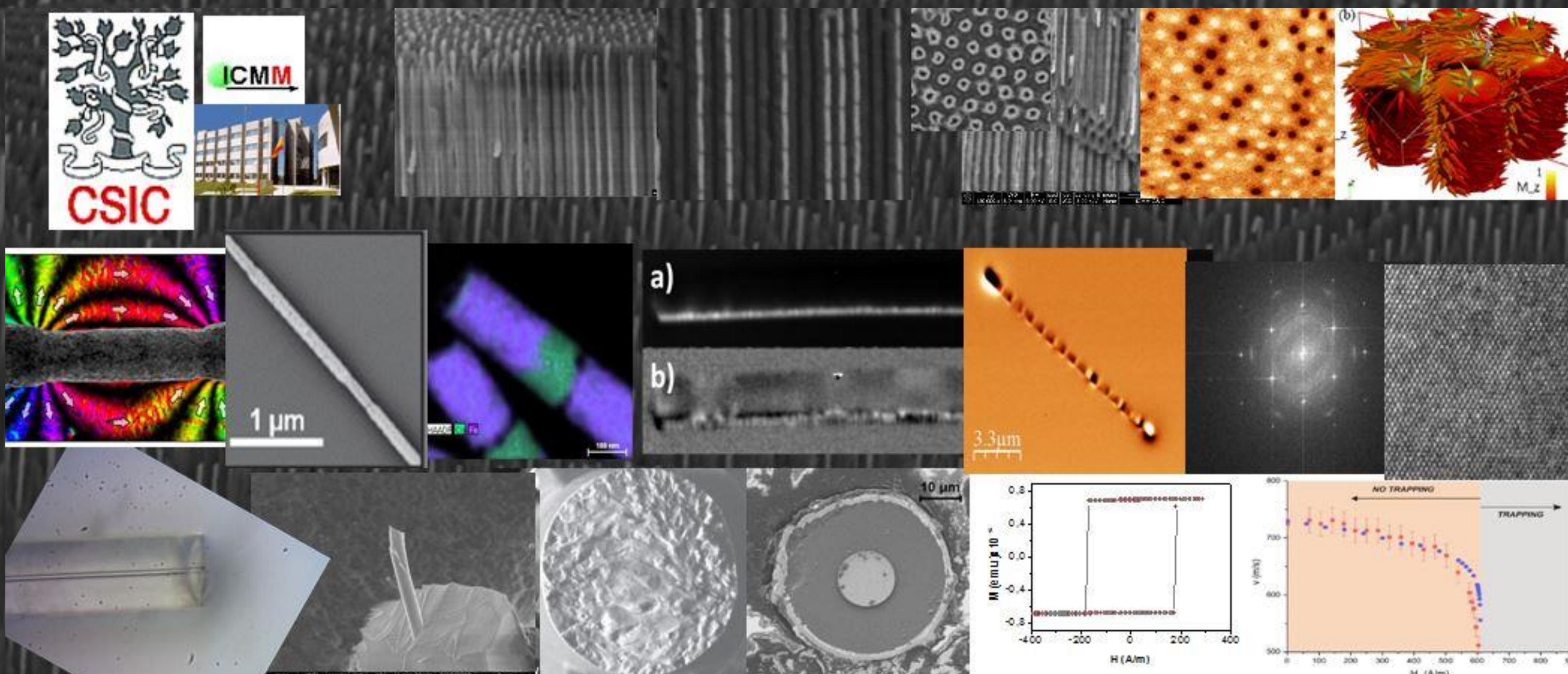
Nano y Microhilos Magnéticos

Manuel Vázquez Villalabeitia



mag
30 000 x

Nano y Microhilos Magnéticos

- Whiskers de hierro (tesina y tesis), (1974-80)
- Cintas Amorfas (postdocs), anisotropías magnetoelásticas (1981-91)
- Microhilos amorfos, GMI, Biestabilidad Magnética (1992-2000)
- Micro & Nanohilos, formación de un Laboratorio/Grupo (2001- 2008)
- Nanohilos cilíndricos: estudios más recientes (2009-2017)

mag	WD	HV	spot	det	Landing E	4 μm
30 000 x	5.0 mm	5.00 kV	3.0	vCD	3.50 keV	ICMM-CSIC

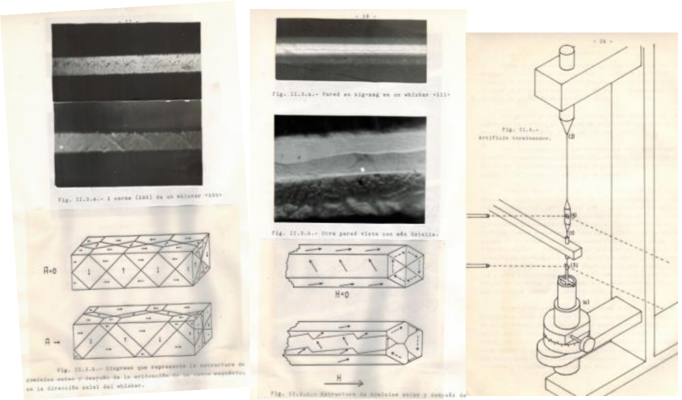
- Laboratorio de Magnetismo UCM (5º Curso Físicas) 1974
Montaje de la práctica de Resonancia Magnética Nuclear

- Koninklijke/Shell laboratories, Amsterdam, Verano 1974
(Beca IAESTE)

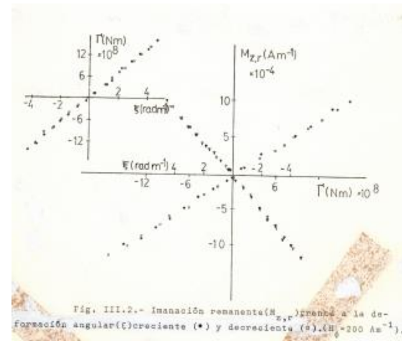
C^{13} Spin-Lattice relaxation times and Nuclear Overhauser effect of olefins adsorbed on Na exchanged zeolites

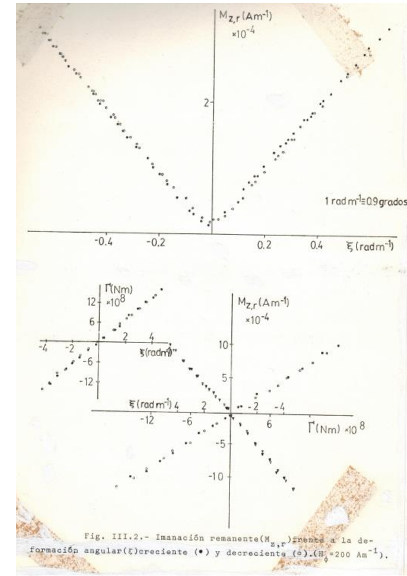
Tesina (Nov. 1974)

Tesis: Laboratorio de Magnetismo UCM, 1975-80
Efecto Wiedemann inverso in whiskers de hierro



Antonio Hernando, Director de Tesis





IEEE Transactions on Magnetics Vol. MAG-13, No. 5, September 1977

INVERSE WIEDEMANN EFFECT IN ⟨100⟩ IRON WHISKERS

A. Hernando, M. Vázquez, V. Madurga
and J. Becerril

Lab. of Magnetism. University Complutense
Madrid. Spain

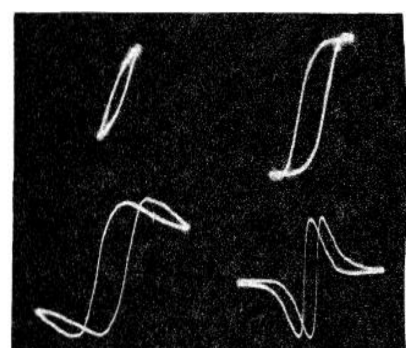


Figure 2. M_z-H_ϕ curves for the whisker u-1 twisted 5°. The amplitude of circular field is:0.1, 0.3, 0.6 and 1 (x1000)A/m

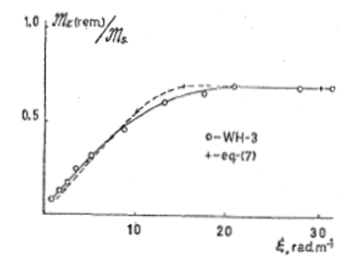


Figure 5. Experimental and theoretical curve for a ⟨100⟩ iron whisker

- Postdoc en Max-Planck-Institute für Metallforschung, Stuttgart, 1981-83 (Beca A.v. Humboldt)

Cintas amorfas: Anisotropía Magnetoelástica, Distribución de tensiones, Estructura de dominios, Aproximación a la saturación, Exponentes críticos

Max-Planck-Institut für Metallforschung, Institut für Physik, Stuttgart[1]*),*
and Institut für Theoretische und Angewandte Physik der Universität Stuttgart

The Effect of Tensile Stresses on the Magnetic Properties of $Co_{58}Fe_5Ni_{10}Si_{11}B_{16}$ Amorphous Alloys

By
M. Vázquez[2]), W. Fernengel, and H. Kronmüller

Helmut Kronmüller supervisor

Inserting (14), (6), and (19) into (30) we obtain

$$\chi_1^{-1} = -\frac{3\lambda_s}{\mu_0 M_s^2}\,\sigma\left\{1 - \frac{m_r(0)\,(\bar\sigma_c^2/\sigma^2)}{1 - m_r(0) + (\bar\sigma_c/\sigma)\,[1 - 2m_r(0)]}\right\}.$$

If we consider (27), (28), and

$$m_r(\infty) \approx \cos\varphi_\perp v_\perp^0 + \cos\varphi_\parallel v_\parallel^0\,,$$

where $m_r(\infty)$ is the value of m_r for very large applied stresses, we find

$$H_c = -\frac{3\lambda_s m_r(\infty)}{\mu_0 M_s}\,\frac{\sigma^2 + \sigma\bar\sigma_t + \sigma\bar\sigma_c + \bar\sigma_t\bar\sigma_c}{\sigma + (\bar\sigma_c v_\perp^0 + \bar\sigma_t v_\parallel^0)}.$$

$$J(\sigma_a, h) = \sum_j^{\lambda>0} V_j\left(V_t(\sigma_a + h/\lambda_j) - V_c(\sigma_a + h/\lambda_j)\,\frac{h}{\lambda_j\bar\sigma_{c,j}}\right) + \sum_j^{\lambda<0} V_j\left(V_c(\sigma_a - h/\lambda_j) + V_t(\sigma_a - h/\lambda_j)\,\frac{h}{\lambda_j\bar\sigma_{t,j}}\right). \qquad (27)$$

Fig. 4 shows the magnetization curves as a function of the applied stress in a series of particular cases considering two phases with positive, λ_1, and negative, λ_2, magnetostriction and fractional volumes, V_1 and V_2, respectively. Different combinations of local magnetostriction constants and fractional volumes have been chosen so that, in all the cases, the macroscopic value of the magnetostriction is $\lambda_s = +0.6\lambda_0$. Nevertheless, some remarkable consequences can be obtained from the results shown in Fig. 4. The remanence increases continuously as the stress is applied so that the effective magnetostriction is considered to be positive. However, the behavior shown in Fig. 4e is the opposite one. For intermediate applied fields, a small applied stress yields a positive increment of the magnetization while

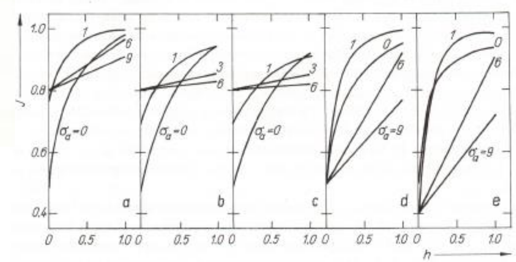
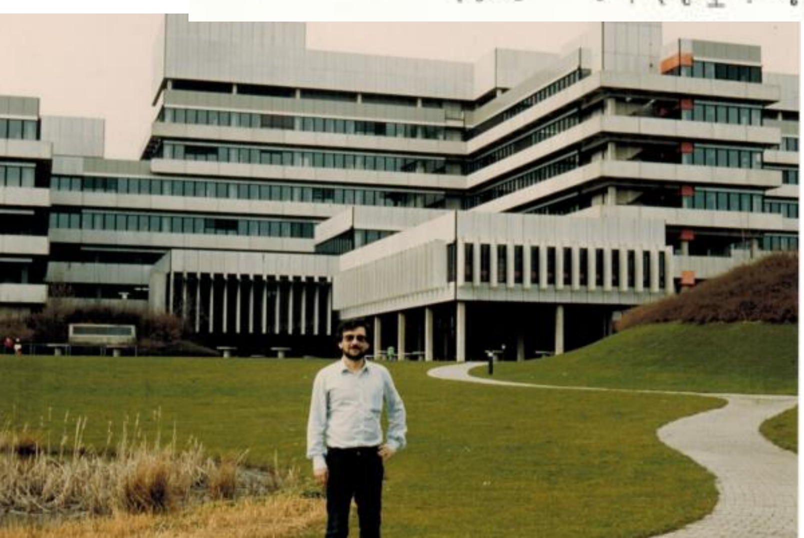
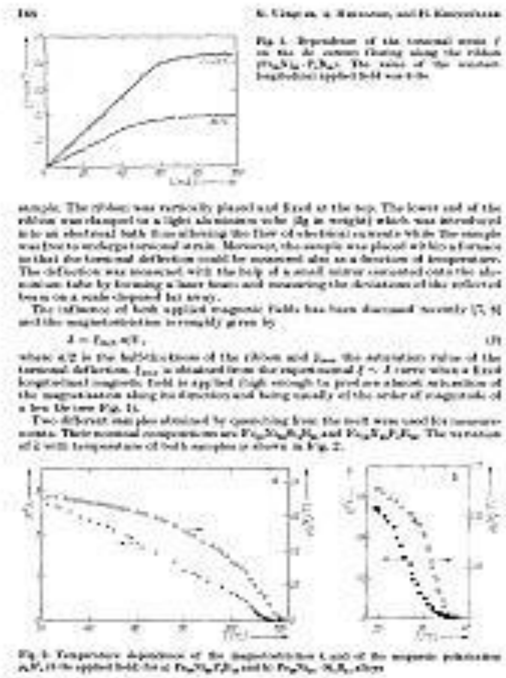


Fig. 4. Magnetization curves for different applied stresses for the case of two phases with positive (λ_1) and negative (λ_2) magnetostriction and fractional volumes V_1 and V_2, respectively. a) $\lambda_1 = 0.8$, $\lambda_2 = 0.2$, $V_1 = 0.8$, $V_2 = 0.2$; b) $\lambda_1 = 1.0$, $\lambda_2 = 1.0$, $V_1 = 0.8$, $V_2 = 0.2$; c) $\lambda_1 = 1.1$, $\lambda_2 = 1.4$, $V_1 = 0.8$, $V_2 = 0.2$; d) $\lambda_1 = 1.4$, $\lambda_2 = 0.2$, $V_1 = 0.5$, $V_2 = 0.5$; e) $\lambda_1 = 1.8$, $\lambda_2 = 0.2$, $V_1 = 0.4$, $V_2 = 0.6$. Note that in all the cases $\lambda_s = +0.6\lambda_0$



Ley de aproximación a la saturación

Exponente crítico de la magnetostricción



phys. stat. sol. (a) **115**, 547 (1989)

Subject classification: 75.60; 75.25; S1.1; S1.2; S1.61; S1.62

U.E.I. de Materiales Magneticos, Instituto de Ciencia de Materiales, Madrid[1]) *(a)*,
Firma Vacuumschmelze GmbH, Hanau[2]) *(b)*,
and Institut für Physik, MPI für Metallforschung, Stuttgart[3]) *(c)*

Approach to Magnetic Saturation in Rapidly Quenched Amorphous Alloys

By

M. Vazquez (a), W. Fernengel (b), and H. Kronmüller (c)

$$\frac{a_1}{\mu_0 H} = 1.1\mu_0 \frac{G^2\lambda_s^2}{(1-\nu)^2}\frac{Nb_{\text{eff}}}{J_s A_{\text{ex}}} D_{\text{dip}}^2 \frac{1}{\mu_0 H}.$$

For $\chi_H D_{\text{dip}} > 1$, the type $1/H^2$ is predominant being given by

$$\frac{a_2}{\mu_0 H^2} = 0.456\mu_0 \frac{G^2\lambda_s^2}{(1-\nu)^2}\frac{Nb_{\text{eff}}}{J_s^2} D_{\text{dip}}^2 \frac{1}{(\mu_0 H)^2}.$$

A. HERNANDO, M. VÁZQUEZ, V. MADURGA

Laboratorio de Magnetismo, Facultad de C. Físicas, Universidad Complutense, Madrid-3, Spain

and

H. KRONMÜLLER

Max-Planck-Institut für Metallforschung, Institut für Physik, Stuttgart, and Institut für Theoretische und Angewandte Physik der Universität Stuttgart, Stuttgart, Fed. Rep. Germany

Received 23 December 1982

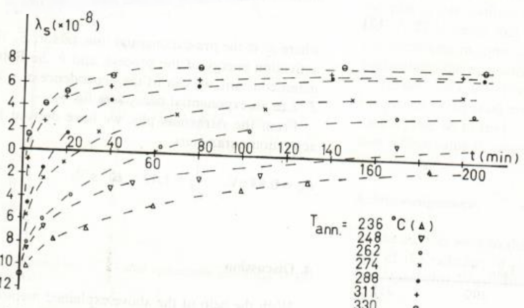


Fig. 3. Relaxation of the magnetostriction constant after different annealing times for a range of annealin

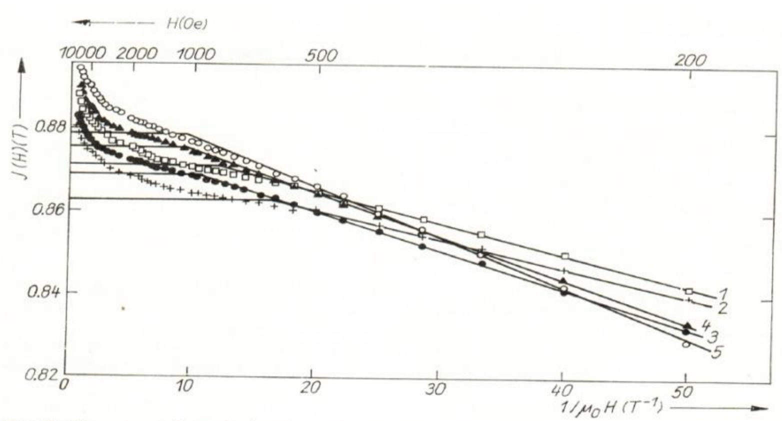


Fig. 3. The magnetic polarization as a function of $1/\mu_0 H$ of the $Fe_{40}Ni_{40}P_{14}B_6$ alloy for the as-cast state (1), after preannealing 2 h at 330 °C (2) and after subsequent thermal treatments: either under transverse magnetic field (3 kOe, 8 h at 240 °C) (3) or under 780 MPa tensile stress at 330 °C during 2 h (4) and 4 h (5)

- Postdoc en Danmarks Tekniske Universitat, Lyngby, Invierno 1984-5 (NATO grant)
Magnetostricción e Imanación a saturación

DTU Technical University of Denmark

MAGNETOSTRICTION AND OTHER MAGNETIC PROPERTIES OF Co–Ni BASED AMORPHOUS ALLOYS

M. VÁZQUEZ *, A. HERNANDO ** and O.V. NIELSEN

Department of Electrophysics, The Technical University of Denmark, DK-2800 Lyngby, Denmark

Received 4 February 1986; in revised form 20 March 1986

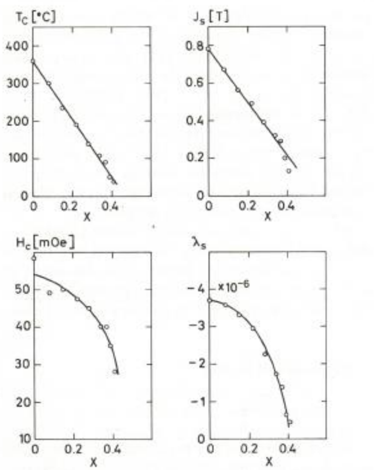


Fig. 1. Curie temperatures T_c, room temperature values of saturation polarization J_s, coercive fields H_c and saturation magnetostriction coefficients λ_s for $(Co_{1-x}Ni_x)_{75}Si_{15}B_{10}$ alloys.

