YRinM 2022

6th Young Researchers in Magnetism

THE SPANISH MAGNETISM CLUB AND THE SPANISH CHAPTER OF THE IEEE MAGNETICS SOCIETY ANNUAL JOINT MEETING

November 17th 2022

CEMAG Club Español de Magnetismo

IEEE MAGNETICS

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6th Young Researchers In Magnetism

The annual meeting of the Spanish Magnetism Club and the Spanish Chapter of the IEEE Magnetics Society will be held in Cádiz (Andalucía, Spain).
The 6th Young Researchers in Magnetism, the traditional special session devoted to young researchers will take place during this meeting, on November 17th. This year, it is again organized for and by the young researchers.

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Program

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9:30 – 10:00	Opening Ceremony
10:00 – 11:00	Oral session 1 Think bigger
11:00 - 11:30	Invited Talk: Dr. María Salvador
11:30 – 12:00	Coffee Break

12:00 - 13:30	Oral session 2 Size matters
13:30 – 14:00	Invited Talk: Dr. Irene Morales
14:00 - 15:15	Lunch

15:15 - 16:30	Oral session 3 Small but feisty
16:30 - 17:15	Coffee Break & Poster Session
17:15 - 17:30	Invited talk 3: Dr. Elizabeth M. Jefremovas
17:30 – 18:00	Round Table Discussion
18:00 - 18:30	Closing Ceremony

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Think bigger

10:00	**S101:** Infrared Thermography for the Direct Characterization of Magnetocaloric Materials via Lock-in Procedure. **Jorge Revuelta**
10:15	**S102:** Influence of Magnetic Relaxation on Magnetoelastic Resonance Sensors. **Beatriz Sisniega**
10:30	**S103:** Field-induced spin wave reflection due to domain wall stretching in synthetic antiferromagnets. **Amina Hadjoudja**
10:45	**S104:** 3D-printing of Alternative Permanent Magnets using tuned MnAlC / hydrogel composite inks. **Zaida Curbelo**

Size matters

12:00	**S201:** Investigation of Fe and Bi effect on the evolution of $Ba_{0.95}Bi_{0.05}Ti_{1-x}Fe_xO_3$ (x=0.025, 0.050 and 0.075) electrical properties under frequency and temperature variation. **Hamida Gouadria**
12:15	**S202:** Effect of oxalate precipitating agent and water/glycerol mixture green solvent on structural, morphological, and magnetic properties of CuO nanoparticles. **Fatma Mabrek**
12:30	**S203:** Microwave-assisted ultra-stable to oxidation Ni_xFe_{1-x} nanoclusters in aqueous media. **Antonio Santana**
12:45	**S204:** Fine tuning of dipolar interactions in closely packed nanoparticle ensembles. **Raul López**
13:00	**S205:** Modelling surface effects on the dynamical magnetization of magnetic nanoparticles. **Pablo Palacios**
13:15	**S206:** The role of iron glycinate complex in fast microwave-assisted synthesis of different phases of iron oxide nanoparticles. **Jose Carlos Frade**

Small but feisty

15:15	**S301:** Detection and navigation control of magnetotactic bacteria under magnetic fields. **Danny Villanueva-Álvaro**
15:30	**S302:** In silico safety analysis of different metallic implants in magnetic hyperthermia treatments. **Irene Rubia**
15:45	**S303:** Gold coated magnetic nanorods under different electromagnetic stimuli. **Marina Lázaro**
16:00	**S304:** Study of different factors that affect photothermal measurements on 30 nm Fe3O4 iron oxide nanoparticles. **Daniel Arranz**
16:15	**S305:** Estimating the heating of complex aggregates of magnetic nanoparticles for hyperthermia. **Javier Ortega**

Poster session

P01: Effect of coexistence of different magnetic orders in $ZnFe_2O_4$ with a low inversion degree. **Miguel Ángel Cobos**
P02: Additive manufacturing of magnetocaloric 3D structures: A cost-effective way for printing cellulose-based metallic structures. **Bosco Rodriguez-Crespo**
P03: Laser writing lithography for magnetoelectric transport properties characterization on electrochemical deposited magnetic nanowires. **Yolanda Álvarez**
P04: Magnetization Reversal Process in Bi-modulated FeCo Cylindrical Nanowires. **João Fradet**
P05: Study of multilayer Solenoid Coils for Magnetic Hyperthermia Applications. **Jose Antonio Vílchez Membrilla**
P06: Anomalous Nernst Effect on Magnetic Multilayers with Flexible Substrate. **Cantia Belloso-Casuso**
P07: Improvement of Magnetic Force Microscopy Measurements Using 3D Nanowire Growth by Focused Electron Beam Induced Deposition. **A.T. Escalante-Quiceno**
P08: Real-time monitoring of breath biomarkers with a magnetoelastic contactless gas sensor: a proof of concept. **Álvaro Peña**
P09: Coercivity development in FeNiPC ribbons as a possible precursor for novel sustainable permanent magnets. **Carlos I. Fernández-Cuevas**
P10: Distinguishing local demagnetization contribution to the magnetization process in multisegmented nanowires. **Jorge Marqués-Marchán**
P11: Co-existence of hexagonal close-packed (HCP) and face-centered cubic (FCC) crystal structures Ni nanoparticles embedded in carbonaceous matrices. **Mona Fadel**

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BOOK OF ABSTRACTS

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Infrared Thermography for the Direct Characterization of Magnetocaloric Materials via Lock-in Procedure

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A large fraction of the total energy consumption is used by refrigeration and cooling devices, with demand expected to triple by 2050. While the conventional vapor compression is the widely extended refrigeration process, it presents two important disadvantages: low efficiency and the use of refrigerants with high global warming potentials that deplete the ozone layer. The magnetocaloric effect (MCE) constitutes one of the most promising alternatives due to its significantly higher coefficient of performance and environmental friendliness.

As it is fundamental that the magnetocaloric materials are accurately and efficiently characterized to implement them in refrigeration devices, this work focuses on developing measurement techniques for magnetocaloric material characterization, including infrared thermography (IRT) and the lock-in procedure for improving the signal-to-noise ratio. Contrary to indirect MCE measurements, such as magnetometry or calorimetry methods, IRT enables the implementation of dynamic tests and therefore the direct measurement of the reversible adiabatic temperature change, approaching the study to the behavior of the material in an actual refrigerator. It is also a non-contact technique, avoiding problems from the thermal mass of samples. A measurement device for MCE has been developed along with software for the analysing and post-processing the results. By using the lock-in technique, the noise level is reduced from 70 to 7 mK. Using gadolinium, the paradigmatic magnetocaloric material, the method is successfully validated as shown in **Figure 1**. The technique is further applied to characterize a custom-made (La,Ce)(Fe,Mn,Si)$_{13}$-H/polymer composite material, which is used for additive manufacturing [1].

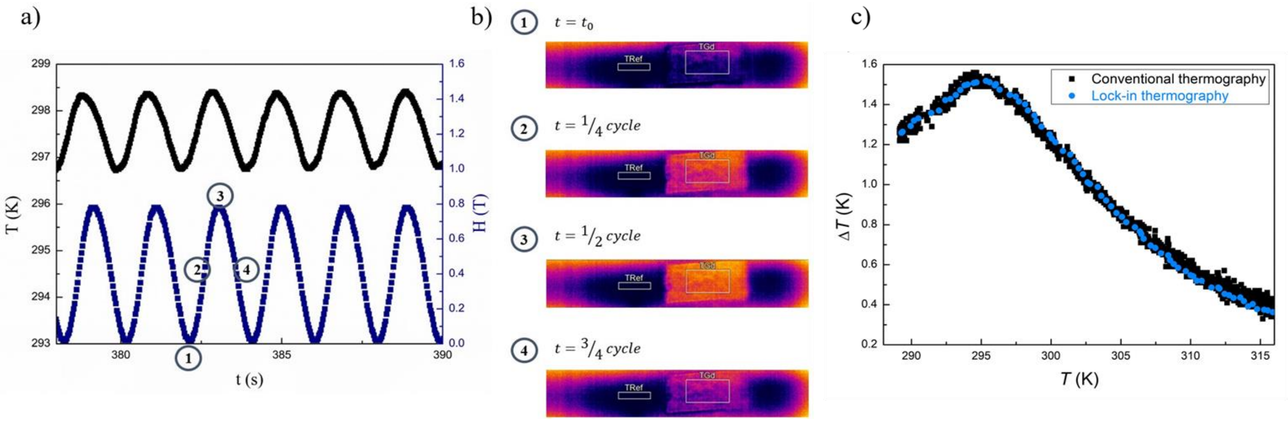

Figure . a) The change in the temperature of gadolinium sample upon variation of the applied magnetic field due to the MCE, b) the corresponding in-situ infrared camera measurements of the gadolinium sample at different stages, c) MCE of the gadolinium sample for 0.8 T as a function of temperature: results obtained by conventional (black) versus lock-in thermography (blue)

Acknowledgements

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Index Terms — Magnetocaloric effect, direct characterization, infrared thermography, lock-in, additive manufacturing.

