asian Symposium MagnTrends, Eastmag 2016, Krasnoiarsk, Russia
- *16th Czech and Slovak Conf. on Magnetism, Kosiçe, 2016*
- Course Magnetism, Univ. Wuhan Hubei, China
- *Advances in Magnetics’16, Bormio, Italy*
- Int. Worksh. Magn. Nano. Magnets., IWMNM, Meersburg, Germany, 2015
- *Recent Trends in Physics, ICRTP, Indore, India, 2016*
- Amophous Nanocrystaline Magnetic Materials Conf, ANMM’2015, Iasi, Romania
- *ISMANAM’2015, Paris*
- Int. Workshop Magnetic Wires, Ordizia, Spain, 2015
- *Summer school, NanoSciences, Ile-de-France, Etiolles, France, 2015*
- Russian School, Urals Federal Univ. Yekaterinburg, 2014
- *Int. Works. Novel Trends in Ferroics Phys. St. Petersburg, 2014*
- MISM Conf., Moscow, 2014
- *INTERMAG 2014, Dresden, 2014*
- DICNMA 2013, S.Sebastian, 2013
- *EINC2013, Easter Island, Chile 2013*
- Spring School Magn. Materials & Applications, BCMaterials, Bilbao. 2013
- *X LAW3M, Buenos Aires, 2013.*
- II Brazilian Works. Magnetism & Dynamics, Natal, Brazil 2012

- *ICAUMS2012, Nara, Japan, 2012*
- Joint Int. Magn. Symp., JEMS, Parma, 2012
- *Baltic School Sol. State & Magn., Kaliningrad, 2012*
- Adv. Electromagn. Symp., AES, Paris, 2012
- *5th Int. Worksh. ANMM, Iasi, 2011.*
- National Meeting NSC Taiwan, Hsinchu, 2011.
- *3rd Works. Chile-Mexico, Los Andes, 2011.*
- TMS Conf., San Diego, 2011
- *3rd International Conference on Advanced Nano Materials, ANM 2010. Agadir, Morocco, 2010*
- LAW3M, Manizales, Colombia, 2010
- *UIMP, La Coruña, 2010*
- 8th EMSA Conf. Bodrum, Turkey 2010
- *III Int. Conf. Quantum, Nano and Micro Technologies, Cancun, Mexico 2009*
- Self-organised Nanomagnets, Aussois, France Abr.2009
- *Int. Work. Non-crystalline Solids, Porto, 2008*
- MISM, Moscow 2008
- *Soft Magnetic Materials Conf., SMM'18 Cardiff. Sept. 2007*
- Latin Amer. Workshop MMM. Rio de Janeiro 2007
- *Int. Workshop non-crystalline solids. Gijon, Spain 2006*
- LAW3M. Reñaca. Chile. Dic. 2005
- *Soft Magnetic Mat. Conf. Bratislava, 2005*
- ISEM Bad Gastein, Austria, 2005
- *90ª Reunion Nacional de Física. La Plata. Argentina. 2005*
- Int. Workshop Nanomagnetism ans Applications. La Habana. Nov. 2004
- *At the Frontiers of the Condensed Matter school, Buenos Aires 2004*
- Joint European Magnetic Symposia. Dresden 2004
- *Meeting British Magnetic Society. Cardiff 2003*
- Soft Magnetic materials Conf. Düsseldorf, 2003
- *Int. Workshop Amorphous and Nanocrystalline Materials. Iasi. Romania, 2003*
- Latin American workshop on magn. Magnetic materials. Chihuahua, 2003
- *Int. WorkshopNon-crystalline solids. Méjico, 2003*
- VI Congreso nacional de Materiales. Madrid, 2002
- *Int. Symp. Electromagnetics, ISEF Cracow. Sept. 2001*
- V Latin-Amer. Workshop, Bariloche, Argentina 2001
- *International Symposium on Advanced Magnetic Materials. San Sebastian. 2000*
- ICM'2000 Conf. Recife, Brazil 2000
- *Früjahr Tagung der Deutsche Physicalische Gesellschaft. Regensburg, 2000*
- Opening ceremony Chungnam Univ. Center. Kyonjyu. 1999
- *MISM international symposium devoted to E. Kondorskii, Moscow 1999*
- Inten. Workshop on Amorphous wires, Films & Micromagnetic Sensor". Nagoya Mayo 1999.
- *18th Ann. Conf. Prop.&Appl. Magnetic materials. Chicago Abril 1999.*
- 1998 Pulver Metallurgy World Congress. Granada, 1998
- *IV Latin-American Workshop on MMM. Sao Paulo. Brasil. Julio 1998*
- Texture and Properties Magnetics Int. Conf. Yekaterinburg, 1997
- *Summer School UCM. El Escorial. Agosto 1997.*
- Université Schneider du Magnétisme" Groupe Schneider, Grenoble. Abril 1997.
- *I Escuela Iberoamericana de Magnetismo" UNAM (Mexico). Abril 1997.*
- V Reunión Nacional de Materiales. Cádiz, Spain 1996
- *EMSA Conf. Iasi, Romania, 1996*
- Corea Int. Conf. KIST, Seoul 1996
- *Soft Magnetic Materials (SMM) Conf. Krakow, 1995*
- ISMANAM Conf. Grenoble, 1994.
- Intern. Workshop on Rapidly Quenched Magnetic Wire and Applications, Albuquerque (New Mexico) 1994.

- *European Magnetic Materials (EMMA) Conf., Kosice, Slovak Rep. 1993*
- International Workshop on Magnetism, Magnetic Materials and Applications. Univ La Habana, Cuba, 1991
- *School on Ciencia y Tecnología de Materiales " Organized Inst. C. Materiales de Madrid. Madrid 1990*
- III Escuela Ibérica de Magnetismo y Materiales Magnéticos ". G.E.F.E.S. Jaca 1989
- *Course on Magnetic Properties of Amorphous Alloys, Depart. Física. Univ. de Sao Paulo, Brazil 1989*
- Curso Internacional sobre Materiales Magnéticos " Centro Internacional de Física. Bogotá, 1988