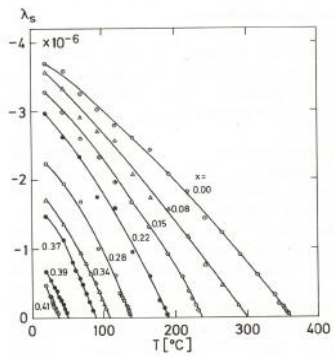


Fig. 3. Temperature dependence of the saturation magnetostriction coefficients λ_s for $(Co_{1-x}Ni_x)_{75}Si_{15}B_{10}$ alloys.

tostriction, respectively, for all compositions.

In earlier works [4–6], a law relating the temperature dependence of J_s and λ_s was found for Co–Fe and Co–FeNi based amorphous alloys, described by

$$\lambda_s(T) = \alpha[J_s(T)]^3 + \beta[J_s(T)]^2. \qquad (2)$$

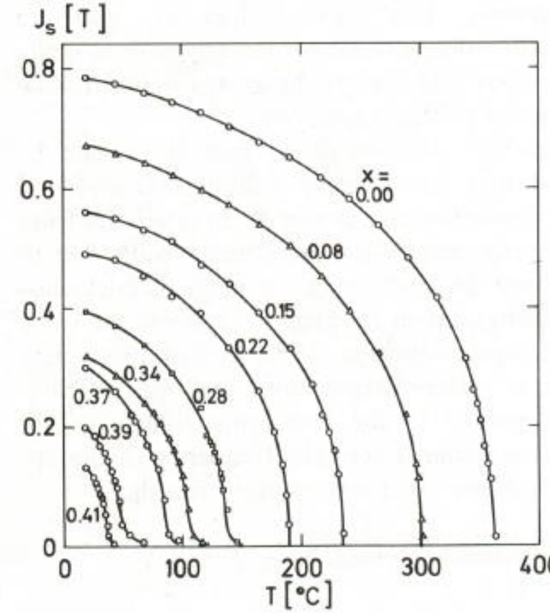


Fig. 2. Temperature dependence of the saturation polarization

$$\lambda_s(T) = \alpha[J_s(T)]^3 + \beta[J_s(T)]^2.$$

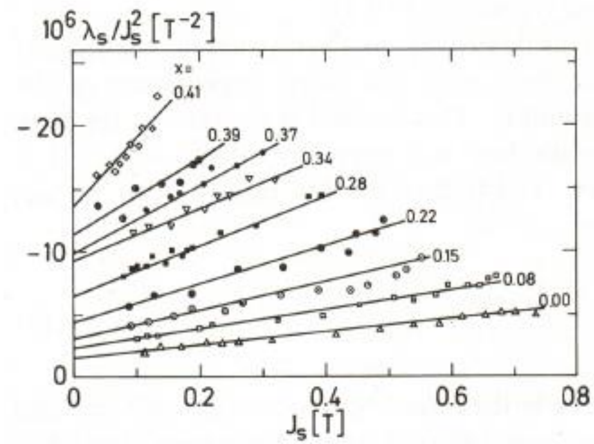
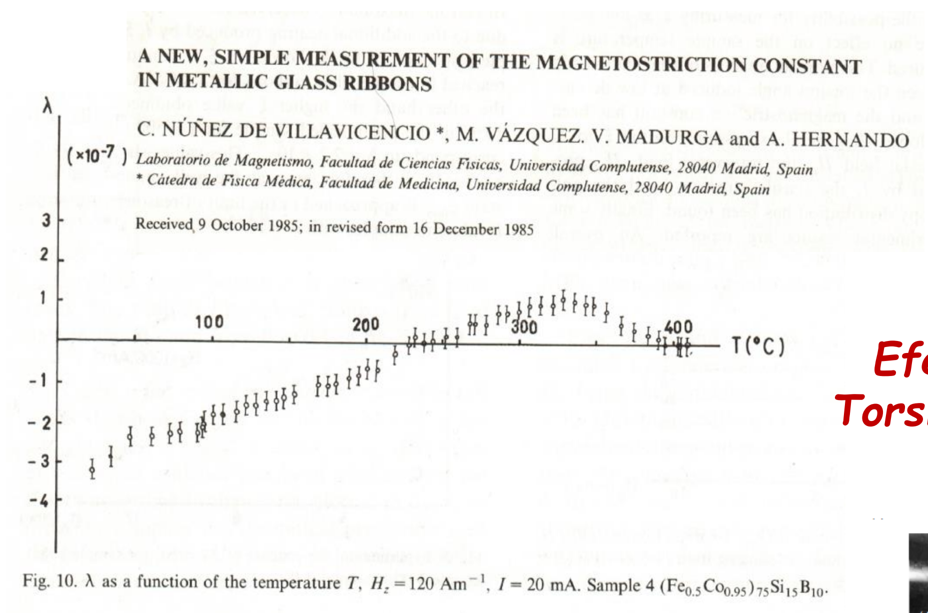


Fig. 4. The data from figs. 2 and 3 fitted to eq. (2) in the text.

Vuelta al Laboratorio de la Complutense, 1985-89

Cintas Amorfas: Anisotropías Inducidas; Magnetostricción; Torsión

Primeras Tesis: Cristina Núñez de Villavicencio; Julian González



A NEW, SIMPLE MEASUREMENT OF THE MAGNETOSTRICTION CONSTANT IN METALLIC GLASS RIBBONS

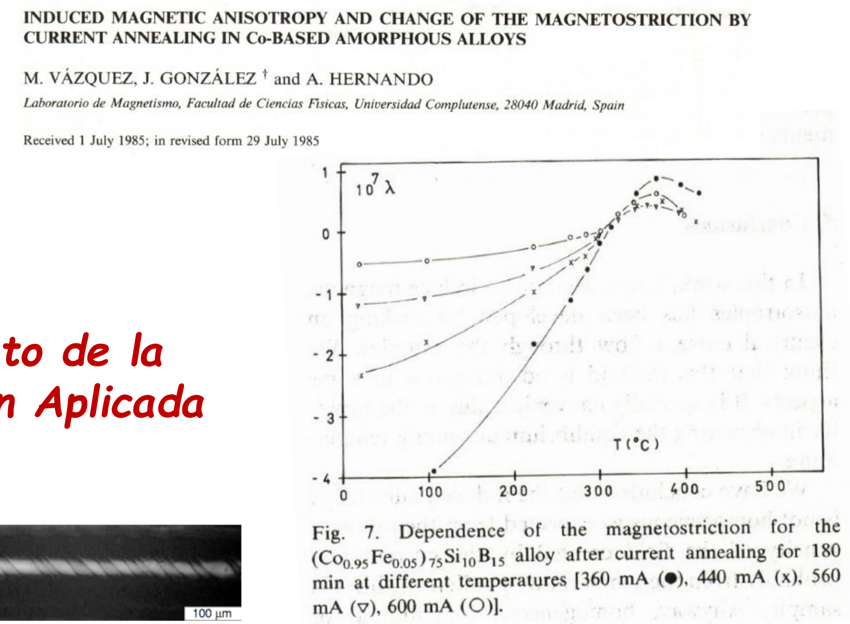
C. NÚÑEZ DE VILLAVICENCIO *, M. VÁZQUEZ, V. MADURGA and A. HERNANDO

Laboratorio de Magnetismo, Facultad de Ciencias Fisicas, Universidad Complutense, 28040 Madrid, Spain

* *Cátedra de Fisica Médica, Facultad de Medicina, Universidad Complutense, 28040 Madrid, Spain*

Received 9 October 1985; in revised form 16 December 1985

Fig. 10. λ as a function of the temperature T, $H_z = 120\ \mathrm{Am^{-1}}$, $I = 20$ mA. Sample 4 $(Fe_{0.5}Co_{0.95})_{75}Si_{15}B_{10}$.



INDUCED MAGNETIC ANISOTROPY AND CHANGE OF THE MAGNETOSTRICTION BY CURRENT ANNEALING IN Co-BASED AMORPHOUS ALLOYS

M. VÁZQUEZ, J. GONZÁLEZ † and A. HERNANDO

Laboratorio de Magnetismo, Facultad de Ciencias Fisicas, Universidad Complutense, 28040 Madrid, Spain

Received 1 July 1985; in revised form 29 July 1985

Fig. 7. Dependence of the magnetostriction for the $(Co_{0.95}Fe_{0.05})_{75}Si_{10}B_{15}$ alloy after current annealing for 180 min at different temperatures [360 mA (●), 440 mA (x), 560 mA (▽), 600 mA (○)].

Efecto de la Torsión Aplicada

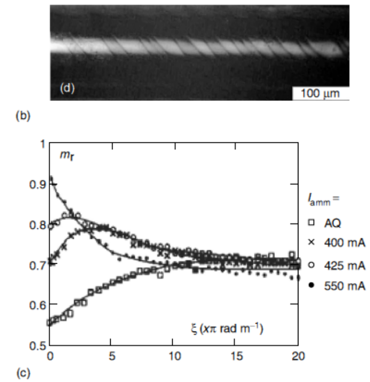


Figure 7. Dependence of switching field on applied tensile stress for a FeSiB in-water-quenched microwire (length = 12, 9.9, 8.4, and 6 cm) (a). (Reproduced from A.M. Severino *et al.*, 1992, with permission from Elsevier. © 1992.) Bitter image of the domain structure at the surface of a torqued microwire (after Hernando *et al.*, to be published), and torsional dependence of remanence for a bistable Fe-based microwire (b). (Reproduced from M. Vázquez *et al.*, 1991, with permission from Elsevier. © 1991.)

$$K_{\mathrm{m.elas}}(r) = \frac{3}{2}\lambda_s \mu \xi r$$

Incorporación al CSIC, Serrano 1989-1992

Primeros estudios en microhilos Amorfos y Nanocristalinos

Tesis de Cristina Gomez Polo; Pilar Marín

- Biestabilidad Magnética: Longitud Crítica; Dominios

- Aleaciones Nanocristalinas, Microstructura & Annealings

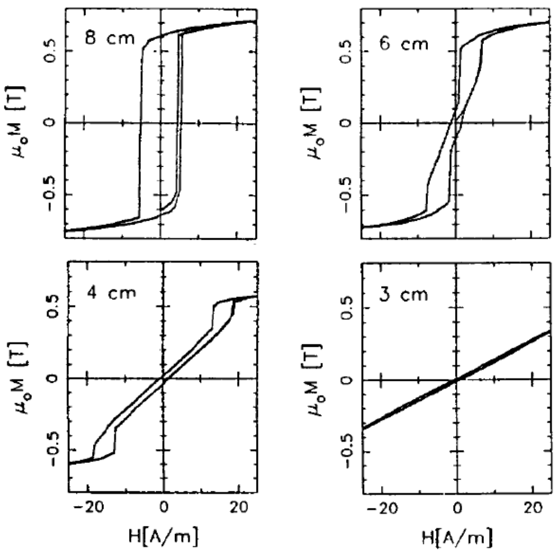


Fig. 3.- The hysteresis loops for an Fe-rich amorphous wire having different length.

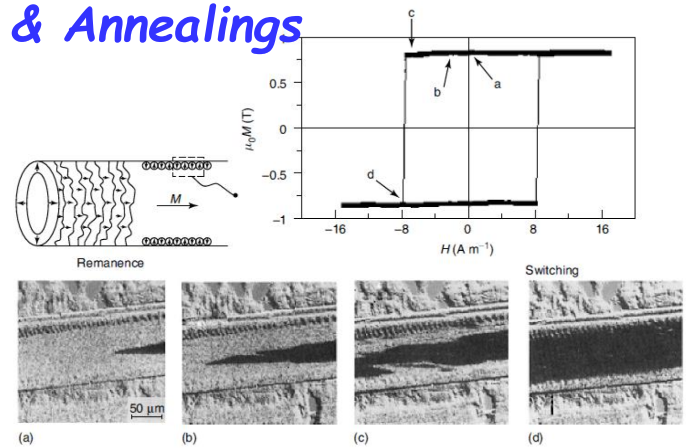


Figure 3. $Fe_{75}Si_{15}B_{10}$ in-water-quenched microwire: correlation between low-field bistable hysteresis loop (top right) and main domain structure (schematic view, top left). Evolution of inner core domain between remanence and switching, as observed by Kerr effect, during magnetization reversal (bottom). (Reproduced from T. Reininger *et al.*, 1993, with permission from American Institute of Physics. © 1993.)

Instituto de Magnetismo Aplicado (1992-2000)
Acuerdo UCM-RENFE-CSIC

Excelente experiencia de grupo:

- organización de investigación,
- elaboración de proyectos,
- formación de estudiantes, 8 doctores
- visitantes extranjeros, 12
- colaboración con empresas / patentes

Materiales Blandos;
Cintas y Microhilos Amorfos
Nanocristales
Películas delgadas
Sensores Varios
Apantallamiento electromagnético

Instituto de Magnetismo Aplicado (1992-2000) investigadores visitantes


Chen Duxing, Baltimore 1996


MMM Alburquerque, 1998


Horia Chiriac Monasterios de Bucovina, 1992

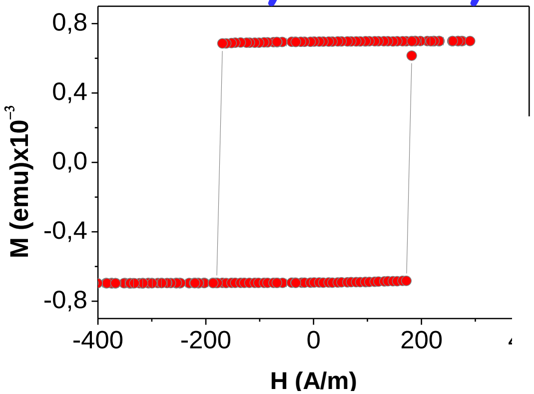

Raul Valenzuela Teotihuacan, 1998

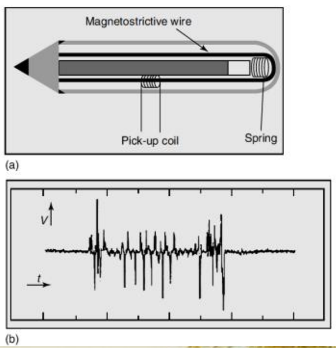

LAW3M, Sao Paulo, 1996

Instituto de Magnetismo Aplicado (1992-2000)

Arcady Zhukov (Biestabilidad Magnética, alta magnetostricción, sensores)

Galina Kurlyandskaya (Giant Magnetoimpedance, magnetostricción cero)





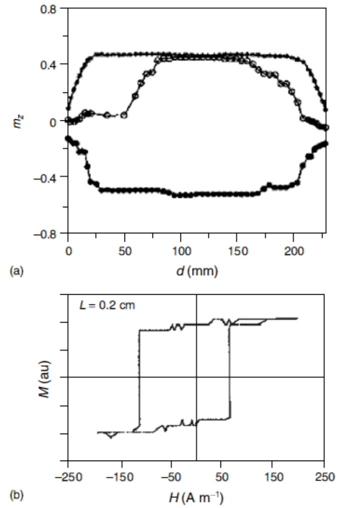


Figure 4. (a) Magnetization profile at the remanence (*), before (○) and after (●) switching for an Fe-rich amorph wire (a). (Reproduced from M. Vázquez *et al.*, 1995, with perr sion from IEEE. *copyright* 1995.) The evidence of bistability glass-coated Fe-rich wires in samples of very short lengths 1996, with permission fi

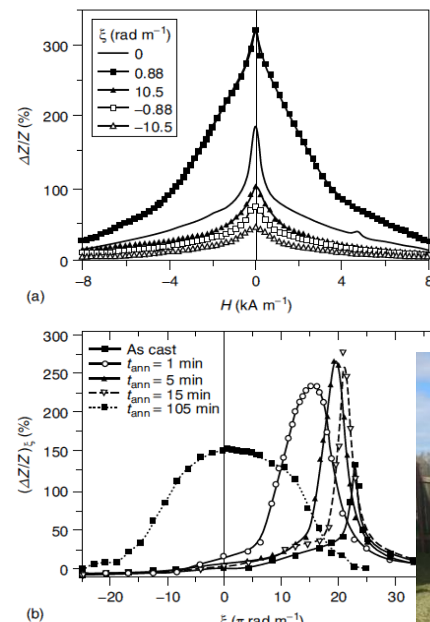
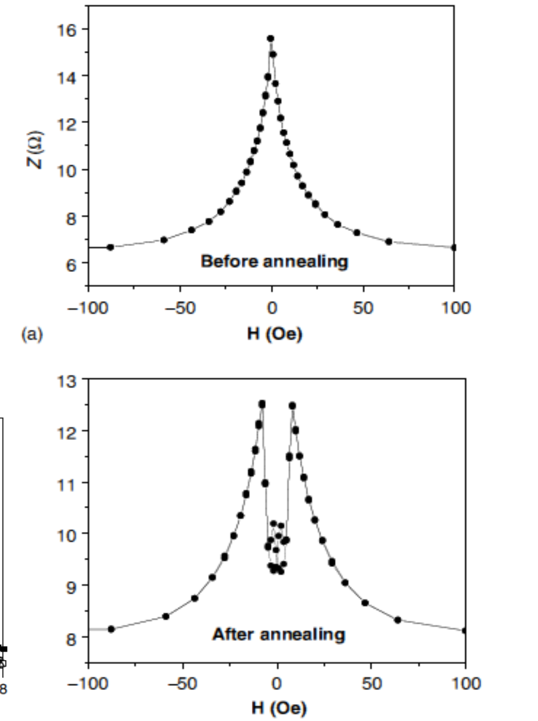


Figure 19. Evolution of magnetoimpedance response microwire under applied torque (a). (Reproduced from *et al.*, 2003, with permission from the American Institute of I © 2003.) Asymmetric torsion impedance after a helical ani is induced by torsion annealing (b). (Reproduced from M. *et al.*, 2003, with permission from Elsevier. © 2003.)