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Influence of Magnetic Relaxation on Magnetoelastic Resonance Sensors

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Magnetoelastic resonance sensors are usually made of amorphous ribbon-shaped ferromagnetic alloys. In these materials, the magnetic and mechanical properties are strongly coupled, so that an elastic wave can be excited in them by the application of an alternating magnetic field and detected by the magnetic changes induced in it. Magnetoelastic sensors can enter in longitudinal resonance at specific frequencies of excitation, and this resonant behavior is highly sensitive to different external parameters, which can be used to design a number of different sensing systems [1].

Although these soft magnetic materials present excellent mechanical and magnetic properties, they suffer the phenomenon of magnetic relaxation [2, 3]. This time-dependence of the magnetization affects the resonance signal of the sensor and can mask the changes produced by the element to be detected, an important drawback of using these amorphous alloys as sensors (where stable properties are crucial). Nevertheless, this issue is not usually addressed in the literature concerning the application of such materials as sensors. In the present work, the influence of such a relaxing behavior is studied, at room temperature, for an amorphous ferromagnetic ribbon of composition $Fe_{73}Cr_5Si_{10}B_{12}$. The magnetic relaxation was observed by monitoring the evolution, under constant bias field, of the magnetoelastic resonance signal (Fig. 1a), and in particular, the value of the resonance frequency f_r (Fig. 1b), which is the parameter commonly used in the magnetoelastic detection. The relaxation was examined under different bias field values ($H = 4$, 7.8 and 10 Oe) and different amplitudes of the excitation field ($h = 20$, 42, 100 and 180 mOe). The study has revealed that relaxation has a considerable effect on the sensor signal, but is very sensitive to the conditions of the experiment. For instance, the amplitude of the excitation field is a key factor that influences this process. Larger excitation field amplitudes (≥ 100 mOe) resulted in a considerable decrease of relaxation times ($\tau < 460\ s$) and in a reduction of the variation in f_r ($\Delta f_r < 77\ Hz$). In addition, the effect of this relaxation on the sensor performance was evaluated for an experimental case of real-time detection of the evolution of a precipitation reaction. Besides, measurements of magnetic relaxation through the monitoring of magnetoelastic sensors signal turned out to be a novel, simple and accurate method for the study of magnetic relaxation processes of these materials.

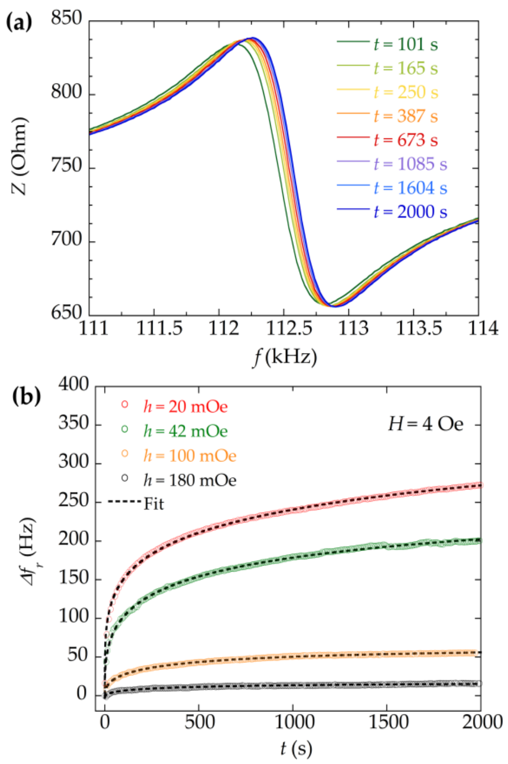

Figure 1: (a) Example of the changes produced in the resonance signal of the sensor due to magnetic relaxation during the measurement time under a constant bias field. (b) Temporal evolution of the resonance frequency of the sensor under constant bias field of Oe and different excitation amplitudes, and numerical fittings of the

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Index Terms — Magnetic relaxation, magnetoelastic resonance, magnetoelastic sensor.

Field-induced spin wave reflection due to domain wall stretching in synthetic antiferromagnets

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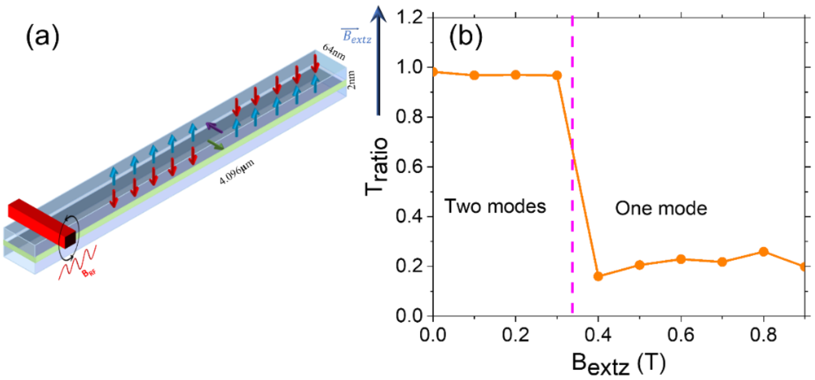
Synthetic antiferromagnets (SAF) are composed by two magnetics layers separated by a nonmagnetic spacer that produces an antiferromagnetic coupling (AF) between them. They are being investigated thoroughly these days because they present remarkable features, such as suppression of skyrmion Hall effect [1] or fast domain wall propagation [2]. From the point of view of magnonics they are also interesting because in the presence of a magnetic field they present two modes and they can be tuned by the strength of the antiferromagnetic coupling [3].

In this work we use micromagnetic simulations to investigate the interaction between spin waves and domain walls (DWs) in SAFs. The DW is initially located at the center of the nanostripe and the spin waves are excited at the left edge by means of a linearly polarized oscillating field mimicking the Oersted field generated by an AC current flowing perpendicular to the nanostripe (fig. 1a). When an out-of-plane field of 300 mT or above is applied, the DW reflects the spin waves very efficiently (fig. 1b). This effect is attributed to the sizable DW stretching exerted by the field, which tends to displace the DW in each layer in opposite directions. Our simulations show that the separation between them increases with the field and is larger than the DW width for applied fields above 0.8 T. The external field, therefore, significantly breaks the AF component at the DW position and, consequently, it acts as a barrier for the AF magnons that reach the DW wall.

We have systematically evaluated spin wave reflection and DW displacement as a function of both the applied field and the excitation frequency finding a large correlation between them. This is explained considering that the magnons transfer linear momentum to the DW when they are reflected, leading to the DW displacement moving away from the spin wave source. Both reflection coefficient and DW displacement increase with the applied field. Regarding the frequency dependence, the external field breaks the symmetry between the two AF modes and it is found that the lower branch, dominated by the layer in which the magnetization is antiparallel to the field, is largely responsible for the observed effect. Magnons from the upper branch, on the other hand, cross the DW without apparent reflection and they transfer their angular momentum to the DW, which leads to its displacement along the magnon flow, although their effect on the net displacement is very small as compared to the dominating effect from the lower branch. This is confirmed when each of the two modes is selectively excited using left and right circularly polarized rf field, respectively.

Figure 1: (a) Schematic representation of excitation of spin waves in a SAF that has a DW. (b) Spin waves transmission as a function of the applied field for an excitation frequency of 50 GHz.



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Index Terms — Synthetic antiferromagnets, spin waves, domain walls.

3D-printing of Alternative Permanent Magnets using tuned MnAlC / hydrogel composite inks

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3D-printing technologies allow for the fabrication of objects with high-performance and tailored properties with a minimal waste generation [1], motivating a great interest of high-tech sectors, such as transport, energy and aerospace. The manufacturing of permanent magnets (PMs) by 3D-printing requires high filling factors and preserving the PM properties along the fabrication process. PMs with the highest magnetic performance are based on rare earth elements, but due to their criticality, searching for rare earth-free alternatives is an urgent issue [2]. MnAl alloys are promising candidates with high availability and diminished environmental impact [3]. Recently, it has been demonstrated the potential of MnAlC alloy for developing alternative PMs by 3D-printing using the Fused Filament Fabrication (FFF) technology [4].

In this study, composite inks (Fig. 1a) have been synthesized by combining gas-atomized ferromagnetic τ-MnAlC particles as filler and hydrogel as matrix, and used for fabricating magnets by the Direct Ink Writing (DIW) technology. The Scanning Electron Microscopy (SEM) images of the composite inks show a smooth surface morphology with the quasi-spherical MnAlC particles homogeneously dispersed along the hydrogel (inset in Fig. 1b). The composite inks have been synthesized with tunable MnAlC particles loading, being possible to prepare highly filled inks exceeding 50 wt.% of MnAlC particles, by optimizing the content of the necessary additives [5] (Fig. 1a). Magnetometry measurements made by Vibrating Sample Magnetometry (VSM) have shown that the magnetic properties of the MnAlC particles are not deteriorated after the ink synthesis (Fig. 1b), 3D-printing and post-processing steps, showing similar coercivity (H_c) and magnetization scaling with particle content. 3D objects with different shapes and sizes have been fabricated by DIW (Fig. 1c) using the composite inks with a 50 wt.% content of MnAlC particles. The resulting 3D-printed objects show structural properties such as mechanical strength and degree of flexibility. The results obtained make of the synthesis of composite inks and the 3D-printing by DIW promising processes for their application in the development of a new generation of alternative rare earth-free PMs by additive manufacturing.