Single peak (a) and two peaks (b) GMI behavi

Visitas/Conferencias Internacionales

Balaton, Hungria, 1987

Benalmádena, 1986

IV International Workshop on
Non-Crystalline Solids

Organized by

Instituto de Magnetismo Aplicado

Expo-Chamartin
MADRID, SPAIN

20th-23rd September 1994

BOOK OF ABSTRACTS

Visitas Anglo-Españolas, 1992

Promotores del EMSA, 1994

IWMW

INTERNATIONAL WORKSHOP ON MAGNETIC WIRES

San Sebastian (Spain), June 20-23, 2001

Organized & Sponsored by:
Ministerio de Ciencia y Tecnología
Consejo Superior de Investigaciones Científicas
Universidad del País Vasco
Universidad Pública de Navarra
Gobierno Vasco
Excmo. Ayuntamiento de San Sebastián

Instituto de Ciencia de Materiales (2001-2008)
Formación de un Nuevo Laboratorio/Grupo

Aspectos a tener en cuenta para alcanzar contribuciones originales:

- Producción autónoma de muestras
- Medidas experimentales originales
- Personal investigador

Finanzas: solicitar fríamente
todo tipo de proyectos

Líneas de Investigación:

Microhilos:

Arcady Zhukov, Rastislav Varga; Giovanni Badini-Confalonieri

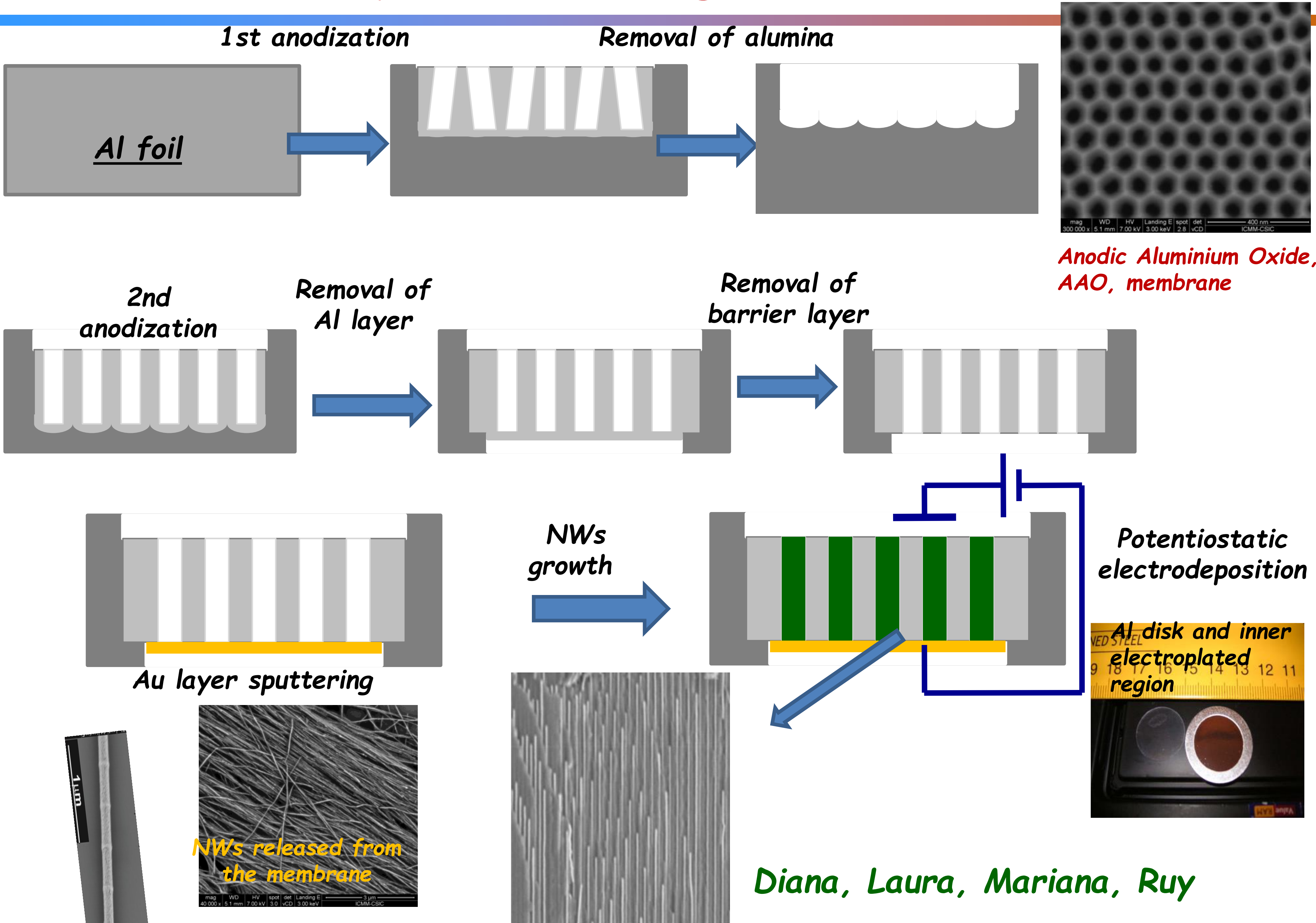
Nanohilos:

Kornelius Nielsch; Manuel Hdez-Velez; Kleber Pirota; Victor Prida

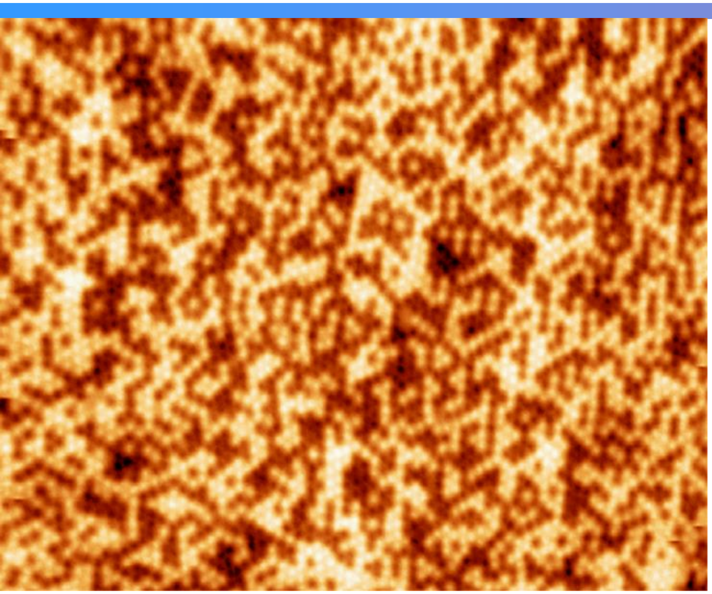
Magnetismo de Superficie, MFM:

Agustina Asenjo

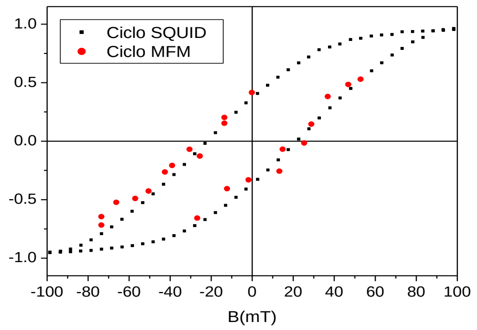
Síntesis electroquímica de arreglos ordenados de nanohilos

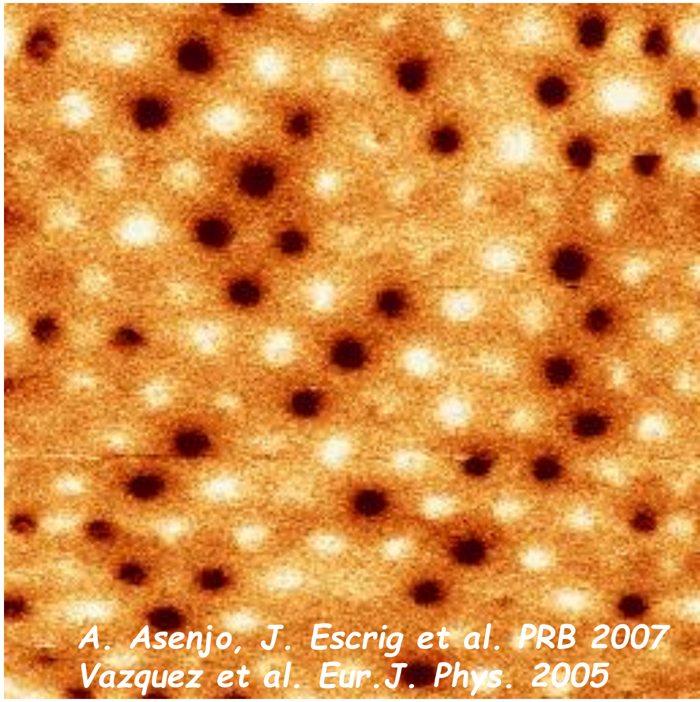


Hysteresis loops & Spin imaging: VSM & SQUID vs. VF-MFM & MTXM



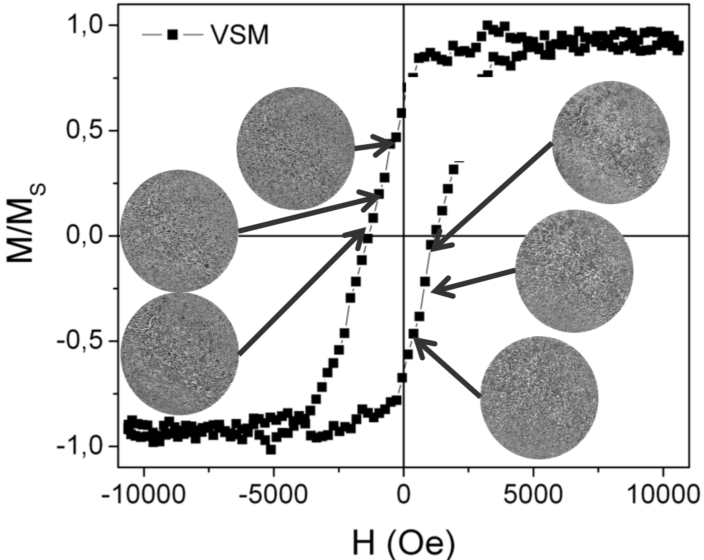
MFM imaging of Ni nanowires (d=180 nm, L = 2 μm)

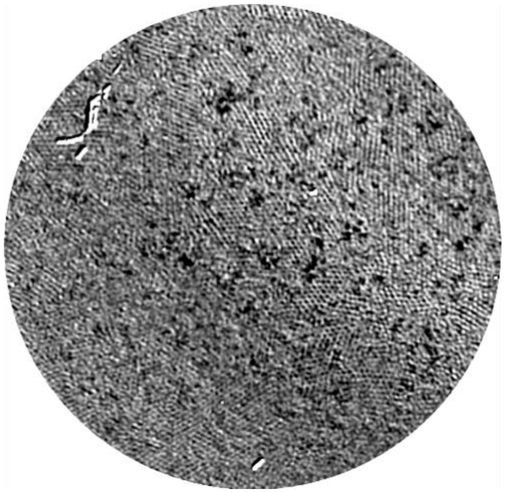




Evidence of Magnetostatic Interactions

MTXM imaging of Co nanowires (d=35 nm, L=150 nm)





Miriam

Advanced Light Source, Berkeley

MTXM: line 6.1.2;

Co edge (778 eV)

Collaboration P. Fischer

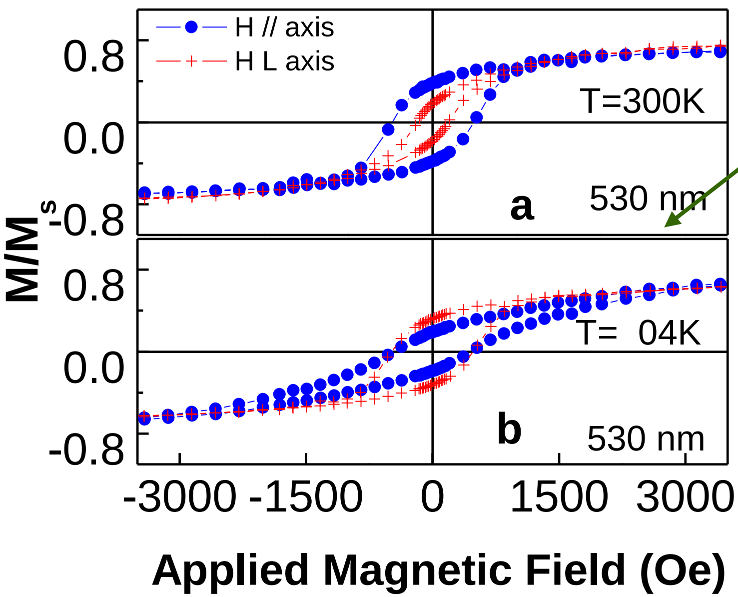
Open Surf. Sci.

Unexpected temperature dependence of Magnetic Anisotropy

Arrays of Ni, Co Nanowires with different length (500 to 2000 nm)

Change of magnetoelastic contribution with temperature

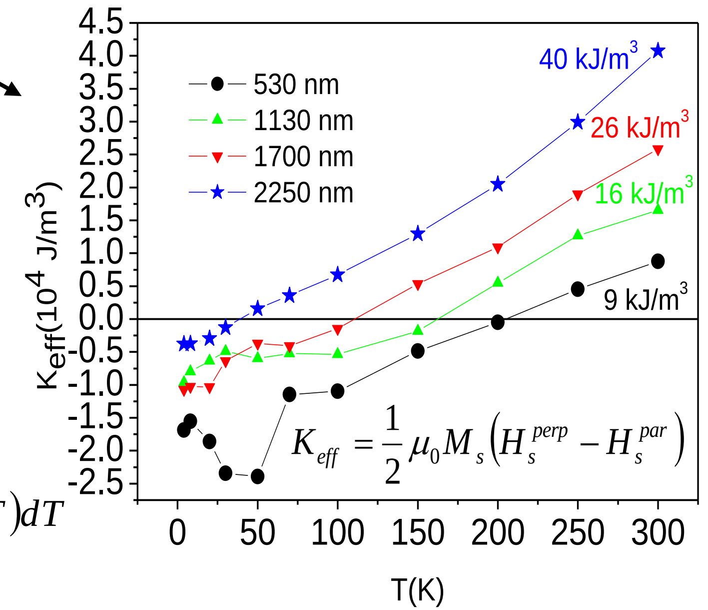
in collaboration with
Un. Campinas (M. Knobel)



Change of Anisotropy Axis with Temperature!!

The crossing temperature depends on wires length

David Navas



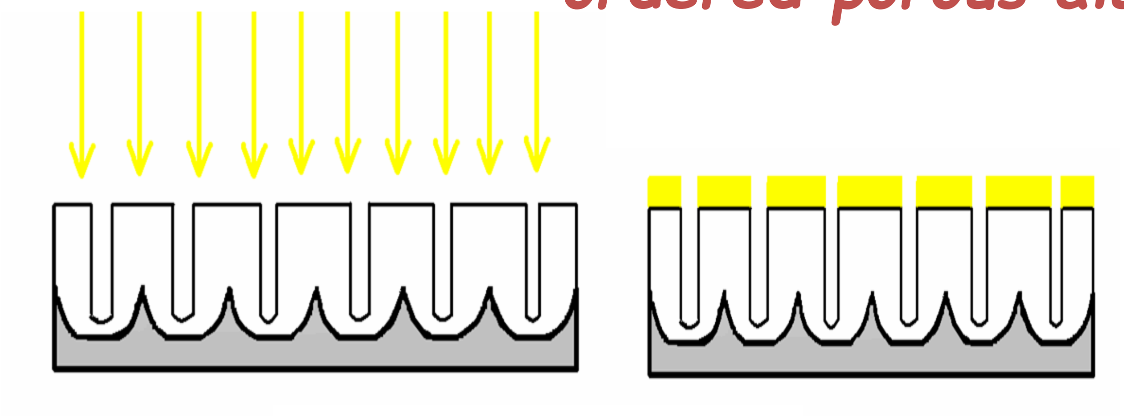
$$K_{tot} = K_{shape}(L) + K_{mag.el.}(\sigma) + K_{cryst}$$

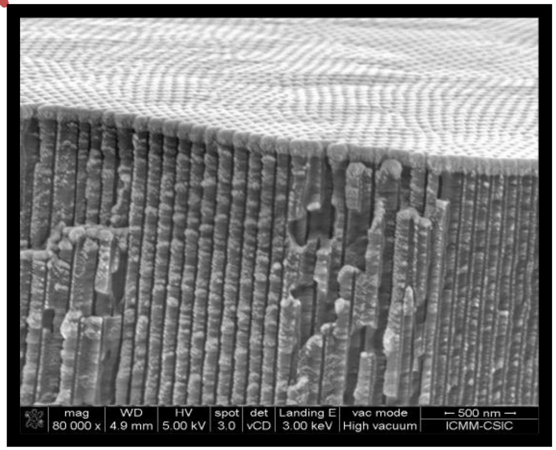
$$K_\sigma(T) = \frac{3}{2}\lambda_s(T)\sigma(T) = \frac{3}{2}\lambda_s(T)E_{eff}(L)\frac{\Delta l}{l}(T) = \frac{3}{2}\lambda_s(T)E_{eff}(L)\int_{T_i}^{T_f}\Delta\alpha(T)\,dT$$

Strong influence of magnetoelastic anisotropy induced by:
a) Different thermal coeficients of wires & matrix
b) Length dependent Young´s Modulus (surface tension)

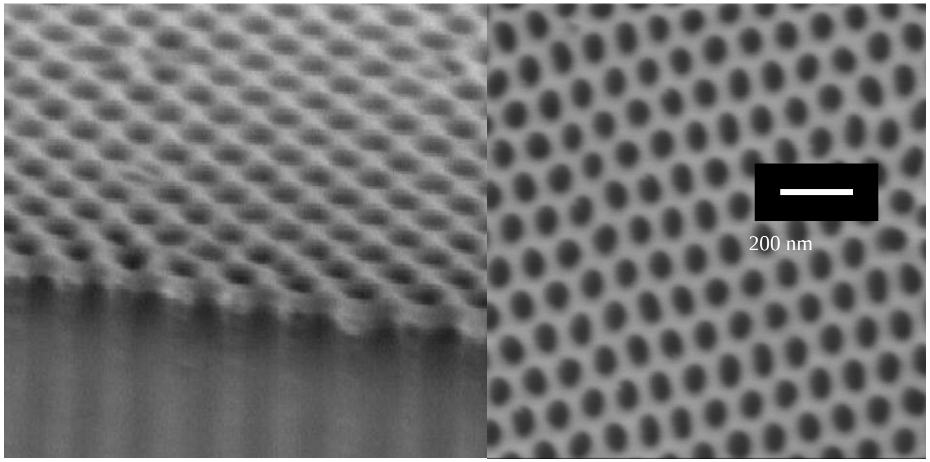
Pirota et al. Phys. Rev. B 76(2007)233410
Navas et al. J. Appl. Phys. 103(2008)

Antidot Py array preparation by ion-beam sputtering on ordered porous alumina

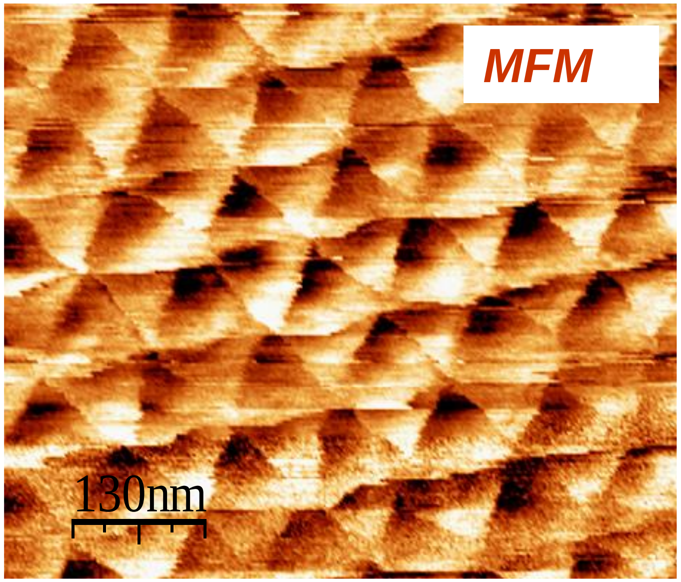




D=105 nm; *FeNi*
layer thickness ≈20 nm Holes
Lenght ≈4 μm



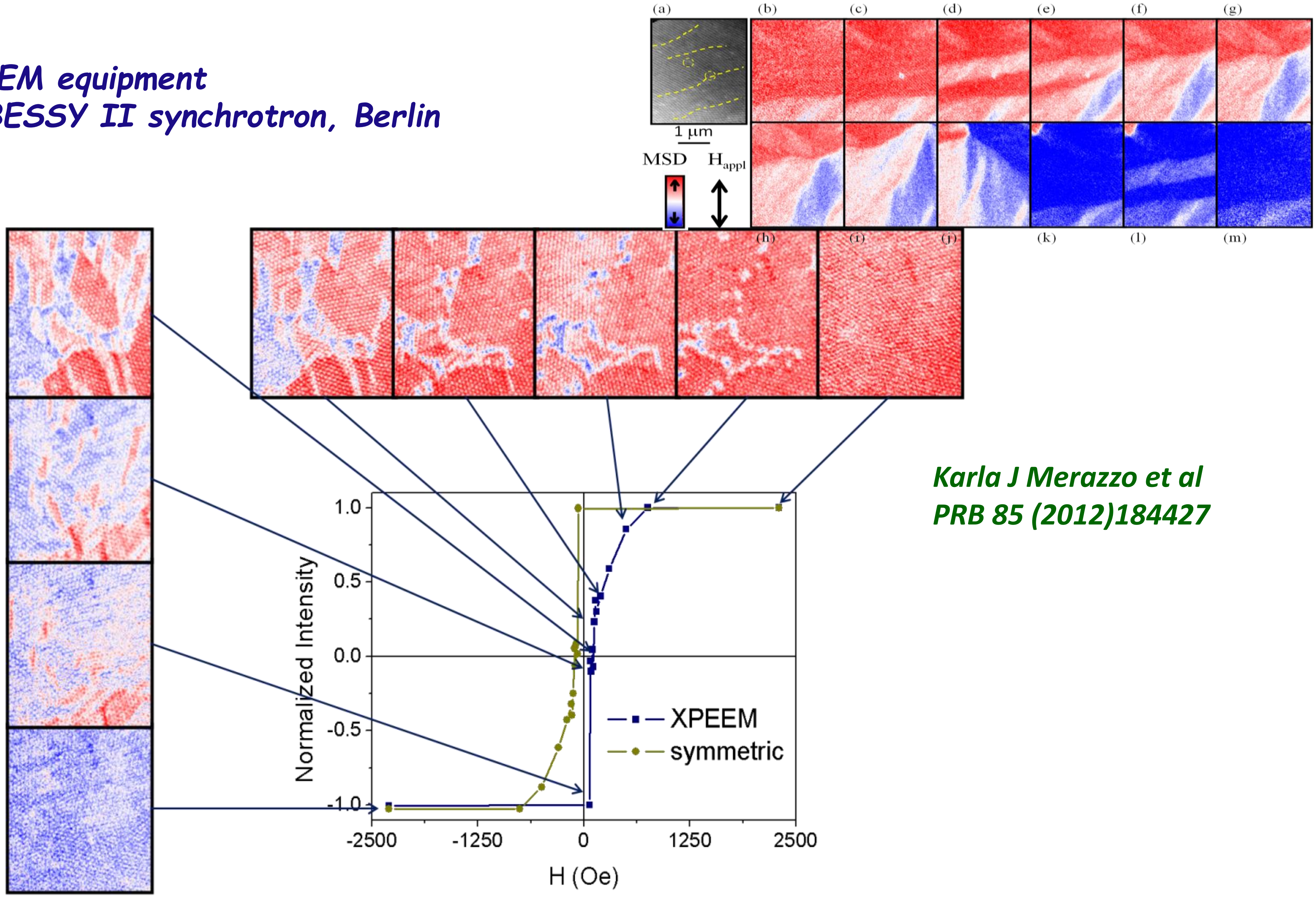
Py antidot array on self-assembled template



Karla, Wagner

Py Antidot Arrays by X-Ray photoemission electron microscopy

XPEEM equipment
at BESSY II synchrotron, Berlin



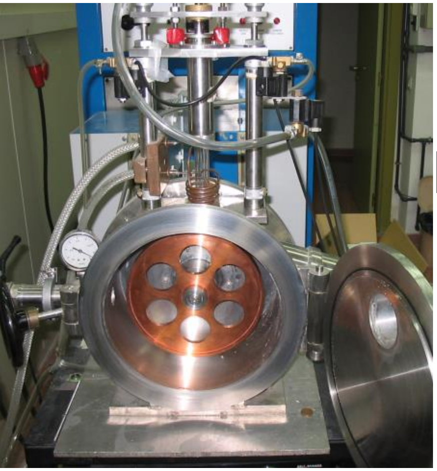
Karla J Merazzo et al
PRB 85 (2012)184427

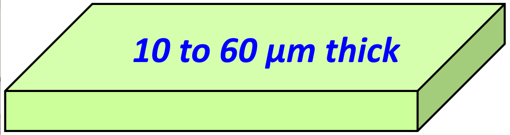
Instituto de Ciencia de Materiales (2001-)
Puesta a punto de un Nuevo Laboratorio

3 equipos de solidificación ultarápida:
hilos, cintas y microhilos cubiertos de pyrex

Families of Metallic Glasses (as produced in ICMM/CSIC, Madrid)

Melt-spun amorphous ribbons

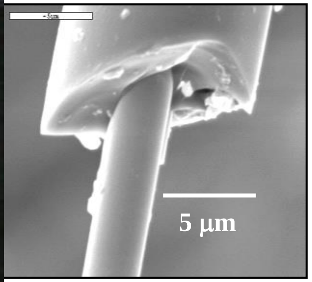




In-water-quenched amorphous wires

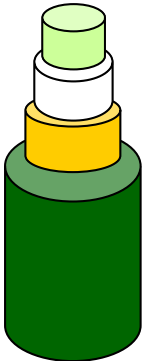
Glass-coated amorphous microwires

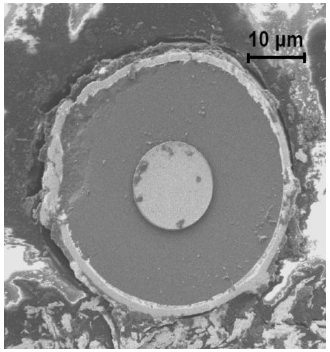
1-20 µm diameter



Bi-magnetic Microwires

Up to 40 µm diameter

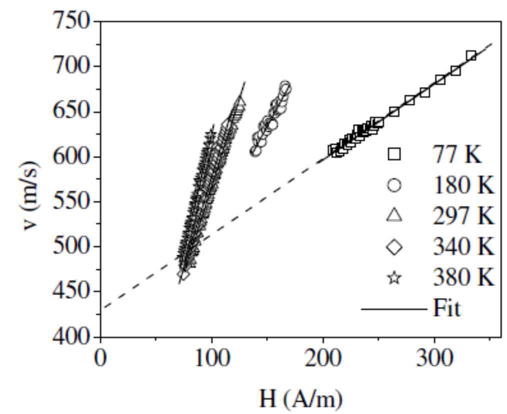




Domain Wall & Dynamics

Rastislav Varga; Giovanni Badini-Confalonieri (Karin, Jacob, Germán)

Single domain wall & fundamental dynamics studies



DW motion equation

$$m\ddot{x} + \beta\dot{x} + \alpha x = 2M_s H$$

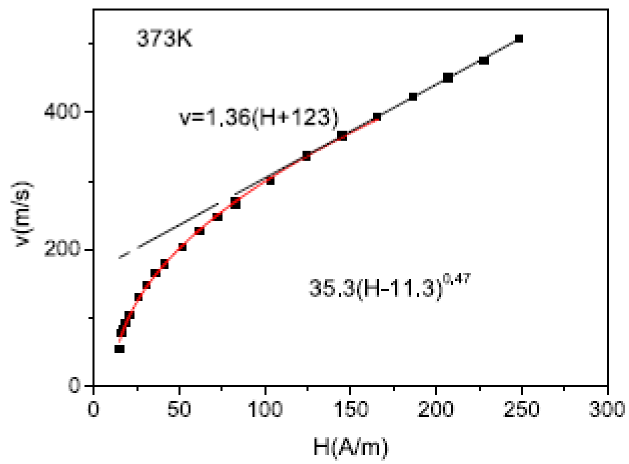
Damping mechanisms

$$\beta = \beta_e + \beta_r + \beta_s = \frac{k_1 M_s(T)^2}{\rho(T)} + k_2[M_s(T)^3(1 + r\Delta T)]^{1/2} + k_3\frac{\tau}{T}$$

β_e - eddy currents
β_r - spin relaxation
β_s - structure relaxation

Varga et al.
Phys. Rev. Letters 94 (2005) 017201

$v = S(H - H_0)$

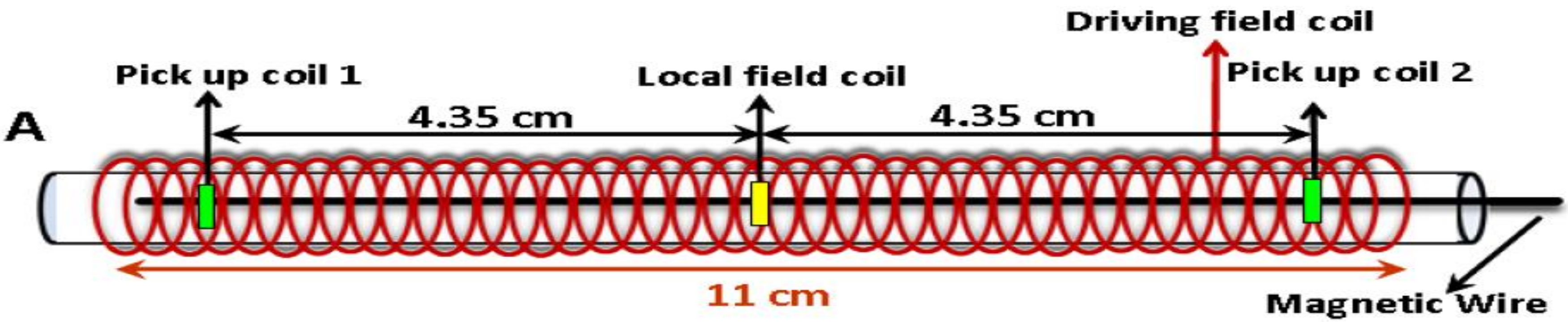


$$v = S'(H - H_0')^{\beta}$$

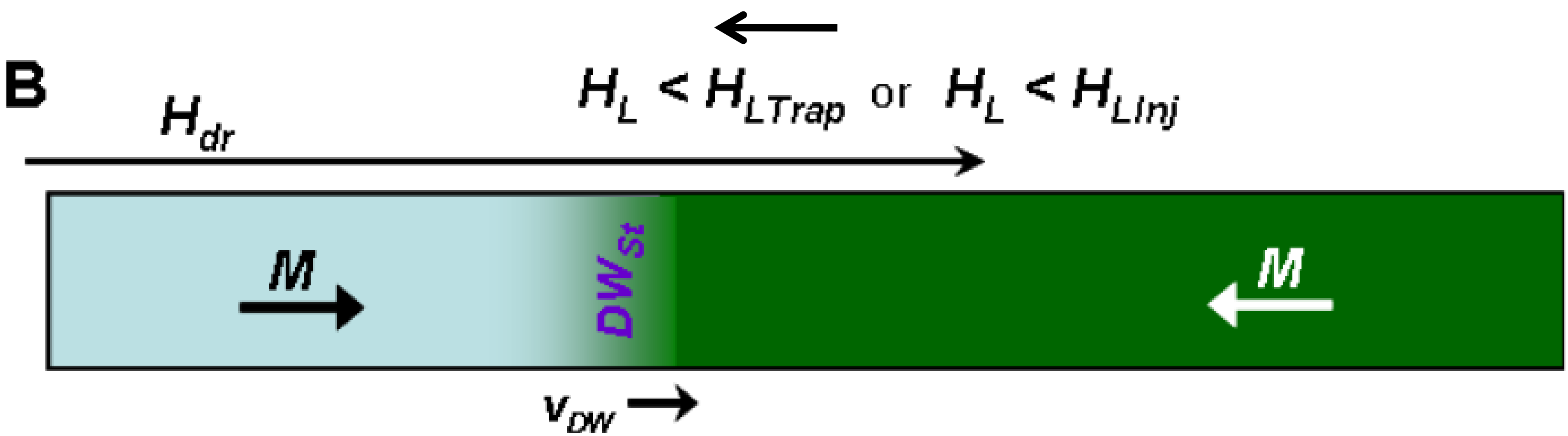
β would reflect the interaction DW with defects

Varga et al.
J. Phys.: Condens. Matter 20 (2008) 445215

Trapping and Injecting Domains Walls: Sixtus & Tonks-like Experiment

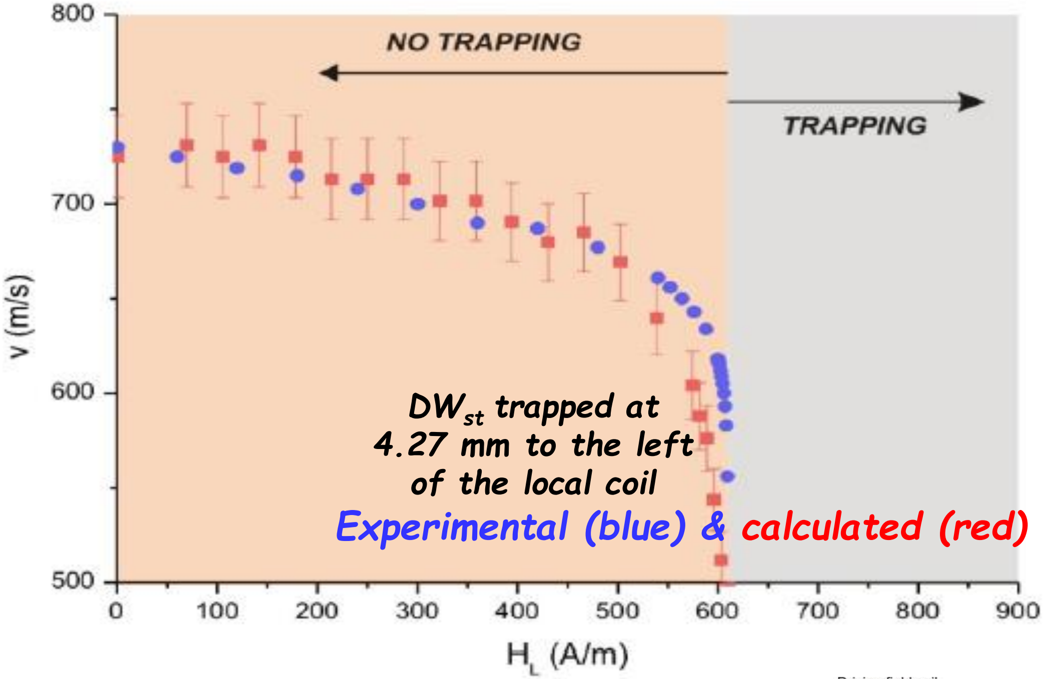


Antiparallel local-field configuration:
The Local field opposes the Drive field



Scheme of domain structure after a standard Domain Wall, DW_{st}, moves under drive field, H_{dr}, plus antiparallel local field