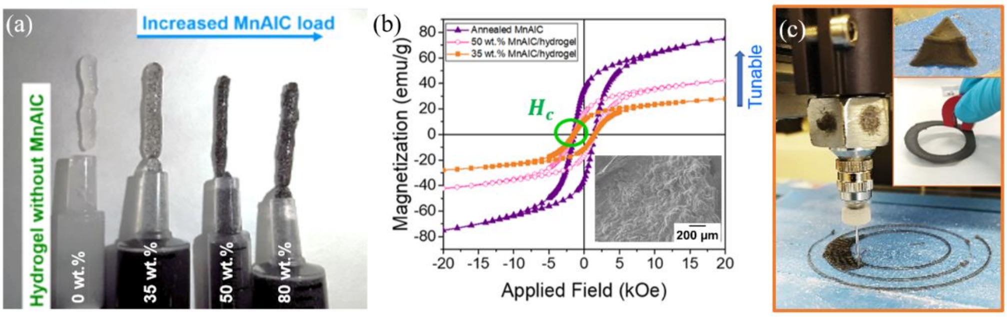

Figure 1. (a) Composite inks with different MnAlC particles load; (b) Room temperature hysteresis loops measured for MnAlC/hydrogel composites with 35 wt% and 50 wt% of MnAlC, compared to the hysteresis loop measured for the starting MnAlC powders (inset shows a SEM image of the MnAlC(50 wt.%)/hydrogel composite); and (c) image of the DIW 3D-printing process with insets showing images of 3D-printed magnetic MnAlC (50 wt.%)/hydrogel pieces with different shapes.

Acknowledgements.
Authors acknowledge Höganäs AB (Sweden) for providing the gas-atomized MnAlC particles through an industrial IMDEA-Höganäs collaboration, and the financial support from MICINN by *NEXUS* project (PID2020-115215RB-C21). E.M.P. acknowledges support from AEI by the JdC-I program (IJC2020-043011-I/MCIN/AEI/10.13039/501100011033) and EU by NextGenerationEU/PRTR.

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Index Terms — Permanent magnet, composite inks, MnAlC, hydrogel, 3D-printing
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How Magnetism Can Improve Rapid Diagnostic Tests

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The SARS-CoV-2 virus has generated an unprecedented need for rapid diagnostic tests to enable the efficient detection and mitigation of COVID-19 pandemic. In its first stages, the diagnostic was based on PCR or other techniques which were scarce, expensive and with the additional problem of the need of hiring trained personnel. The availability of the gold standard tests used at that time (i.e., PCR) hindered the response in well-funded health care systems. This situation was even more dire in low- and middle-income countries. Lateral flow assays (LFAs) appeared as the most promising rapid tests thanks to their low cost and ease of use. Traditional ones use gold or latex nanoparticles to detect the presence of the molecule of choice. In such a case, LFAs are limited to qualitative detection and lack the necessary sensitivity for low-concentration analysis (giving rise to frequent fake negative results), especially in complex biological matrices. The use of magnetic nanoparticles as detection labels coupled with magnetic sensors would improve both limitations [1].

Developing magnetic LFAs offers advantages (i.e., magnetic concentration of the analyte) and challenges (i.e., optimization for biomarker detection). Then, the quantification of the nanoparticles can be performed by different approaches thanks to the magnetic properties of the labels, which should be addressed without adding excessive complexity to the method. We have developed in our laboratory LFAs for real-world applications. Two recent examples will be presented in this talk: Detecting antibodies generated by SARS-CoV-2 and quantifying pneumolysin, the protein that indicates pneumococcal pneumonia in urine [2]. A radio-frequency inductive sensor based on a planar coil to both excite and detect the particles was used for that purpose. Other sensing approaches, such as magnetoresistive (MR) sensors are of great interest. MR sensors, which are based on ultrathin layers of specific composition, offer high sensitivities. In addition, combined with the standard complementary metal–oxide–semiconductor (CMOS), MR sensors can be successfully integrated into chips and microelectronic circuits, providing compact, high-performance sensing and large-scale manufacturability at low cost. These properties will allow the development of point of care devices suitable for healthcare, food safety and environmental control.

Acknowledgements (Times New Roman 11 points)

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Investigation of Fe and Bi effect on the evolution of $Ba_{0.95}Bi_{0.05}Ti_{1-x}Fe_xO_3$ (x=0.025, 0.050 and 0.075) electrical properties under frequency and temperature variation.

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Perovskite materials with general formula ABO_3 have attracted the attention of various researchers due to theirs different properties as ferroelectric, dielectric, magnetic, multiferroïc…[1-3]. Multiferroïc materials are defined as materials in which more than one ferroïc order (ferroelectric, ferromagnetic, ferroelastic) coexist[4]

In this study, multiferroïc samples $Ba_{0.95}Bi_{0.05}Ti_{1-x}Fe_xO_3$ was elaborated using sol gel method. The samples were sintered at 1000°C for 2 hours. They were characterized using X-ray diffraction, Scanning Electron Microscope and impedance complex spectroscopy. The prepared samples were crystallized in a tetragonal structure with space group *P4mm*. The average crystallite size calculated by Debye-Scherrer were found in nanoscale dimension and increases by introduction of strain. From SEM micrograph, the grain size was estimated to be in microscale dimension which indicates the presence of many grains. The incorporation of Fe^{3+} into Ti^{4+}sites is proved by the apparition of several peaks corresponding to Fe-O in the characteristic band Ti-O. The dielectric constant versus temperature plot revealed the existence of two transition phases: the first one is ferroelectric-paraelectric transition phase (T_{F-P}) and the second is transition from ferroelectric orthorhombic to ferroelectric tetragonal phase (T_{O-T}). Dielectric and complex impedance have been studied at temperatures ranging from 450K to 650K. Jonscher's augmented equation for x=0.025 and Jonscher's power law for x=0.075 were used to fit ac conductivity. To represent the conduction mechanism of both compounds, the Non-Overlapping Small Polaron Tunneling (NSPT) model is appropriate.

***Keywords*:**

Dielectric properties, AC conductivity, NSPT model, Activation energy, VRH model.

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Effect of oxalate precipitating agent and water/glycerol mixture green solvent on structural, morphological, and magnetic properties of CuO nanoparticles

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Copper oxide has long been a special material because of its unique structural features and original physico-chemical properties especially in magnetism [1, 2]. The present study aims to the integration of "oxalic conversion" route in "green chemistry" for the synthesis of copper oxide nanoparticles (CuO-NPs) with controllable structural, morphological, and magnetic properties. Two oxalate-containing precursors ($H_2C_2O_4.2H_2O$ and $(NH_4)_2C_2O_4.H_2O$) and different volume ratio of mixed water/glycerol solvent were tested. Thermogravimetric analysis (TGA) and Fourier Transform Infrared Spectroscopy (FTIR) suggest the formation of pure CuO-NPs at the temperature of 400°C. The purity was then confirmed by X-Ray Powder Diffraction (XRPD) and crystallite sizes were calculated using Scherrer method. Transmission Electron Microscopy (TEM) images revealed oval-shaped CuO-NPs and Scanning Electron Microscopy (SEM) showed that morphological features of copper oxalate precursors and their corresponding oxides were affected with glycerol (V/V) ratio as well as $C_2O_4^{2-}$ starting material type. The magnetic properties of CuO-NPs were determined by measuring the temperature dependence of magnetization as well as the hysteresis curves at 5 and 300 K. The obtained results show simultaneous coexistence of dominant antiferromagnetic and weak ferromagnetic behaviour.

Acknowledgements

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Microwave-assisted ultra-stable to oxidation Ni_xFe_{1-x} nanoclusters in aqueous media

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Metal alloys with high magnetic permeability offer a wide range of applications in technology, such as electromagnetic shielding or energy storage. Down to the nanoscale, the number of applications of this type of materials grows exponentially, enabling magnetic inks for 3D direct printing, more capable catalysts, magnetic hyperthermia agents, or tags for cell labelling. The higher the permeability, the greater the response of the material to an applied magnetic field, being more effective. This would allow to reduce the amount of material that is required for a particular application. Metal alloys have difficulties in biological environments as a result of strong oxidising conditions. Some ways to solve this problem are to coat metals with different materials such as silica, organic polymers or even graphene to create a protective layer against oxidation[1],[2].

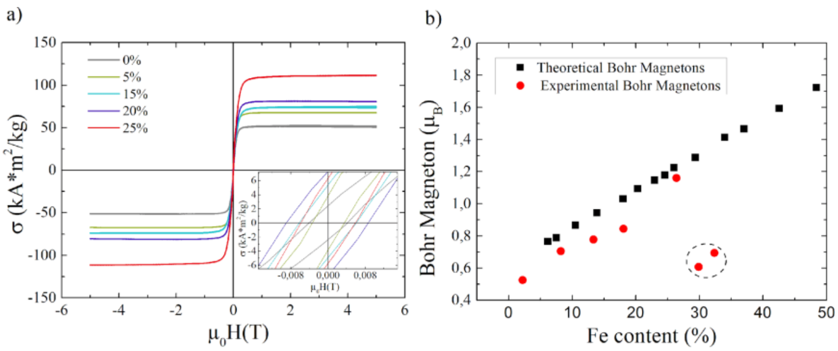

Figure. a) Hysteresis loops at 300 K of samples with 0, 5, 15, 20 and 25% Fe content. b) Variation of the experimental atomic magnetic moment (M_{NiFe}) values with the Fe content in the Ni_xFe_{1-x} nanoclusters (red circles) and as described by the theoretical Slater-Pauling.

In our research, we achieved a method to obtain oxidation resistant **Ni_xFe_{1-x} nanoclusters** that features high permeability and saturation magnetisation. This protection is given by the 1,12-dodecanediol, which coats Ni_xFe_{1-x} nanoclusters and precludes corrosion due to its reducing character. The microwave reactor-assisted synthesis method consists of a 10-minute single step method in aqueous media, where the stoichiometry of the metal nanoparticles can be controlled by changing metal precursors.[3]

Acknowledgements

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Fine tuning of dipolar interactions in closely packed nanoparticle ensembles

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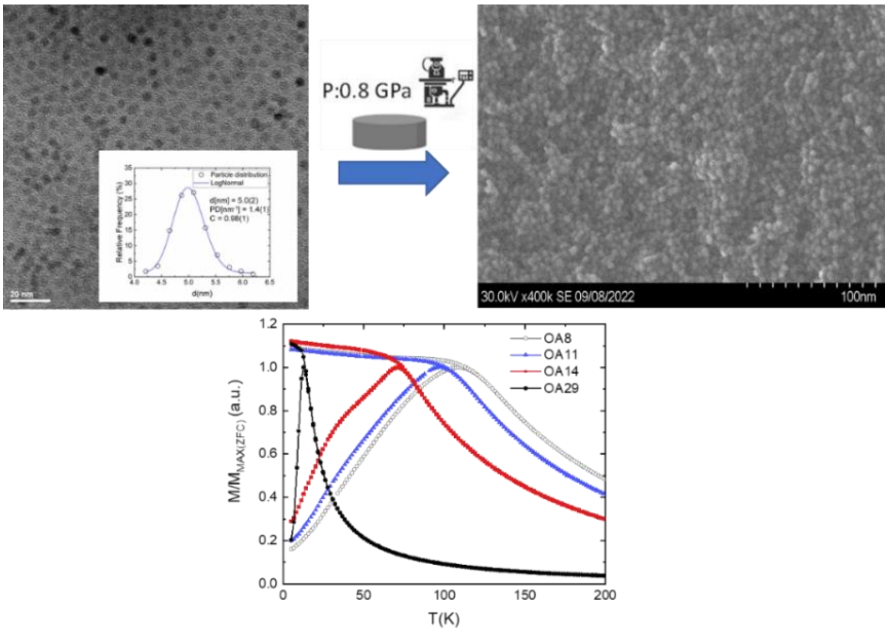
In nanotechnology, the control of the individual or collective-like magnetic response of an assembly of nanoparticles (NPs) is important for various applications[1], [2]. Here, a series of monodisperse maghemite (γ-Fe_2O_3) nanoparticles (5 nm in diameter) with different content of surface-bound oleic acid (from 29 wt% to 8.2wt%) were pressed to form closely packed particle ensembles. These discs show super-spin glass (SSG) behavior, that is collective behavior, as observed in previous studies[3], for all the series but the disc corresponding to the 29 wt% surfactant. In principle, the progressive removing of the oleic acid would allow the tuning of the interparticle distance and thus the dipolar interactions at the origin of the SSG behavior [4]. Thus, in this contribution, different indicators of the 'dipolar strength' (namely, the peak temperature of the ZFC curve, the ZFC memory and δM curves dip depths) are evaluated from DC magnetic measurements. AC magnetic measurements are also performed to study the SSG transition in the samples. All these measurements show an increase in all those proxies with the packing fraction (i.e. with dipolar interactions). Interestingly, the coercivity of the samples also increases with the strength of the interactions, in contrast to other results in the literature [5].



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Modelling surface effects on the dynamical magnetization of magnetic nanoparticles

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Recent years have witnessed an increasing number of biomedical applications based on magnetic nanoparticles (MNPs) dispersed in colloidal suspensions. In this context, Brownian motion of MNPs in fluids is coupled by long ranged hydrodynamic and magnetic interactions. In this work, we present an efficient scheme for simulating this kind of systems implemented in a high-performance GPU code (UAMMD) [1]. By solving these complex dynamics, our numerical simulations permit to simulate multitude of experimental systems. In particular, we have applied our model to simulate the surface effects on dynamical magnetization of MNP formulation with distinct magnetic nanocrystal (magnetite and cobalt ferrite) and surfaces (non-coating, and dextran and streptavidin coating) (see Figure 1a).

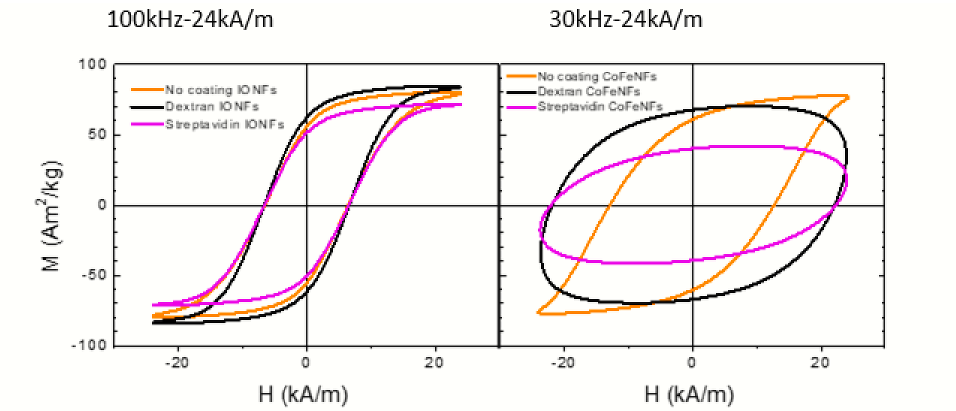

Figure 1.a) AC hysteresis loops of non-coated, and dextran and streptavidin coated iron oxide and cobalt ferrite nanoflowers dispersed in aqueous solution at 1 g/L magnetic element concentration under alternating magnetic fields (100 kHz-24 kA/m and 30 kHz-24 kA/m).

When MNPs are subjected to AC magnetic fields at radio frequencies (10-100 kHz), there is a phase-lag between the MNP magnetic moment and the external magnetic field, resulting in an opening of AC magnetization cycles (see Figure 1b). The shape of the MNP AC hysteresis loops depends on the magnetic relaxation and hydrodynamic properties of MNPs. Indeed, we have observed the shape of the loops, and hence their area, is very sensitive to changes in the diffusion of the particles when MNP magnetic moments relax via Brownian process. By contrast when the magnetic moments of the particles relax via Neel process the loops almost do not vary with the diffusion coefficient of the particles. Exploiting this phenomenon, we have been able to detect the presence of the analyte in the solution.

Acknowledgements

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The role of iron glycinate complex in fast microwave-assited synthesis of different phases of iron oxide nanoparticles

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The production of magnetic nanoparticles for use in humans is subjected to stringent requirements by the regulatory authorities as part of their approval process. The relevant parameters and conditions – especially for iron oxides - to the synthesis are known, but parasitic phases appear at times even in reactions that are carried out using the most popular methods. This entails additional post-production separation and purification steps, with the subsequent increase in economic and time costs.

Following an aqueous microwave synthesis method based on the use of glycine, it has been found that by using glycinates we can avoid the formation of parasitic phases within the same reaction. It is hypothesised that glycine protects iron from forming early aquocomplexes or oxohydroxides, also allowing a homogeneous size distribution in the resulting nanoparticles. This is particularly interesting to prevent premature reactions when precursors are mixed. Furthermore, glycine also serves as a surfactant, limiting the growth of unwanted clusters and favouring the formation of nanoparticles of a few nanometres in size.

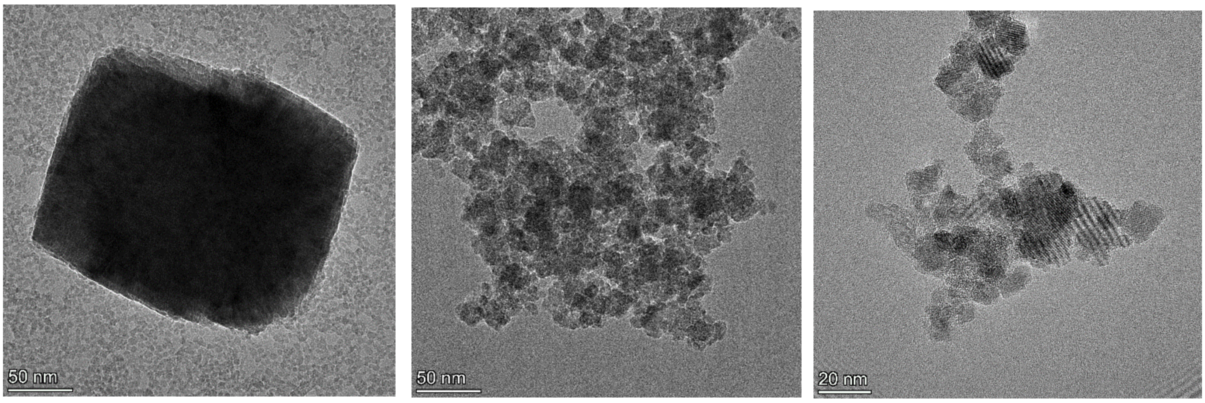

Figure 1. *TEM pictures of the synthesized hematite (left), maghemite (right) and magnetite (centre) nanoparticles by the proposed glycine-based microwave method.*

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We acknowledge support from the Ministry of Science through the grant PID2020-117544RB-I00 and the Ramón y Cajal grant RYC2018-025253-I.