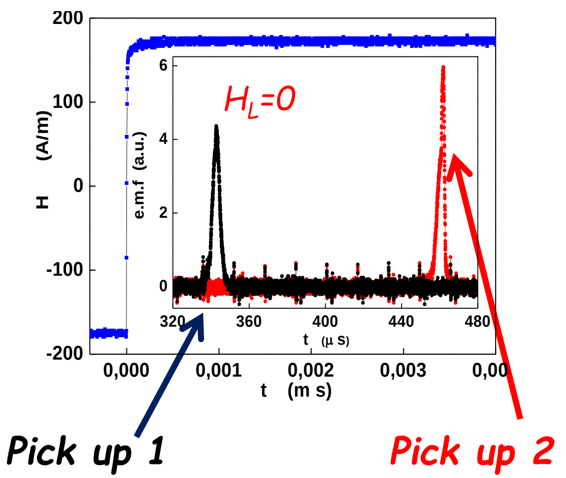
Trapping a domain wall: Antiparallel local-field configuration

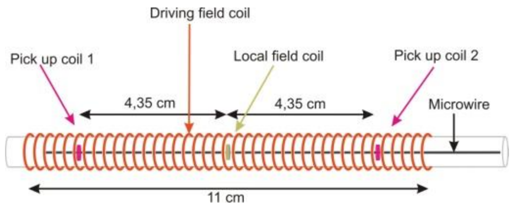


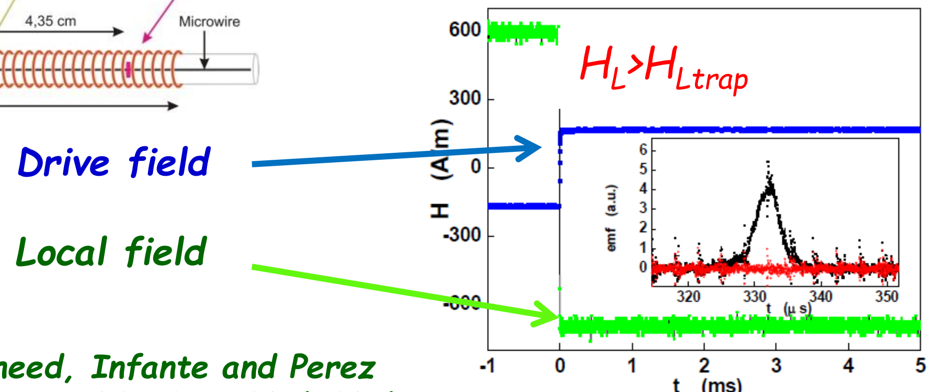
Velocity, v, of the standard wall, DW_{st}, under drive field H_{dr}= 170 A/m, as a function of the antiparallel local field, H_L.

The wall gets trapped at H_L=610 A/m

$$mv\frac{dv}{dx}+\beta v+kx=2\mu_0 M_s S\left(H_{dr}+H_L\left(x\right)\right)$$

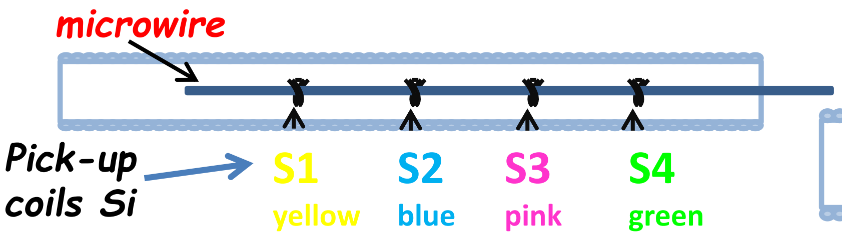


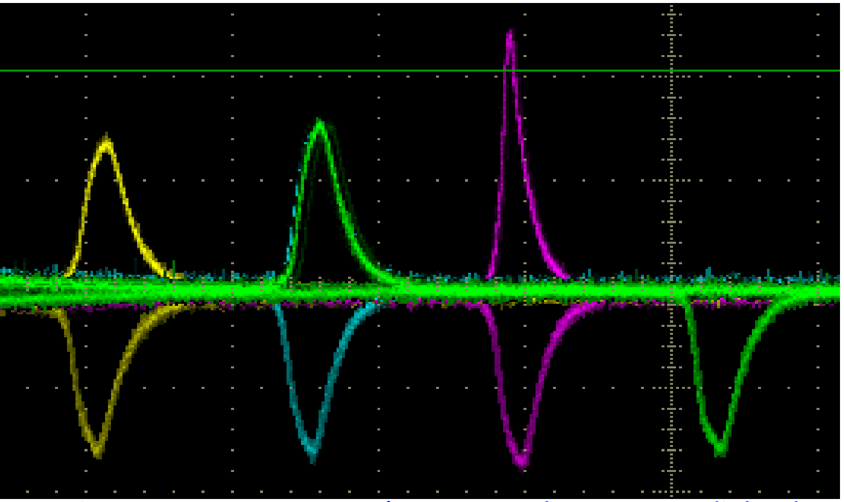




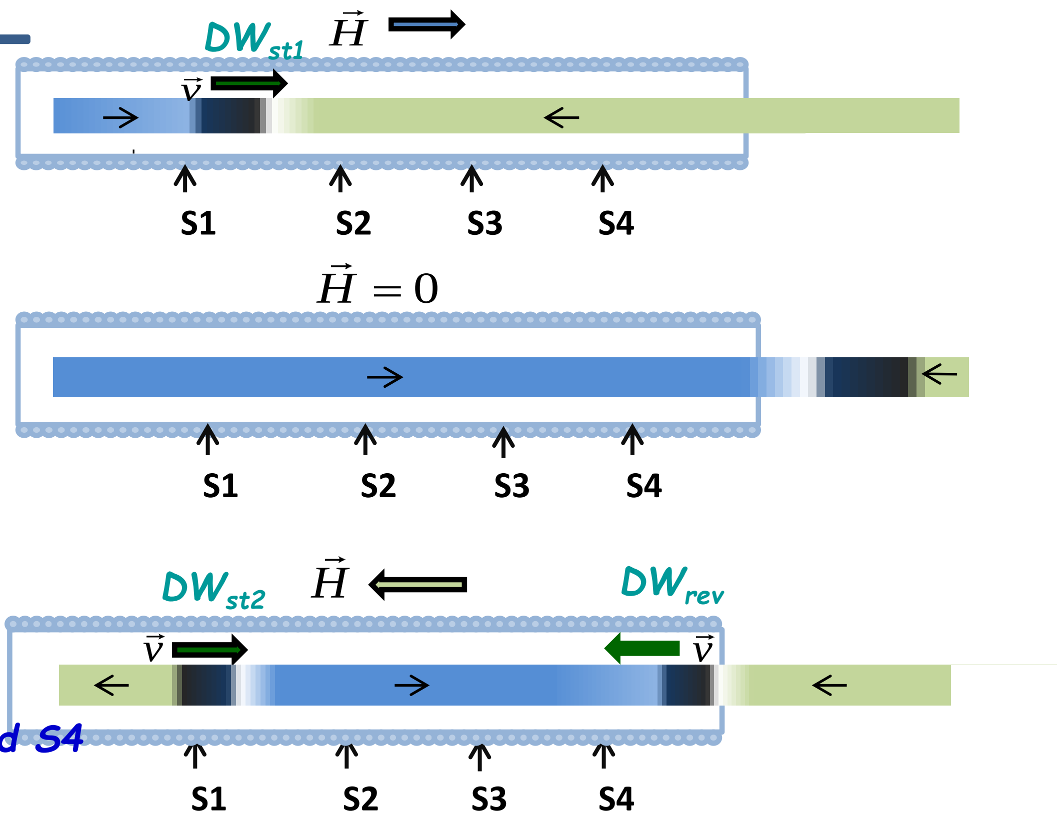
Vázquez, Basheed, Infante and Perez
Phys. Rev. Letters 108,037201 (2012)

Observando cómo se aniquilan 2 paredes moviéndose en direcciones opuestas





$Fe_{79}Si_{10}B_8C_3$ microwire
(d_{met}=20.5 μm, D_{tot}=30.5 μm)



For H_{app}=-281 A/m, signals at S2 (blue) and S4 (green) are picked up simultaneously.

Also, signal in S3 (pink) has higher amplitude and reduced width.

DW_{st2} and DW_{rev} arrive to S3 simultaneously:

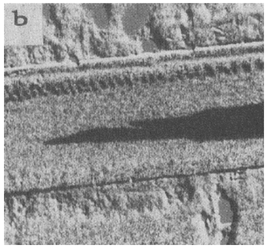
We are observing the collapse of two single domain walls moving along opposite directions

A. Jimenez, R.Perez del Real and M. Vázquez, invited talks at JEMS Sept.2012, Parma (EPJ 2013) and at MMM, Jan. 2013, Chicago

Know-how at ICMM/CSIC: Magnetic Nano and Microwires
1- Materials Production at Laboratory scale

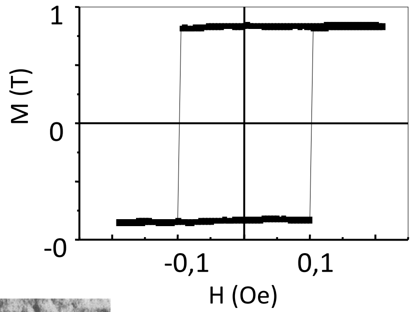
Melt-spinning unit under controlled atmosphere, ICMM/CSIC

Production & Magnetics amorphous ribbons

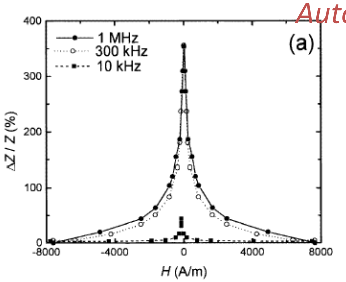


Amorphous Wire Domain structure

Amorphous wires (in-rotating-water)



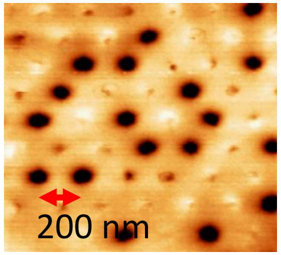
First studies in glass-coated microwires



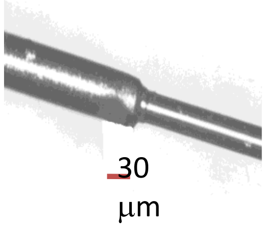
Reporting Giant Magnetoimpedance in amorphous microwires

Autonomous Fabrication of Amorphous Wires and Microwires

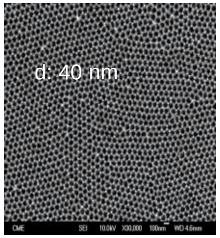
MFM image of Ni nanowire array



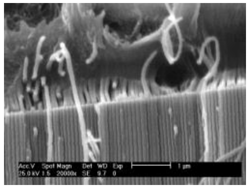
Arrays of Magnetic Nanowires Autonomous Fabrication

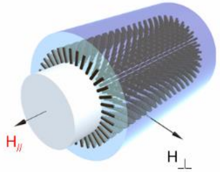


Multilayer Microwires



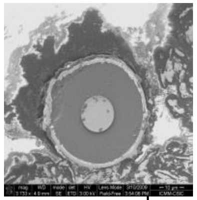
Metallic & Polymeric nanoporous membranes





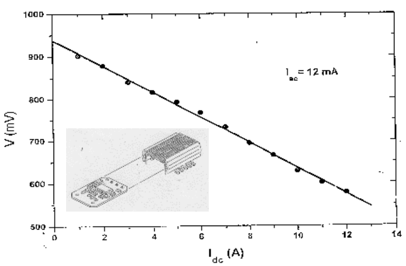
Radial array of nanowires

Bimetallic bimagnetic / microwires

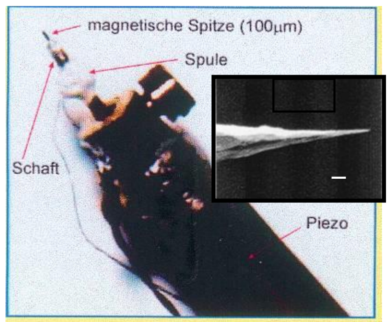


1980-1900 | 1989 | 1993 | 1994-6 | 2002 | 2005 | 2006 | 2007 | 2008

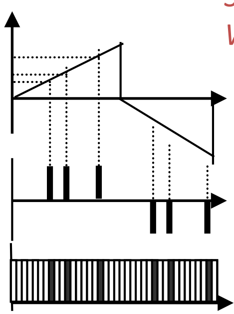
Know-how at ICMM/CSIC: Microwires and sensing devices
2.- Wire Sensor & Technological Developments



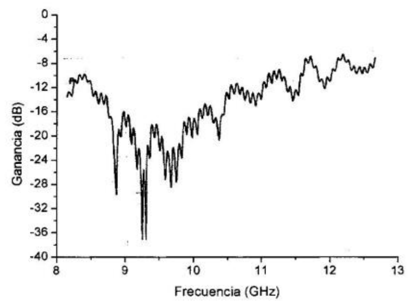
DC current sensor based on MI (Unitika wire) for power electronics



Sharpned Amorphous Wire Tip for SPMTM

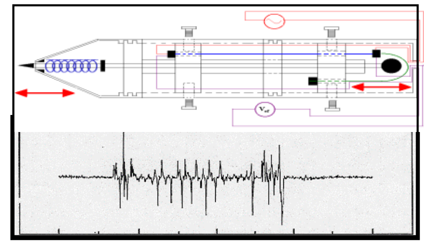


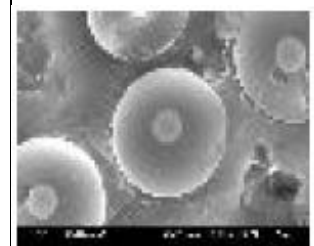
Magnetic Encoding based on bistable glass-coated microwires



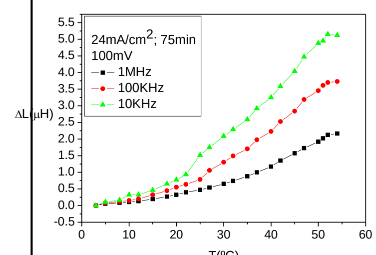
Glass-coated Microwires in polymeric films for electromagnetic screening

Magnetoelastic Pen for Siganture Identification
MI in glass-coated microwire (Patent)





New-generation 1 micron-size Wire for GMI sensor (Aichi, Toyota Group)



Multifunctional Sensor based on Multilayer Microwire (Patent)

Microwires for Flux-Gate sensor (Quantec Geotech, Montreal)

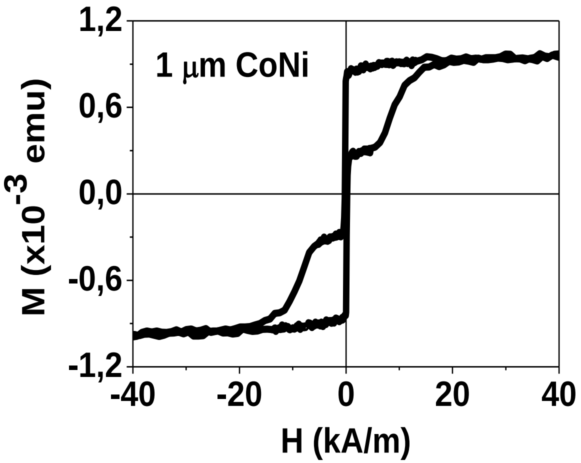
Magnetic Shape Memory Wires (Patent)

Bimetalic Wire with helical anisotropy (Patent)

1996 1997 1999 2000 2003 2006 2007 2008-9

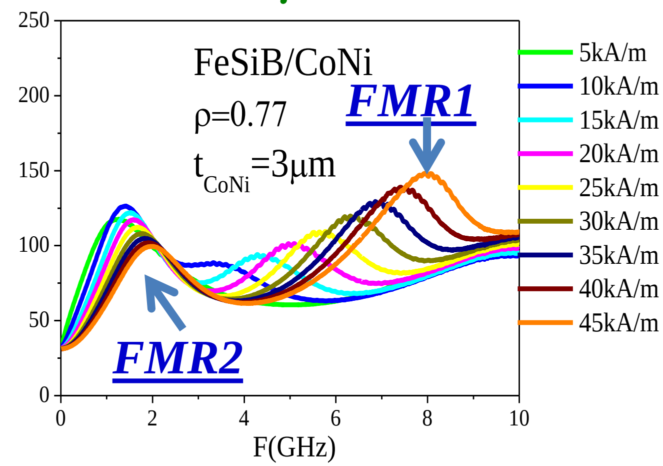
6 Patents based on Multilayer Microwire

FeSiB/CoNi (Soft/Hard)