An insight on magnetic nanocrystal hydrogels and aerogels: bridging the nano- to the macro-scale

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The assembly of inorganic nanocrystals (NCs) into macroscopic self-supported networks, either hydrogels or aerogels, constitute a new interesting type of materials, characterized by their low density, large specific surface area and open porous structure [1]. Therefore, in these materials it is possible to exploit the nanoscopic properties of the building blocks in the macroscopic scale, either preserving these nanoscopic properties or exhibiting collective properties that are not present neither in the NCs alone nor in the bulk material. Depending on the building blocks of the so-called aerogels, their coatings and design, they can be of interest for applications such as catalysis, sensing, energy harvesting, environmental remediation and biomedicine.

The formation of NC-based gels is done synthesizing high-quality NC colloids by wet-chemical routes, followed by their controlled destabilization in order to get the NC assembled together into self-supported highly porous networks. In this talk, different magnetic NC-based gels will be introduced, while the focus will be on the synthesis and structural and magnetic characterization of maghemite NC-based gels (Figure 1). For the gelation, a versatile and universal amphiphilic polymer coating strategy will be shown, which allows to perform the water transfer of the NCs avoiding ligand exchanges [2]. Finally, the importance of the structure and the magnetic interactions between the NCs in the final gel properties will be highlighted and different applications will be discussed.

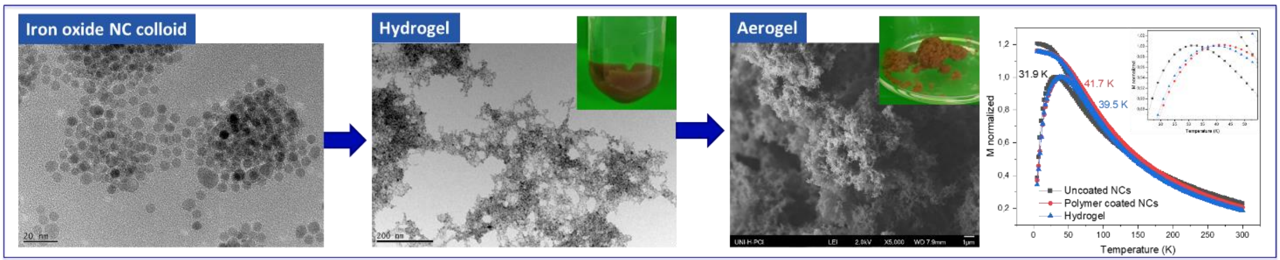

Figure 1: TEM images of the γ-Fe_2O_3 NC colloid and hydrogel, SEM image of the aerogel and SQUID measurement (ZFCFC) of the uncoated NCs, polymer coated NCs and hydrogel.

Acknowledgements

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Detection and navigation control of magnetotactic bacteria under magnetic fields

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Magnetotactic bacteria (MTB) are microorganisms with the ability to align and navigate along geomagnetic field lines to reach hypoxic regions. To develop this ability, MTB biomineralize magnetic nanoparticles, called magnetosomas that organize forming a chain to respond optimally to an external magnetic field. The intrinsic properties of MTB, such as self-propulsion, aerotaxis, and their capability to grow and proliferate in regions with low oxygen concentrations, make them suitable as bioagents for potential anticancer applications. In addition, the presence of the magnetic chain allows controlling their navigation. All these characteristics explain why MTB are considered as a promising nanobiorobots for biological applications [1,2]. The latter indicates that MTB nanobiorobots could be employed as localized drug transport, tumor monitoring agent, and even in cancer treatments (magnetic hyperthermia) [3,4].

However, its activity as a bioagents is limited by its navigation control [5]. Trying to shed light on this matter, in order to study their mobility we have developed software algorithms for the automatic detection and tracking of magnetotactic bacteria, applying image-sequencing techniques to the analysis of videos acquired by optical microscopy. We have worked with two different species *(Magnetospirillum gryphiswaldense* and *Magnetospirillum magneticum*) in different biological media, supplying controlled flows to emulate blood stream. In addition, we have precisely controlled the magnitude and direction of the external magnetic field applied to regulate navigation and evaluate their swimming capacity.

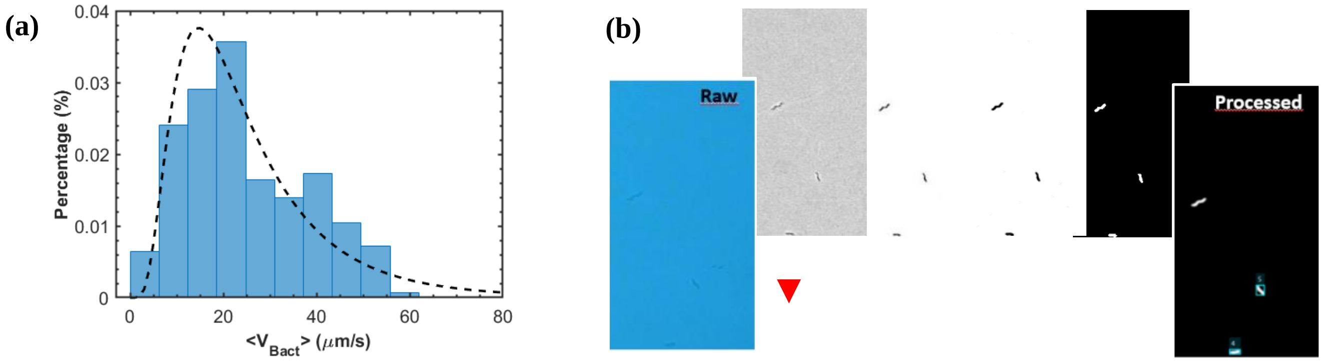

Figure 1: (a) Percentage histograms (%) of the swimming velocity of *Magnetospirillum gryphiswaldense* under a magnetic field of 6.4 mT. **(b)** Image processing steps from a raw to a processed image with MTB.

Acknowledgements

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Index Terms — Magnetotactic bacteria, *Magnetospirillum gryphiswaldense*, *Magnetospirillum magneticum*, navigation control of MTB.

In silico safety analysis of different metallic implants in magnetic hyperthermia treatments

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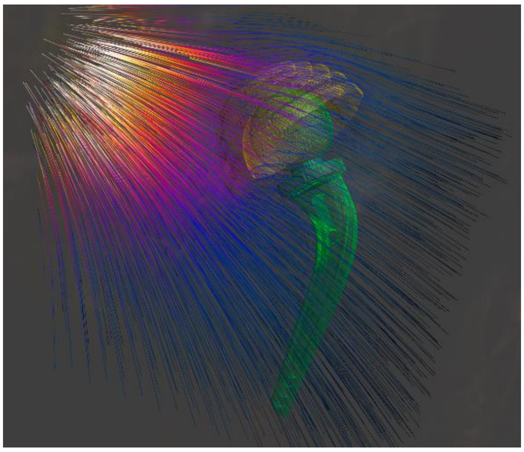
Magnetic hyperthermia (MH) is a nanoparticle-driven therapy that uses the heat released by magnetic nanoparticles under an alternating magnetic field exposure to induce apoptosis in cancerous cells. It has been and is being trialled as an adjuvant for the standard of care to successfully treat several types of localized tumours [1, 2]. Computer simulations (in silico testing) in MH can predict the thermal dose of several clinical setups in a cheap and fast way. This allows for analysing the treatment safety in terms of dosimetry and temperature rise, as well as assessing possible hot spots due to induced currents, leading MH on its way towards personalized medicine.



The versatility of the simulations to evaluate many clinical situations allows us to study the actual risks of the current exclusion criteria [1, 3]. Nowadays, bearing any kind of metallic objects, such as orthopaedic implants, constitutes an absolute contraindication for the treatment. This is based on the knowledge obtained from MRI-related studies, but there is an important lack in the literature about the quantification of these risks in the context of clinical MH.

In this work, we studied the actual risks of potential MH patients carrying different metallic prostheses using computer simulations. We also analysed the influence of the presence of these objects in the effective magnetic field during the therapy. We have considered different treatment setups varying target sites, implant types and materials to evaluate the temperature increase and the dosimetric values in the major tissue groups. Finally, using these safety parameters, a multi-criteria decision analysis has been performed to asses a risk index for each tissue group in every clinical situation analysed [4, 5].

Acknowledgements

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Index Terms — Magnetic hyperthermia, eddy currents, medical implants, electromagnetic dosimetry, in silico.

Gold coated magnetic nanorods under different electromagnetic stimuli

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Magnetic nanoparticles (MNPs) have been widely used in many different fields, but one of their potential uses is in biomedicine, mainly in research into the treatment and diagnosis of cancer. These nanoparticles respond to magnetic fields and allow the possibility of directing them to certain parts of the body and keeping them there while they perform their therapeutic function, one of their most important characteristics in this area.

In addition, in the case where an alternating magnetic field is applied, the technique will be called magnetic hyperthermia. These ac fields usually have intensities around 20 kA/m and frequencies of 100-200 kHz. Their application produces a loss of energy in the form of heat that can be localized in the tumour and cause cancer cell death (42-46°C) [1].

Another possible source of local heating is called photothermia. In this technique, the MNPs are subjected to the action of a beam of light of appropriate wavelength and intensity [2]. The particles can absorb part of this radiation (visible or IR) and re-emit it in the form of heat. Both electromagnetic stimuli can be used separately or together to enhance the desired response, which we call dual therapy [3].

In this work we present the synthesis and characterization of magnetic nanorods (MNRs). They are coated with a polymeric triple layer, improving their biocompatibility, and with gold seeds (Fig 1a) [4,5]. The MNRs and subjected to magnetic hyperthermia, photothermia and a mixed technique of both and the specific absorption rate (SAR) of each technique is evaluated (Fig 1b). Moreover, their drug release is evaluated using these techniques.

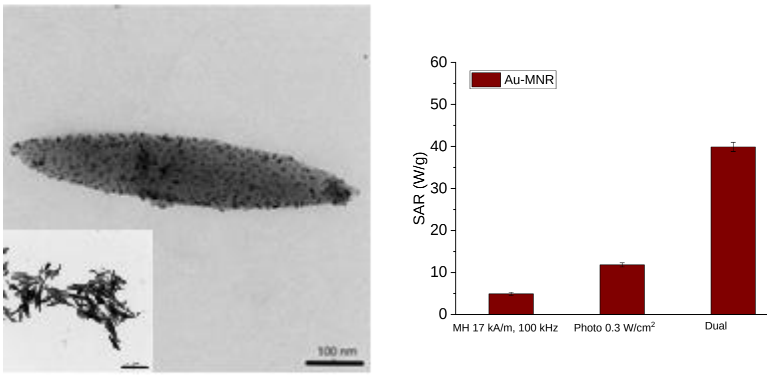

Figure 1. HRTEM image of gold coated nanoparticles (a) and comparison between SAR values of magnetic hyperthermia, photothermia and dual techniques (b).

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Study of different factors that affect photothermal measurements on 30 nm Fe_3O_4 iron oxide nanoparticles

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Studies on the photothermal behavior of iron oxides under the irradiation of infrared lasers are a current and active topic of study. Significant progress is being done by varying the size of nanoparticles, studying different morphologies, or testing different organic or inorganic coatings [1, 2]. These advances bring us closer to future biomedical applications [3]. However, it has been observed that several important factors that are relevant for the measurements are not usually considered in the description of the experimental setups.

This work aims to investigate different factors that can affect photothermia measurements. In particular, some factors which are generally not considered in existing works. Measurements have been performed on a 30 nm magnetite sample using two lasers, one at $\lambda = 800$ nm and the other at $\lambda = 1064$ nm, thus working in the two biological windows. Measurements have been made in vessels with the same geometry, but different sizes to analyze the effect of volume on the sample heating efficiency (SAR). Also, we studied the behavior of the sample when irradiated with the same intensity (W/cm^2), but with different power. We have observed that these factors remarkably affect the results of the measurements. These results suggest that standardization of measurements should be considered in the future.

Acknowledgments
This work was supported by Projects FIS2017-87360P and RTI2018-095856-BC21. We also acknowledge the Sistema Nacional de Garantía Juvenil for providing the predoctoral contract through the Comunidad Autónoma de Madrid (PEJ-2020-AI/IND-17711).

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Estimating the heating of complex aggregates of magnetic nanoparticles for hyperthermia

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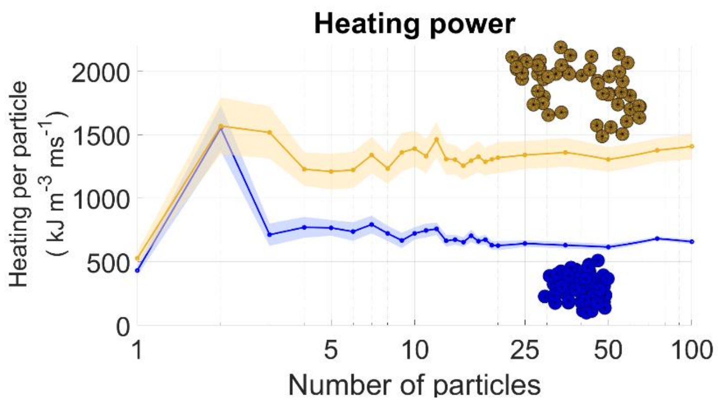
Clinical studies using magnetic nanoparticles must meet strict safety regulations that require knowledge and control of the particles [1]. Because the behaviour of nanoparticle aggregates is different from their unclustered counterparts, one of the challenges in magnetic hyperthermia is controlling the heat generated by nanoparticle clusters.

In silico approaches are often used to optimize treatment parameters, but these suffer from the drawback that methods that account for single particle dynamics are not capable of simulating the large number of particles used in therapy, whereas simulations at large scales require the use of effective parameters that are difficult to assess to correctly estimate the heating.

Our work closes the gap between both approaches by studying the heating of nanoparticle clusters, as found in biological tissues [3], allowing to translate results from small clusters to practical cases. Building on our previous work [4], we simulate magnetic nanoparticle clusters with different shapes and sizes.

Our results suggest that starting from relatively small clusters of about 25 particles, the heat released per particle tends to converge to a value which depends on the shape of the clusters, where those clusters that are more elongated release more heat than the compact ones.

This work shows that it is possible to predict the outcome of large clusters of particles of any shape based on a simulation of a moderately sized cluster with the same geometrical and magnetic parameters. Our results can complement ongoing projects [4] to perform multi-scale simulations that to make accurate estimates of the heat released by magnetic nanoparticles during magnetic hyperthermia, leading to the optimization of the treatment.



Heating power as a function of the number of particles in the aggregate for two different aggregates.

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Index Terms — Magnetic nanoparticle hyperthermia, micromagnetic simulations, fractals, particle aggregates.

How to get a life after PhD

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We are all aware about how to get a PhD grant. FPU or FPI acronyms mean something to every one of us, and there might be even the case that some of us have already applied (even several times) for them. Nevertheless, very little is known about what comes after the PhD. There is usually an abrupt change, first order transition, from the last months of PhD, writing the manuscript and preparing the Thesis Defense (hectic and sinusoidal-emotional phase), to a “no-man’s land” phase, where the new and fresh Doctor does not really know what to do with such a degree (apart from the typical joke of being an useless Doctor in an emergency situation).

In this talk, I will explain where and how to find Postdoctoral Fellowships/positions, explaining in closer detail some selected ones among them. Details on the duration, salary and procedures for application will be provided. Besides, some personal remarks on how to choose a Project that may seem tailored made to yourself will be provided. Indeed, the latter are on my own, based on my mindset and experience so far, so the participants are more than welcome to share and make any comment, questions or point of view they might have.

Acknowledgements

Elizabeth Martín Jefremovas was supported by the Alexander von Humboldt Foundation Postdoctoral Fellowship

Round table: Science and life

Speakers: Agustina Asenjo[1], Arantxa Fraile[2,3] and Montserrat Rivas[4]

Moderator: Elizabeth Martín Jefremovas[5]

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Dr. Asenjo, Dr. Fraile and Dr. Rivas are three of the most well-known scientists in the Spanish Magnetism community. Their contributions to understanding fundamental aspects of magnetism [1], so as the different strategies developed to implement their knowledge towards instrumentation [2] or biomedical applications [3] have pushed further the limits of knowledge and technology. At the same time, these three experts are also well-known, reputed and valued for their human qualities. Although publishing is usually the gold-standard used for rating a scientific career, living a life that is worth it goes beyond filling-in a LaTeX template. Is it possible to balance a successful scientific career with a joyful life path?

In this round table, we will have the opportunity to ask these three experts how they managed to put these aspects together. To ease the discussions, we will follow a three-blocks structure, each of them starting with a "big-frame" question:

1. Where did you develop your Postdoctoral stay? How was the experience?

2. How did you get your current position? How do manage to balance your scientific career and your life-side? Have you ever found an hindrance because of your gender?

3. What would you say to 25-year-old you?

Students are encouraged to ask any question they might have and participate from this round-table actively. Remember, there are no "stupid" questions, no referees allowed in the room 😉! We believe this round table as a way to bring outstanding scientist closer, building bridges between the present we live in and the future we want to be.

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Effect of coexistence of different magnetic orders in ZnFe2O4 with a low inversion degree

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Zinc ferrite have a spinel structure $(Zn_{1-\delta}Fe_{\delta})^A[Zn_{\delta}Fe_{2-\delta}]^BO_4$, where A and B represent tetrahedral and octahedral sites and δ is the inversion degree. At equilibrium, this ferrite type is denominated 'normal' because divalent cations (Zn) are on the tetrahedral sites and iron (Fe) at the octahedral ones. However, if ferrite size is reduced to nanometric scale, some disorder is induced and δ increases. It has been recently reported that the magnetic properties of the nanoparticles are independent of the synthesis procedure and it depends solely on δ. Therefore, after any synthesis route, δ can be gradually modified through mechanical and thermal treatments [1].