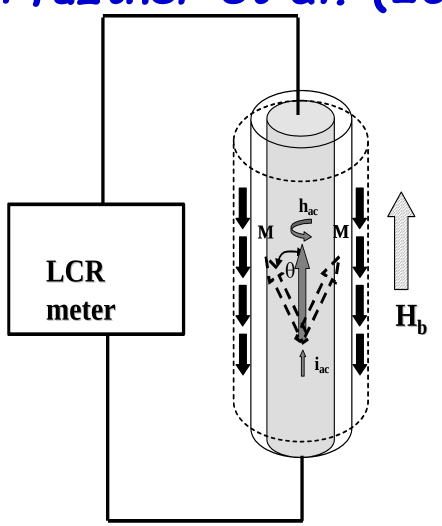


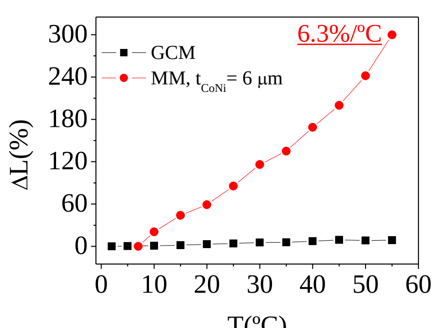
FMR absorption

Rhimou ElKammouni

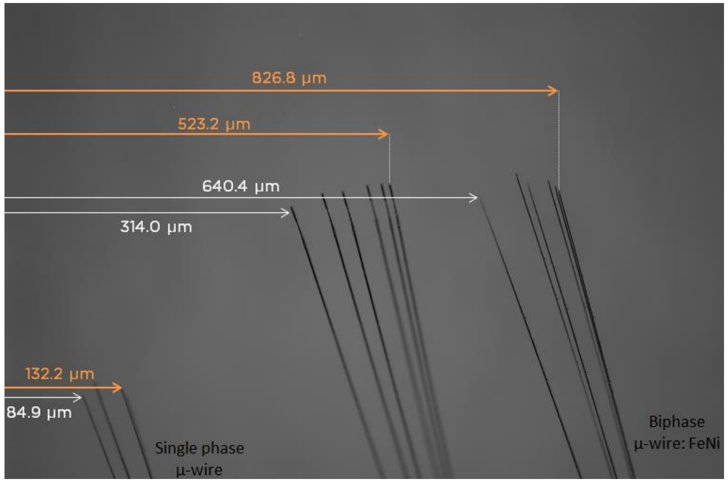


Temperature & Stress sensor (EU)
G. Badini, J. Torrejon, K. Pirota, H. Pfüztner et al. (2007)





Microactuator based on bimagnetic asymmetric core/shell microwires (2017) EU/Russia (Valeria Rodionova)



Instituto de Ciencia de Materiales (2001 -)
Organizacion de Congresos, Intermag 2008

IEEE

INTERMAG 08

Madrid

Main Menu

con los Nobel Peter Grünberg y Albert Fert, y la ministra Cristina Garmendia

Instituto de Ciencia de Materiales (2008-2017)
Visitas de investigadores y Distinguished Lecturers


L. Schultz & R.Cowburn

Relaciones Internacionales (2008-2017)

Instituto de Ciencia de Materiales (2009-2017)
Grupo de Nanomagnetismo y Procesos de Imanación

- Magnetismo de Microhilos:
  control sobre paredes individuales

- 8 Patentes: sensores diversos,
  diseño de nuevos microhilos

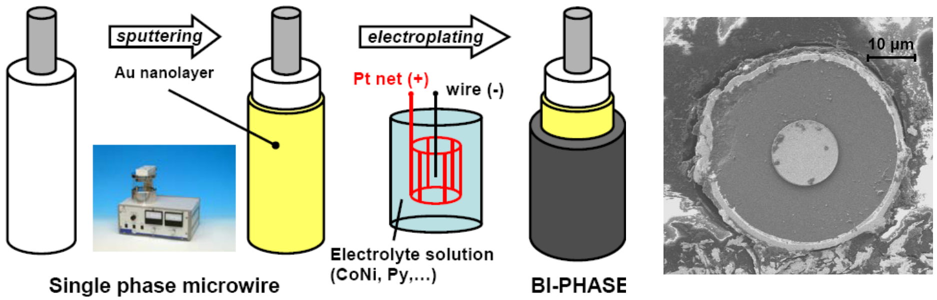
- Proyectos con empresas
  Aichi (Japón), IBM (USA), Micro-Epsilon Messtechnik (Germany), Quantec Geotech (Canada), AIRBUS (France), PREMO (Spain)

- Suministro de microhilos & proyectos
  (Un. Pub. Navarra,..)

Coordinated European Projects

“**Magnetstrictive bi-layers for multifunctional sensor families**” 2003-2007 EU-Growth IPs: H. Pfützner (Techn. Un. Vienna), M Vazquez (CSIC), Cardiff Un. (T. Moses), Fiat (J.Chiricco), ELCAT (Germany).

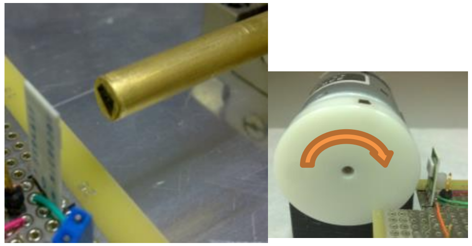
Bimagnetic microwire



- “**Magnetic nanoparticles combined with submicron bubbles for oncologing imaging (NANOMAGDYE)**” 2008-2012, FP7-NMP-2007; IPs: G. Pourroy (CNRS, Grenoble), I. Bernhard (Saarland Un.), M. Vázquez (CSIC), P. Chirico (Softech, Italy), P. Vertesy (Hungarian Ac. Sc.)

- **“Rare Earth Free Permanent Magnets (REFREEPERMAG)”**, 2012-2016 FP7NMP.2011 IPs: D. Niarchos (NCRS, Athens), M. Vázquez (CSIC), M.Farle (Univ. Duisburg-Essen), J.Fidler (Techn. Un. Vienna), O. Erikson (Un. Uppsala), S. Fähler (IFW, Dresden), F.Ott (CEA, France), G. Viau (Un. Toulouse), Magnetfabrik Bonn, Wittenstein Cyber Motor.

REFREEPERMAG



Position Sensor & Tachometer

Instituto de Ciencia de Materiales (2009-2017)
Grupo de Nanomagnetismo y Procesos de Imanación

Magnetismo de Nanohilos aislados

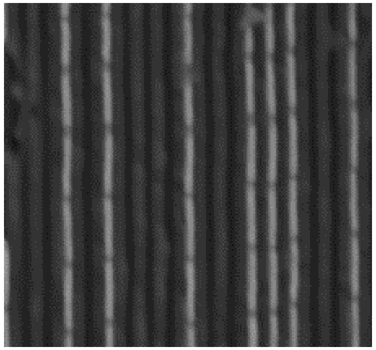
Cristina Bran

Agustina Asenjo; Rafael P del Real; Oksana Chubykalo-Fesenko

Various families of magnetic nanowire arrays prepared by electrochemical route at ICMM/CSIC, Madrid

1.- Uniform Nanowires:

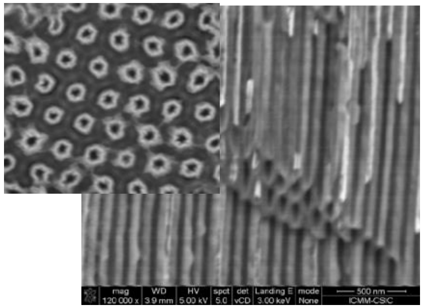
Nanodots, Nanowires
(reduced diameter, combined with ALD)



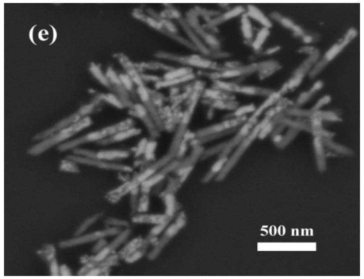
Co/Cu multisegmented

2.- Modulated Nanowires :

a) Longitudinal
Multisegmented, Multilayer,



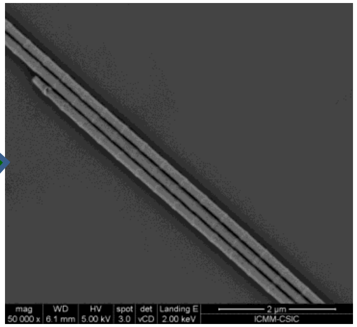
Ni nanotubes



Fe&Au core&shell

b) Radial
Nanotubes, Core/Shell

c) Diameter Modulated

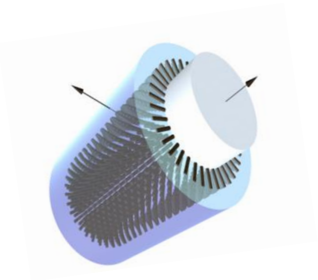


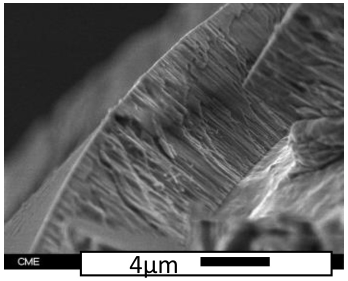
CoFe diameter modulated

Co nanowires

3.- Radial nanowires in Cylindrical template

Ruy

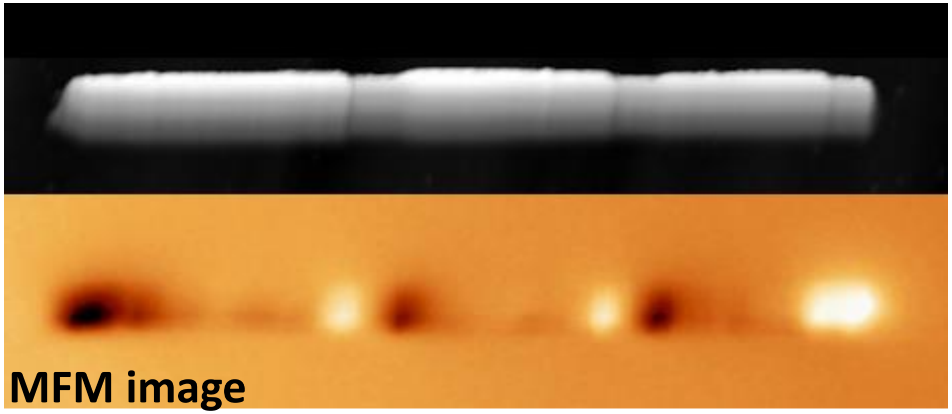




Tailored Geometry & Composition (Co, Fe, Ni & alloys)

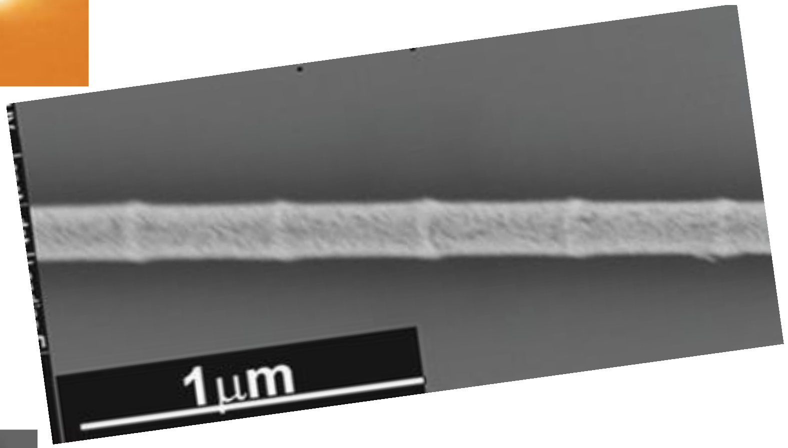
20 to 200 nm Diameter
100 nm to 40 μm Long

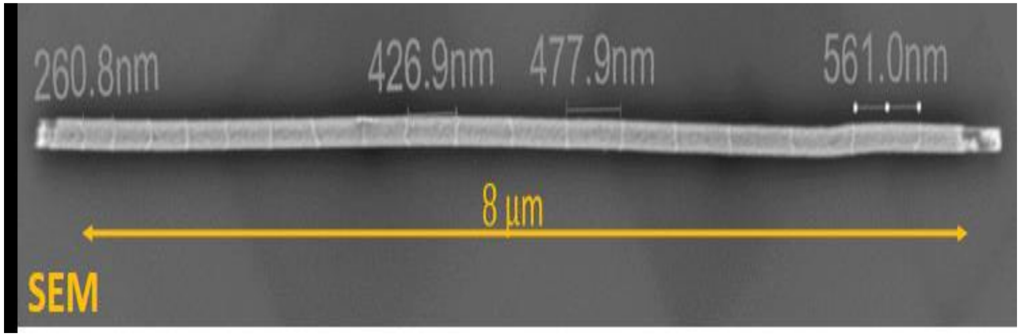
Nacho, Oscar



FeCo Diameter- modulated

FeCo/Cu Bamboo-like (antinotches) modulated



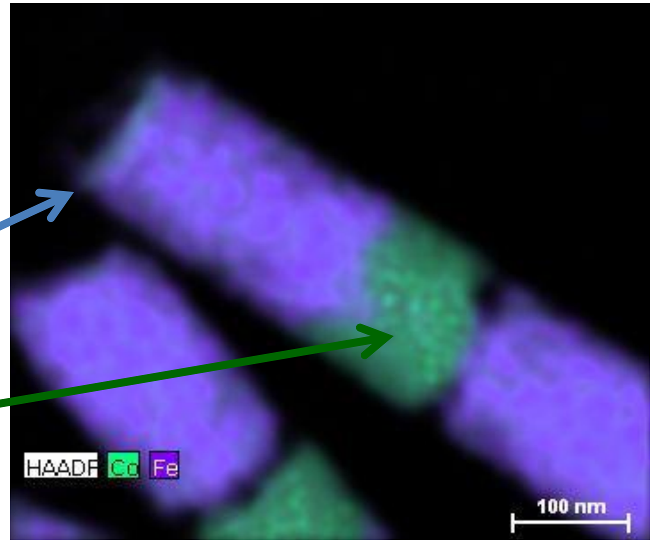


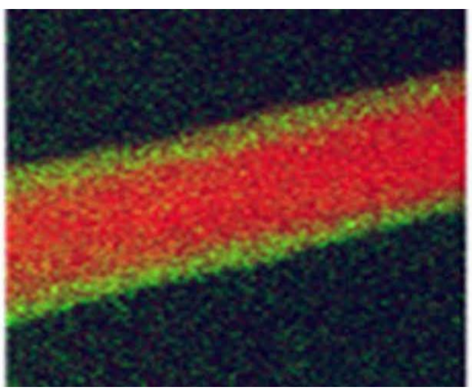
Multisegmented FeCo/Cu with increasing FeCo segment lentght

Anisotropy & Composition modulated

CoFe (bcc 110)

Co (hcp 002)

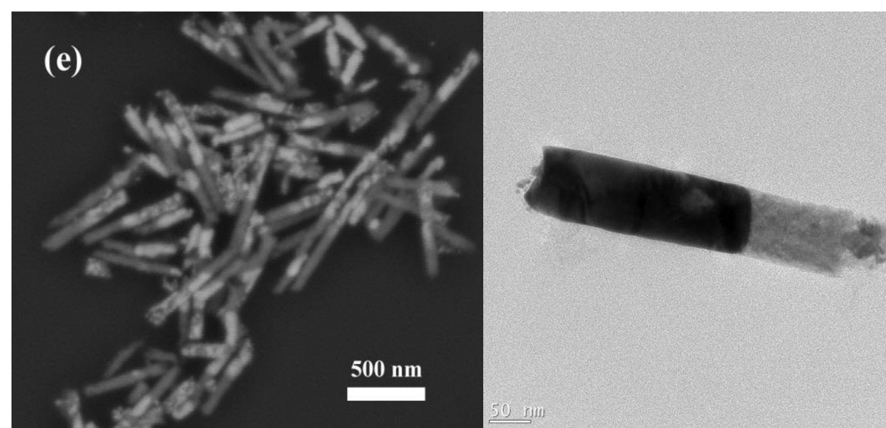




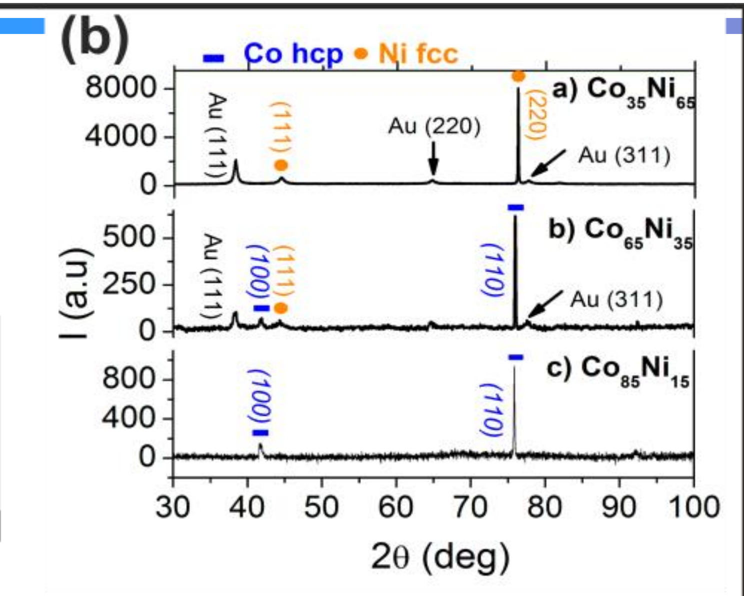
Fe/Fe_3O_4 core/shell nanowire (KAUST)

Yuri Ivanov, Jurgen Kosel (KAUST)

Fe/Au core/shell nanowires

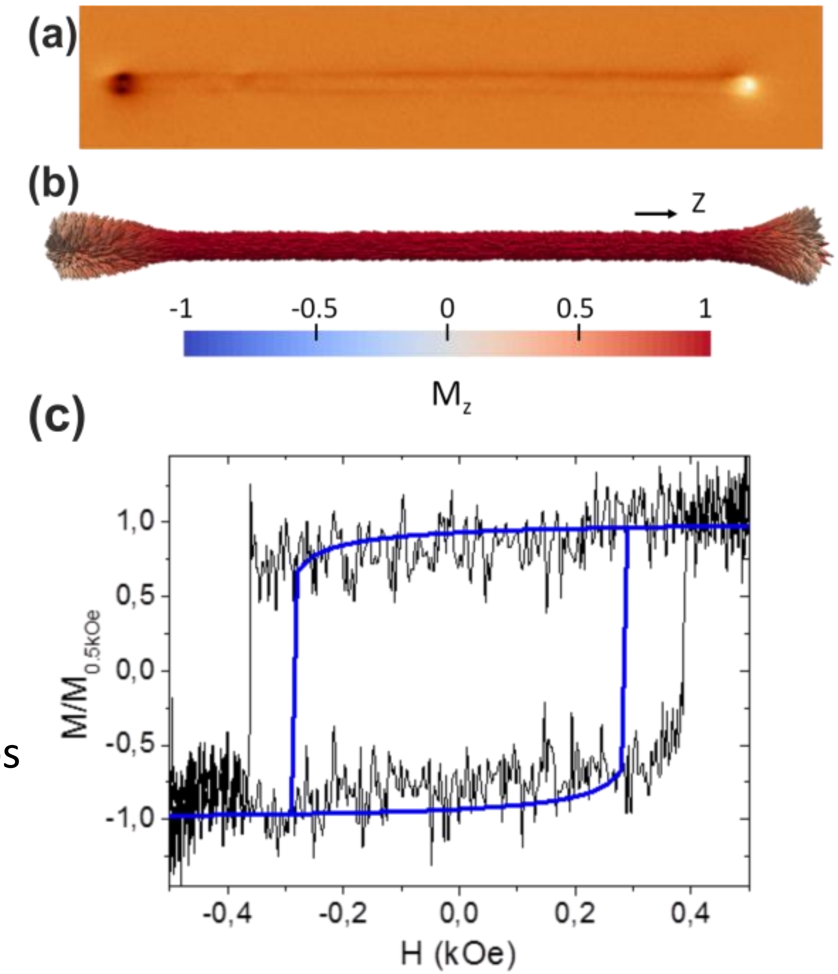


Crystal Structure; Domain Structure; Magnetizat. Reversal



$Co_xNi_{(100-x)}$ allow nanowires

Single Domain in fcc $Co_{35}Ni_{65}$

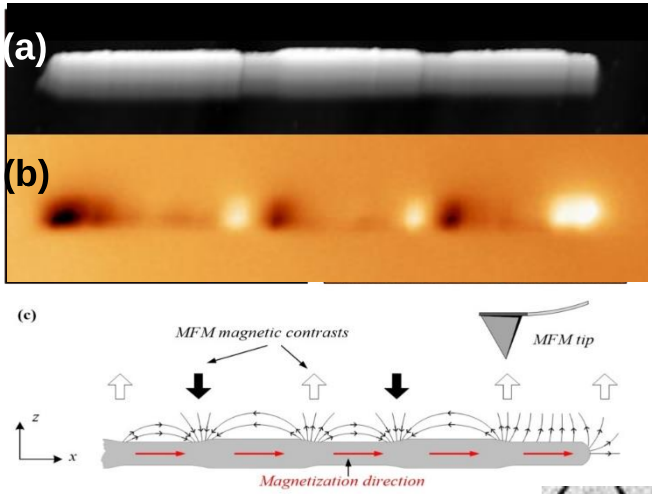


(a) MFM image,

(b) Remanence: micromagnetic simulated

(c) MOKE (black) and simulated (blue) loops

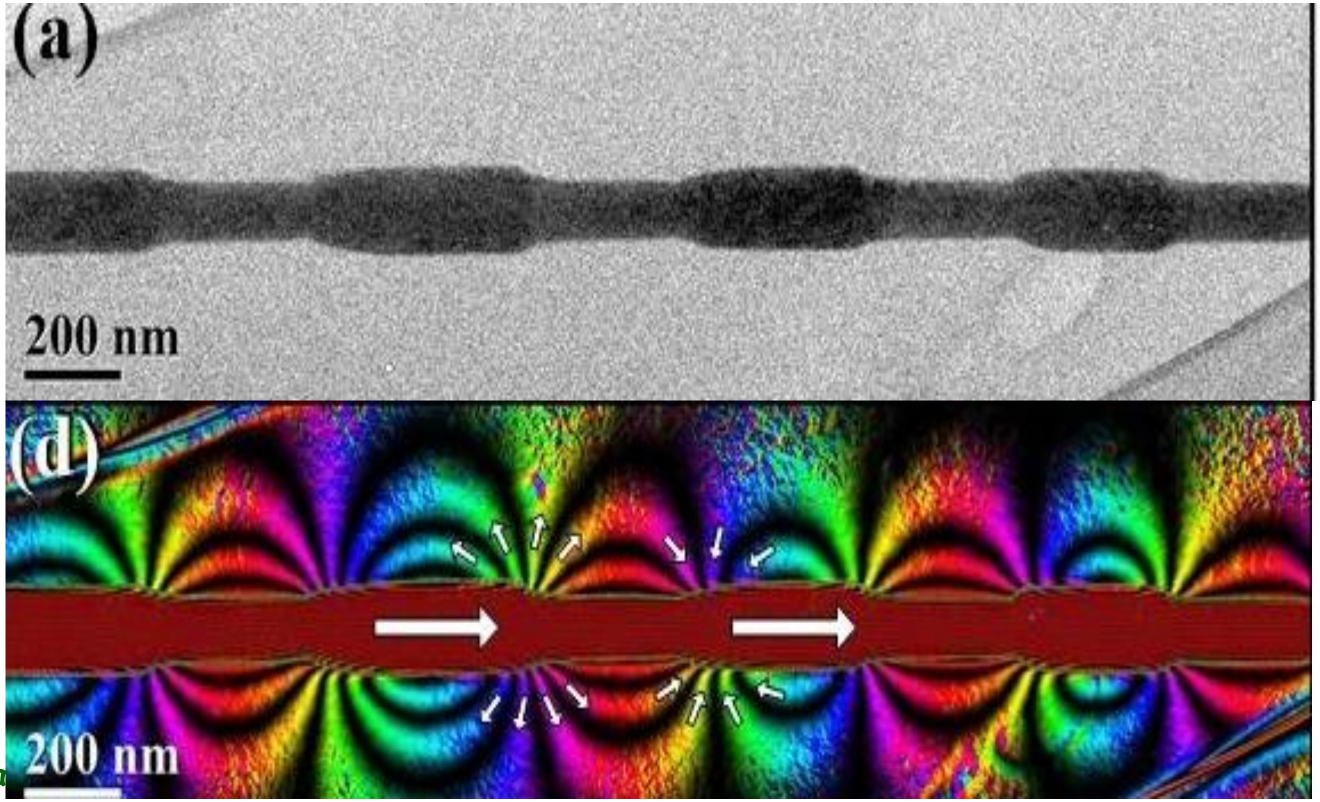
Magnetic Force Microscopy & Electron Holography imaging



Topographic AFM (a) and
Magnetic MFM (b) images of FeCo modulated NW

Interpretation of bright and dark MFM contrasts

Axial Domain and stray fields at modulations

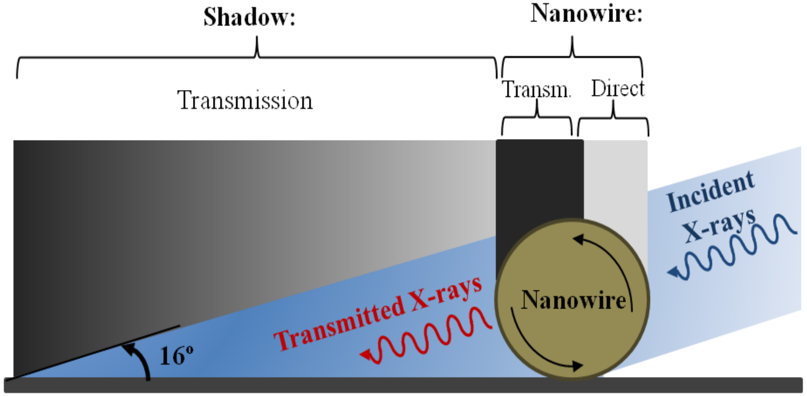


SEM (a) and Electron Holography (d) images of the magnetic flux

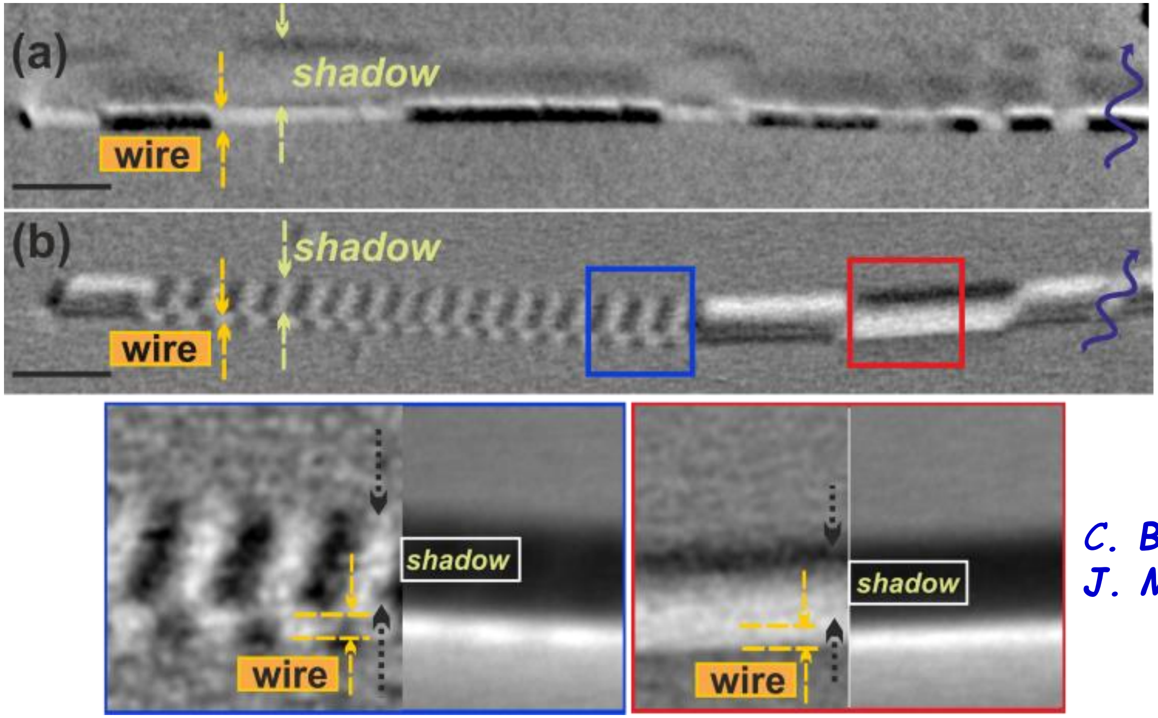
E. Snoek, Toulouse
A.Asenjo

L. Robriguez, C. Bran, E. Berganza et al. ACS Nano 10 (2017) 9669

Photo-emission electron microscopy with X-ray magnetic circular dichroism (PEEM-XMCD): surface and bulk spin configuration



Imaging Transverse and Vortex domains



hcp $Co_{85}Ni_{15}$

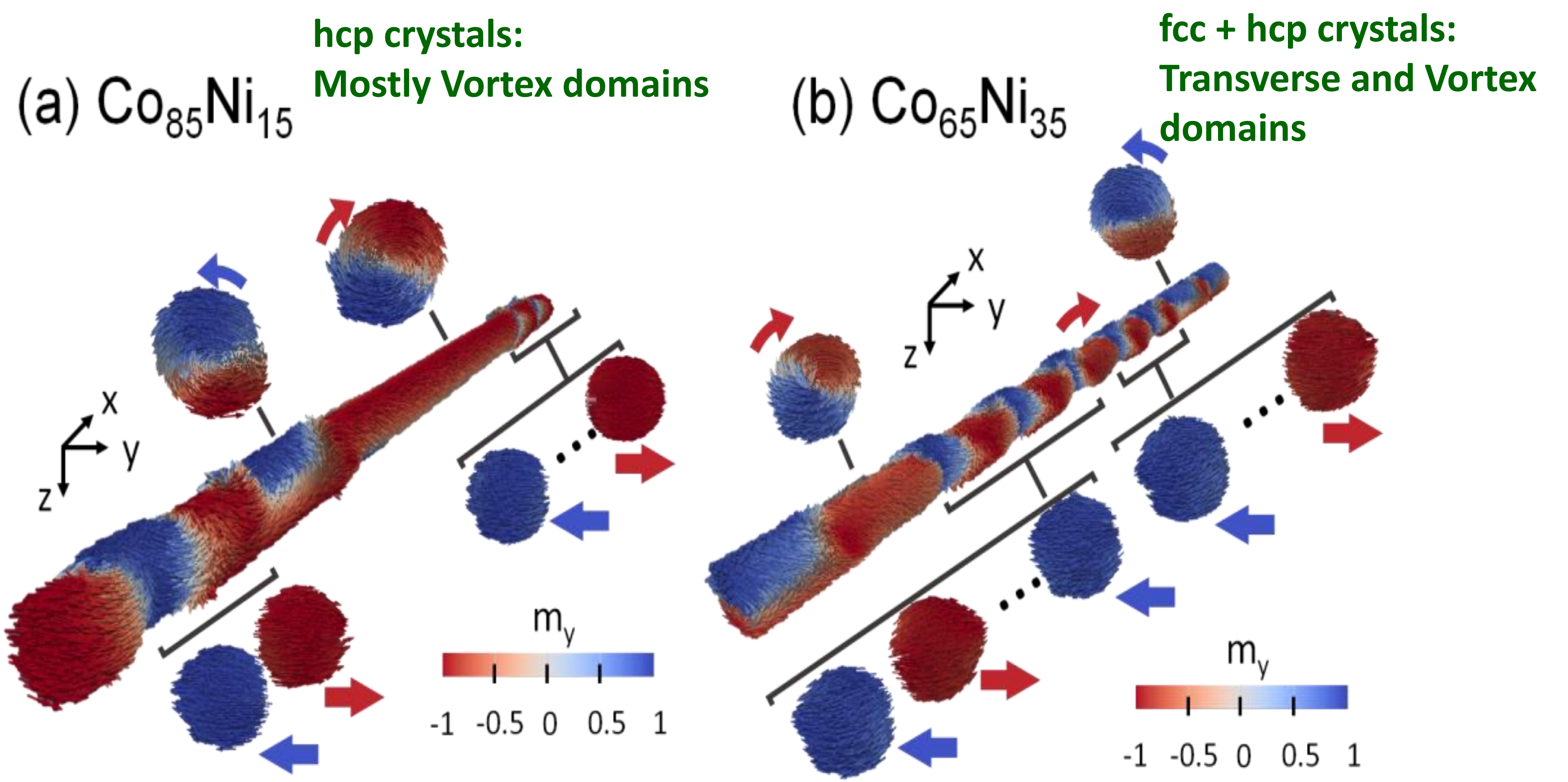
hcp, fcc $Co_{65}Ni_{35}$

C. Bran , L. Aballe et al.
J. Mater. Chem. C 4 (2016) 978

Bran et al
(Phys Rev Sept2017)

Transverse Domain   Vortex Domain

Simulated Domain Structure in CoNi alloy nanowires: Vortex and Transverse Domains



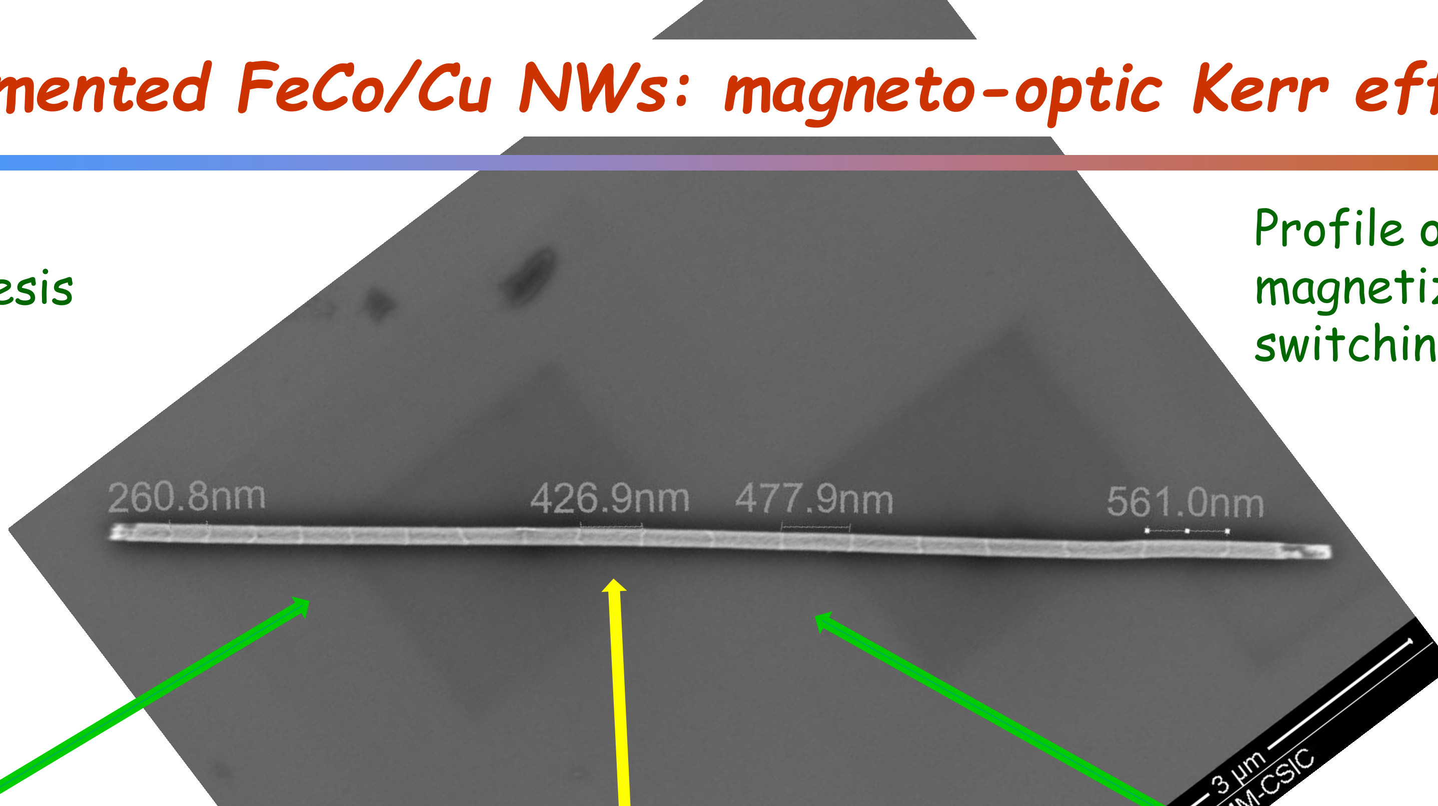
JA Fernández-Roldán & O. Chubykalo-Fesenko