Magnetic properties of the spinel ferrites are governed by the type of cations on the A and B sites and the magnetic interaction between them through the O^{2-} anions. It is elsewhere reported that exist three possible kinds of super-exchange interactions, namely J_{AA}, J_{BB} and J_{AB}, between cations in A and B positions, and J_{AB} is the stronger. Therefore, when a single iron cation jumps from octahedral to tetrahedral site, the rest iron cations in octahedral arrange antiparallel to the tetrahedral iron site.

In this work, the magnetic behaviour of $(Zn_{1-\delta}Fe_{\delta})^A[Zn_{\delta}Fe_{2-\delta}]^BO_4$ with $\delta \sim 0.05$ to 0.15 has been investigated with the microstructural properties by X-Ray diffraction (XRD) and Neutron powder diffraction (NPD) at low temperatures. Is has been determined the coexistence at low temperatures of antiferromagnetism (AFM) and ferrimagnetism (FM) phases [2]. Considering this behaviour, a subsequent calorimetric study leads to discover a hidden magnetic entropy [3] originated by frustrated magnetic moments and, finally, an anomalous Curie-Weiss temperature produced by ferrimagnetic clusters [4]. These characteristics lead to improve the structural comprehension of this material that is formed by **FM clusters, AFM and spin-glass interphases (figure)**.

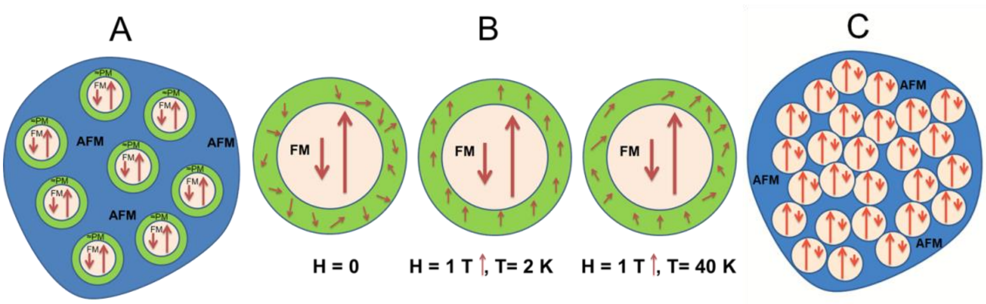

Figure. (**A**) magnetic arrangement of ZFO-0.05 sample, white circles representing ferrimagnetic particles, the blue area is AFM converted to PM at 40 K, and the green crown represents the disordered interphase between AFM and FM regions; (**B**) Different orientation of interphase area depending on the applied field (0, 1 T), and temperature; (**C**) Magnetic arrangement of ZFO-0.27 with percolating FM clusters and blue AFM regions.

Acknowledgements

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Additive manufacturing of magnetocaloric 3D structures: A cost-effective way for printing cellulose-based metallic structures.

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Solid-state refrigeration based on magnetocaloric effect is seen as a potential alternative to current less-efficient gas expansion-compression based conventional refrigeration. The heat exchanger, the functional element of this kind of refrigerator, is composed by the magnetocaloric alloy. Additive Manufacturing (AM) is a useful technique to build efficient heat exchangers, and since current AM techniques are expensive and energy consuming a cost-effective way has to be explored.

In this work, we developed original inks and implemented printing technique to print 3D metallic structures that would act as the heat exchanger of a magnetic refrigerator, printing at room temperature in a green and a cost-effective way using various metallic powders (including magnetic and magnetocaloric powders), and cellulose as matrix with water as dissolvent. The magnetocaloric ink containing more than 90 wt.% of powder was elaborated by achieving an optimal viscosity whereby high maximum number of layers (250 layers reached) with highest printing resolution (0.5mm wall thickness) was obtained. The elaborated technological route of the treatment of printed structures included: (i) special heat treatments to dry printed structures so the polymer was removed by calcination followed by a sintering to get entirely metallic structure, and (ii) electrodeposition of nickel to protect printed structure from any corrosion. We also demonstrated that any incorrectly printed workpiece can be recycled re-dissolving it in the water so material loss is reduced significantly making the printing more cost-efficient and environmentally friendly.

Laser writing lithography for magnetoelectric transport properties characterization on electrochemical deposited magnetic nanowires

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Spintronics is a multidisciplinary research field that studies, among others, the spin of the electron and magnetoelectric effects influencing the features of electric transport behaviour in magnetic materials. At the end of the 20th century, spintronics was postulated as a potential solution to the intrinsic limitations of modern microelectronics to increase the density of data storage. If not only the charge but also the spin of the electron is considered, the amount of data transferred per electron scales up. Moreover, the possibility of controlling the magnetization reversal of a material with a spin polarized current through the Spin Transfer Torque (STT) mechanism can speed up data manipulation processes [1]. To successfully interact with magnetic domain walls, high current densities must be used, which makes magnetic nanowires excellent candidates due to their extremely small cross section. To study the transport properties on single nanowires, a specific protocol must be followed for placing electrical contacts on isolated nanostructures avoiding especially the electric contact resistance and contact oxidation drawbacks [2]. Barcoded ferromagnetic Pt/Ni/Pt nanowires covered with a thin SiO2 layer protection and Pt conductive end segments, were fabricated by means of electrochemical methods, using nanoporous alumina membranes as patterned templates. A contact measurement prototypal methodology was implemented to characterize the magnetoelectric transport properties of single nanostructures under the effect of an applied magnetic field using a direct laser writing lithography method.

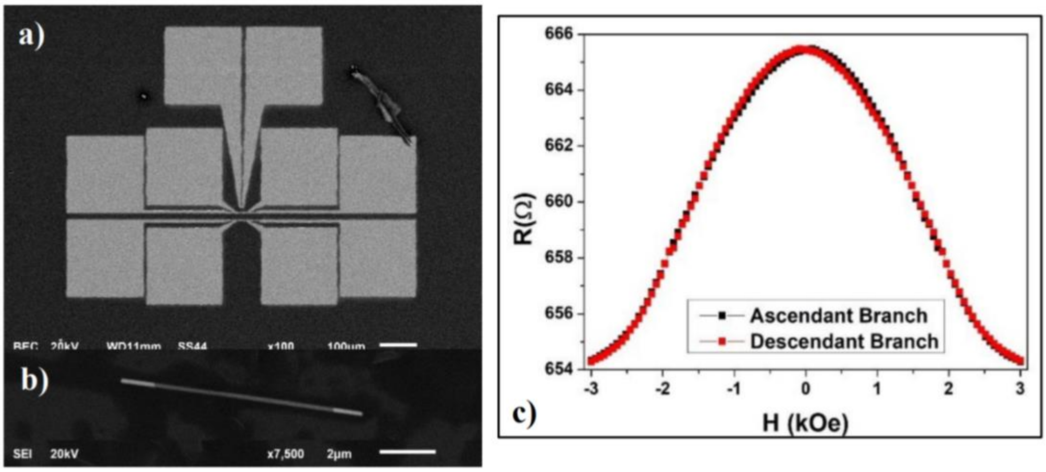

Figure 1: a) Lithographyc design of electrical contacts platform suitable for electrical transport characterization under thermal gradients. b) Fabricated Pt/Ni/Pt barcoded single nanowire. c) Nanowire electrical resistance as a function of perpendicularly applied magnetic field.

Acknowledgements

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Magnetization Reversal Process in Bi-modulated FeCo Cylindrical Nanowires

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The understanding and control of magnetic structures is essential for the development of novel applications in several areas such as biomedicine, data storage, microwave technology [1]. Cylindrical nanowires offer an alternative to nanostripes due to geometry induced effects such as the suppression of the Walker breakdown [2]. Cylindrical geometry stabilizes a number of novel magnetic textures such as Bloch Point Domain Walls (BPDW) and vortex and skyrmion tubes. Especially interesting are the modulated cylindrical nanowires with variation in magnetization or diameter since complex configuration can be found [3]. In this work, the magnetization reversal process of a cylindrical nanowire modulated in diameter is investigated by Variable Field Magnetic Force Microscopy (VF-MFM) and non-standard 3D mode imaging techniques [4]. These results will be compared with the previous Magneto-Optical Kerr Effect (MOKE) measurements [5] and the preliminary studies using Photo Emission Electron Microscopy and X-ray Magnetic Circular Dichroism (PEEM-XMCD) techniques. The experimental results, together with micromagnetic simulations reveal a complex magnetization reversal process, mediated by the thin segment and the formation of a vortex tube in the thick segment.

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Study of multilayer Solenoid Coils for Magnetic Hyperthermia Applications

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Magnetic Hyperthermia (MH) is a cancer treatment based on rising the temperature of a body local region in a range between 42 and 46 ºC with the aim of destroying tumor cells [1]. The effectiveness MH hinges on the ability to generate high magnetic fields in bounded regions of the space, so as to increase the local temperature of an area under treatment by means of induction heating.