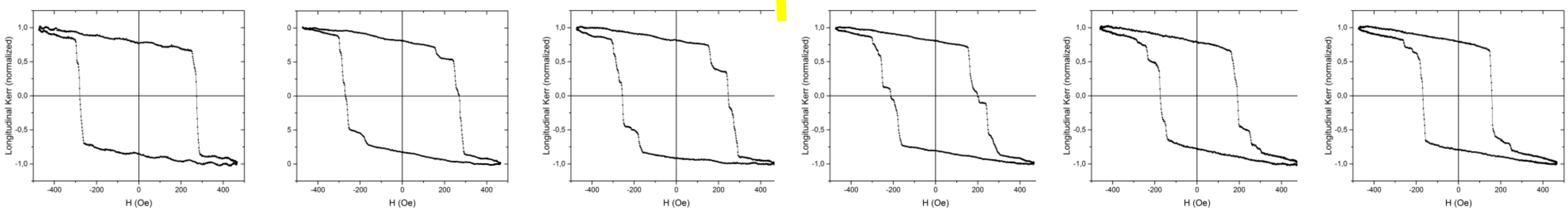
Multisegmented FeCo/Cu NWs: magneto-optic Kerr effect

Local hysteresis loops

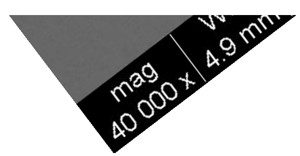
Profile of magnetization switching

Jessi Meyer
Ester Palmero

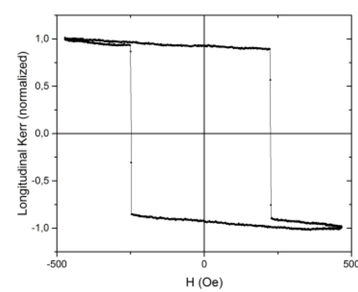




Stepped propagation of a domain wall



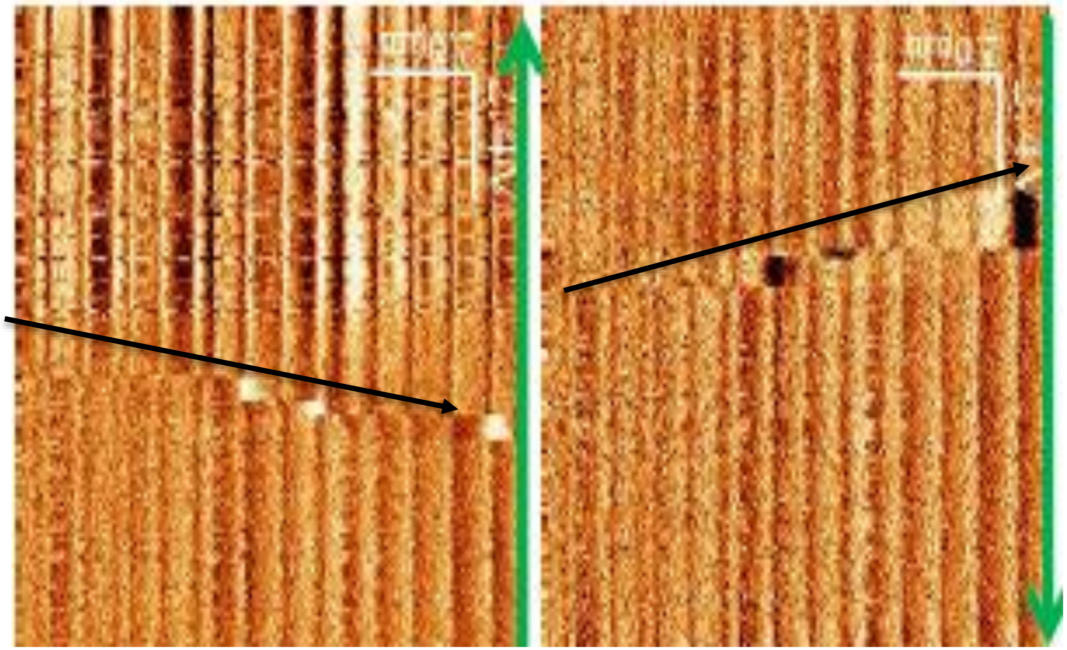
Loop of a uniform wire



Multisegmented Nanowires, MFM imaging

FeCo/Cu with increasing FeCo segment lenght from one end

Eider Berganza



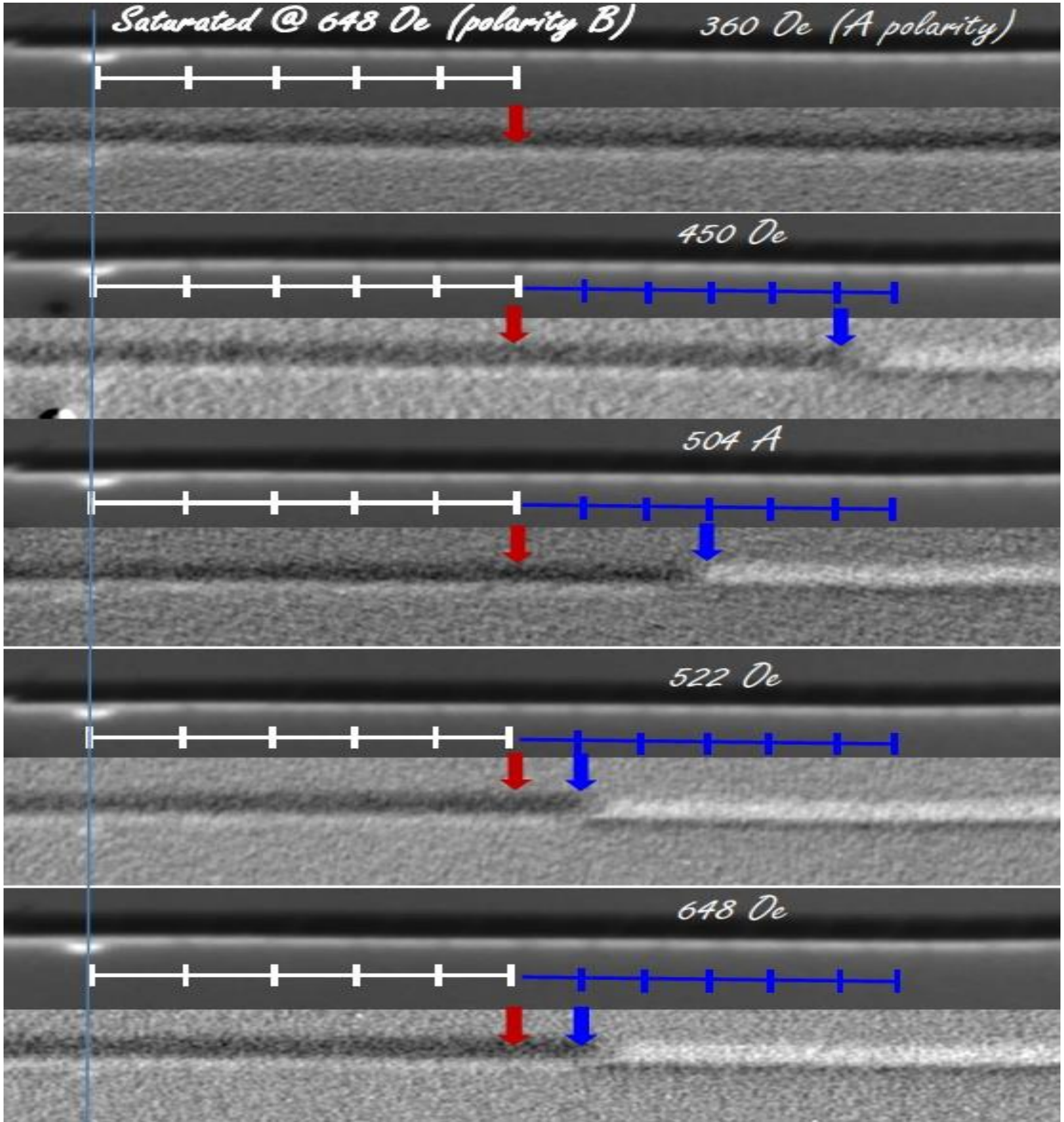
H applied

Unidirectional Reversal from short to longer segments in quantified steps

FeCo/Cu with increasing FeCo segment lenght from one end

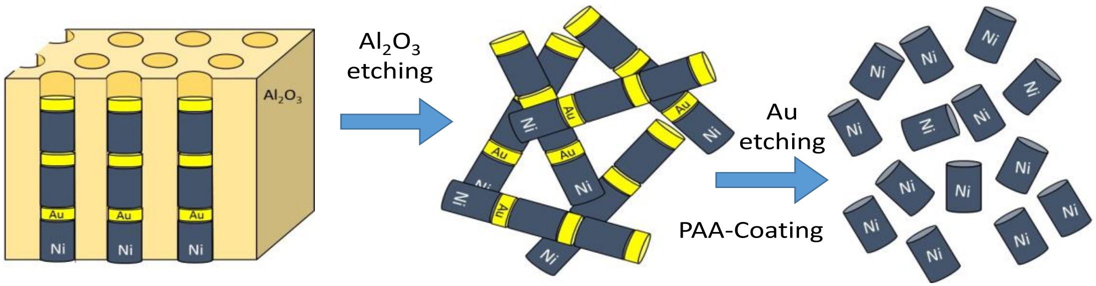
Stepped motion of the single domain wall (PEEM-XMCD)

Cristina Bran

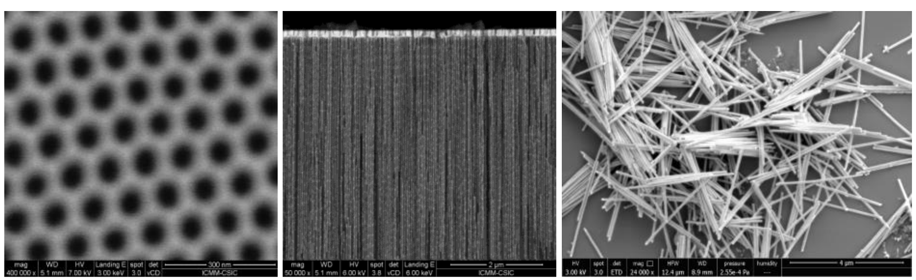


A colloidally stable water dispersion of Ni nanopillars as efficient T_2-MRI contrast agent

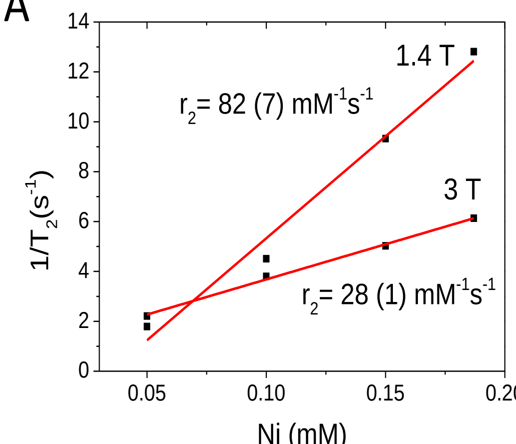
Bañobre, Rivas et al., J.Mater.Chem. B, 5 (2017)3283



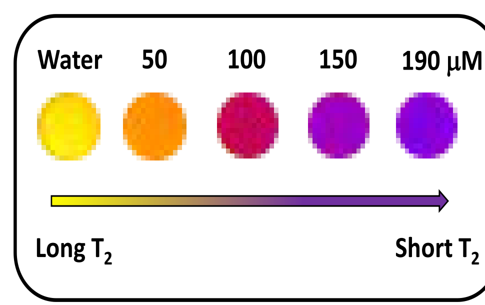
A B C



A



B



A) Transversal relaxivity (r_2) of a water solution of PAA-coated Ni nanowires at 1.41 T and 3 T at 37 ºC.

B) T_2 map of PAA-coated Ni nanowires acquired at 3 T and 37 ºC.

Contactos Hispanomericanos
Latin-American Workshops

my Taiwanese Magnetic Family

Spanish Moais

Ural Federal University

named after the first President of Russia B.N.Yeltsin

LABORATORY OF MAGNETIC SENSORS

The aim of the Laboratory of Magnetic Sensors is to become a world-class center for the development of new magnetic materials and effective functional transducers on their basis.

Under the supervision of Professor Vazquez, research is being conducted among others, on the following topics:

- Development of physical and chemical basis of synthesis technologies of new composite and film materials for sensor technologies.
- Magnetodynamics of nanostructured materials with high magnetic permeability: giant magnetoimpedance, ferromagnetic resonance, non-resonant magnetoabsorption.
- Functional polymer/magnetic nanoparticles composites (in collaboration with the Institute of Electrophysics of the Ural Branch of the Russian Academy of Sciences).
- Flexible magnetoelectronics.
- Magnetic nanoparticles for biological applications and magnetic biosensing.
- Film structure with exchange bias.
- Anodic alumina membranes with ordered pores.

The Laboratory is well equipped, including specific sample preparation equipment and different magnetometry characterization techniques. A big effort is being made to renovate some of the experimental facilities, including a new Kerr effect magnetometer or microwaves techniques.

Some of the research results obtained in the Laboratory have already

International Head

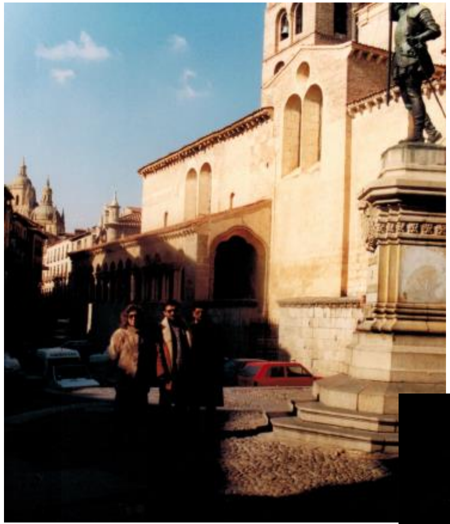
Dr. Manuel Vazquez Villabeitia
Professor of Research at the Institute of Materials Science of Madrid from the Spanish National Council for Research

UrFU Co-head

ir Vas'kovskiy
Department of Magnetism
ic Nanomaterials
Natural Sciences
skovskiy@urfu.ru

our Siberian Magnetic Sensors Lab.

Prof. to Univ. Wuhan, China



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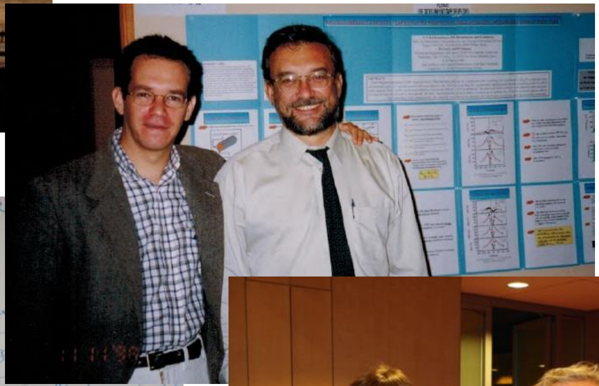
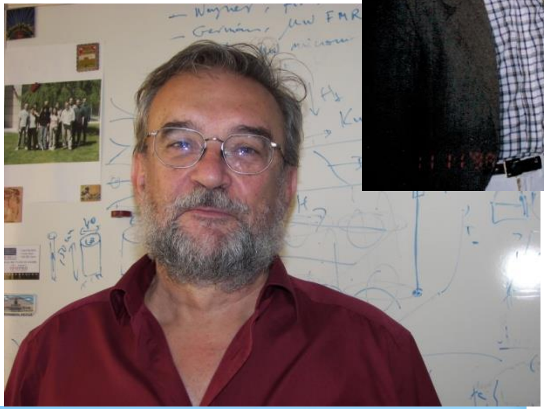
Th T01-D074





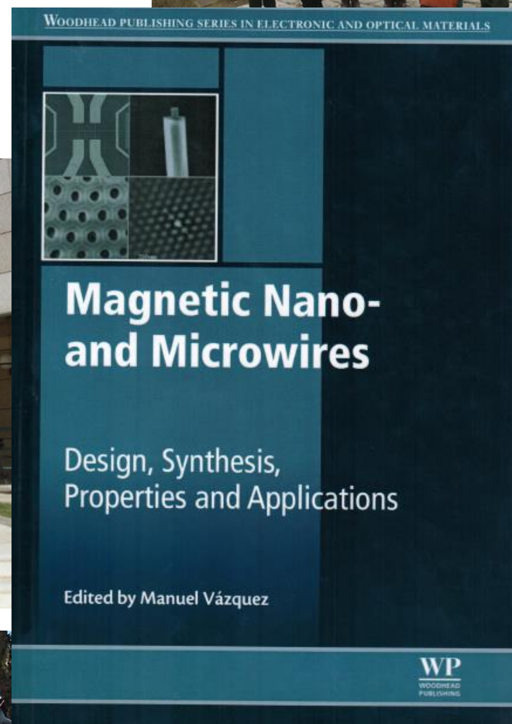
Recientes actividades de internacionalización

IUPAP, ICM 2015

IEEE Magnetics Society Summer School
Santander, 2017

INTERMAG 2017, Dublin

Grupo magnético: 20 doctores
30-40 postdocs y visitantes



IEEE Magnetics Society (http://www.ieeemagnetics.org/)

What is the IEEE Magnetics Society ?

a) One of 46 Societies/Councils from the IEEE (Institute of Electrical and Electronic Engineers)

b) MagSoc is the *52 Years old, worldwide largest (over 3,000 members) non-profit Association dealing with magnetics*

c) *Managed by Volunteers, supported by professional administration*

Presidency of IEEE Magnetics Society, 2017-18

IEEE MAGNETICS

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Governed by the Administrative Committee

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- Secretary
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24 Elected AdCom Members

+ 11 Committee Chairs

- Conferences (Intermag, MMM)
- Technical
- Honors & Awards
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- Membership
- Publicity
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- Chapters
- Nominations
- Publications (IEEE Trans Magn, Magn. Letters)

Join the Magnetics Society:

if interested, contact: Manuel Vazquez, at manuel.v.vazquez@ieee.org