A parameter of interest in MH is the specific absorption rate (SAR) which quantifies the amount of energy absorbed by the nanoparticles per unit mass. This parameter is directly proportional to the frequency and the square of the intensity of the applied magnetic field [2]. The latter is determined by the current intensity that passes through a solenoid (or field "applicator") and is directly proportional to the number of turns of the same according to the expression for an ideal solenoid ($B = \mu_0 INL$). However, the possibility of increasing the magnetic field strength is usually limited by the current generator and the power of the system source.

On the other hand, an increase in the number of turns is not always feasible, since it will produce a decrease in the resonance frequency (due to fixed capacitances of the oscillator system) and other electrical/electronic problems associated with the oscillator circuit components. Moreover, in commercial magnetic hyperthermia equipment, single layer solenoids are always used [3].

In this work, we study the possibility of improving the generator system by increasing the number of turns/layer as established by theory or whether there is any other drawbacks to achieve the maximum efficiency of the system at constant power.

Experimental results and simulations of different multilayer coils reveal the existence of an optimal number of layers in terms of the achievable H-field (Fig. 1), which also reveal other features of the proposed approach to be considered for magnetic hyperthermia purposes.

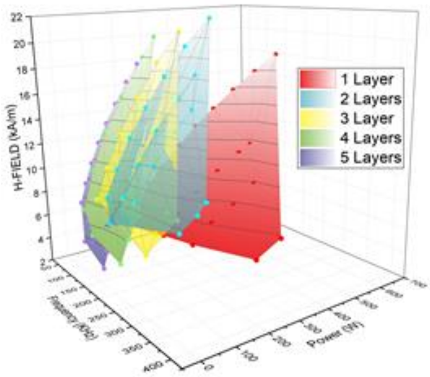

Fig. 1. 3D simulated n/layer solenoid as a function of frequency and power supply

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Anomalous Nernst Effect on Magnetic Multilayers with Flexible Substrate

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One of the thermoelectric effects that is currently attracting a considerable interest because of its potential for energy harvesting is the anomalous Nernst effect (ANE). ANE is a thermomagnetic phenomenon with potential applications in thermal energy harvesting. Our aim is to study and increase the ANE coefficient of materials and record the power density generated by the ANE by using flexible substrates in order to increase the number of applications it may be used.

Therefore, we make use of a micrometer-sized Hall bar device consisting of $[Co_{0.5nm}/Pt_{0.5nm}]_{10}$ sputtered multilayers, which present a high ANE coefficient and thermopower (~1 μV/K), low electrical resistivity, and perpendicular magnetic anisotropy (PMA) when grown on a SiN_x/Si substrate. Furthermore, flexible substrates (like polymide, acetate…) allow to analyze the effect strain has in the properties of the samples. This way, the devices shown in this work, are composed by magnetic multilayers with high PMA exposed to in-plane thermal gradient. VSM and VF-MFM are other experimental techniques employed to accomplish the magnetic characterization. Additionally, a MATLAB software will be developed to measure Seebeck and Hall effects too in order to fully characterize the manufactured devices.

We believe that this design may find uses in harvesting wasted energy, e.g., in electronic devices.

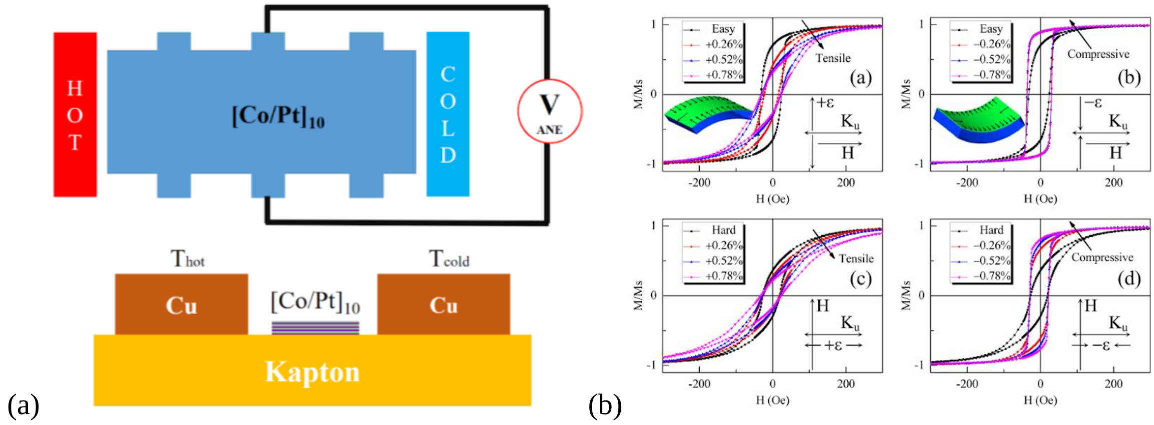

Figure 1. (a) Scheme of the device and ANE measurement used technique, (b) Hysteresis loops for $Fe_{81}Ga_{19}$/PET obtained under various external strains using different measuring configurations [5].

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Improvement of Magnetic Force Microscopy Measurements Using 3D Nanowire Growth by Focused Electron Beam Induced Deposition

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High-resolution nano- and micro-structures can be grown using the direct-write, resist-free nanolithography technology known as Focused Electron Beam Induced Deposition (FEBID). This approach allows for sub-100 nm lateral resolution, sometimes reaching 10 nm. Here, we report the fabrication of 3D magnetic nanowires for Magnetic Force Microscopy (MFM) using Focused Electron Beam Induced Deposition (FEBID). (Fig. 1).

Due to their high aspect ratio and good magnetic behaviour, these 3D magnetic nanowires provide a number of advantages over commercial magnetic tips when used for simultaneous topographical and magnetic measurements. The main advantages are the low non-magnetic tip-sample interaction, the high lateral resolution, the high coercive field (900 Oe) [1-3] and the excellent performance of the tips in liquid environments [4] for possible application in the study of magnetic biological samples. The sharp 10 nm diameter tip enables a high lateral resolution. Depending on the particular needs of the samples, the shape, length and diameter of the tip can be adjusted. Due to its versatility and reproducibility, this process creates magnetically hard nanowires that can be customised to a specific requirement.

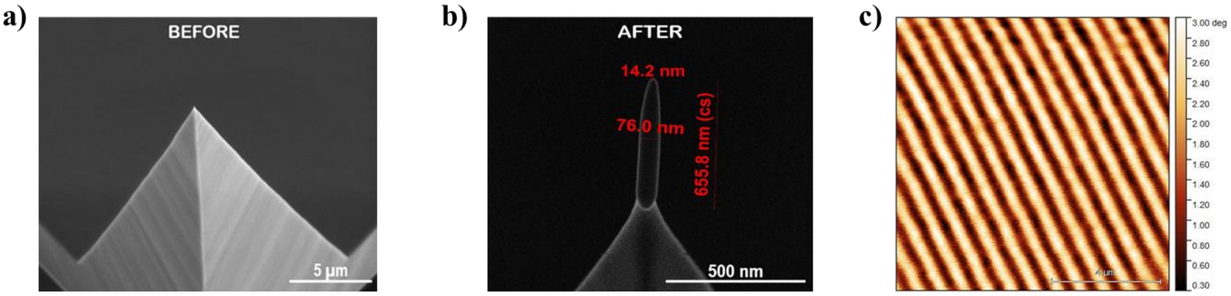

Fig 1. Before (a) and after (b) growth of a 3D Fe-based magnetic tip by FEBID on the tip of a commercial MFM Akiyama probe (NenoVision s.r.o) and (c) high-MFM contrast measurement of a reference sample (magnetic tape) obtained by Fe-FEBID magnetic tip.

Acknowledgements

The authors acknowledge NenoVision s.r.o for their collaboration in the MFM measurements and for providing the probes and the grant PDC2021-120852-C21 funded by MCIN/AEI/ 10.13039/501100011033 and by the European Union NextGenerationEU.

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Index Terms — Magnetic Force Microscopy, Focused Electron Beam Induced Deposition, 3D Magnetic Nanowires.

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Real-time monitoring of breath biomarkers with a magnetoelastic contactless gas sensor: a proof of concept.

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In the quest for effective gas sensors for breath analysis, magnetoelastic resonance-based gas sensors (MEGSs) are remarkable candidates. Thanks to their intrinsic contact-less operation, they can be used as non-invasive and portable devices. However, traditional monitoring techniques are bound to slow detection, which hinders their application for fast bio-related reactions. Here we present a method for real-time monitoring of the resonance frequency. Here we present a proof of concept for real-time monitoring of gaseous biomarkers based on resonance frequency. This method was validated with a MEGS based on a Metglass 2826MB microribbon with a polyvinylpyrrolidone (PVP) nanofiber electrospun functionalization. The device provided a low-noise (RMS = 1.7 Hz), fast (<2 min) and highly reproducible response to humidity (Δf= 46-182 Hz for 17-95% RH), ammonia (Δf= 112 Hz for 40 ppm) and acetone (Δf= 44 Hz for 40 ppm). These analytes are highly important in biomedical applications, particularly ammonia and acetone, which are biomarkers related to diseases such as diabetes. Furthermore, the capability of distinguishing between breath and regular air was demonstrated with real breath measurements. The sensor also exhibited strong resistance to benzene, a common gaseous interferent in breath analysis.

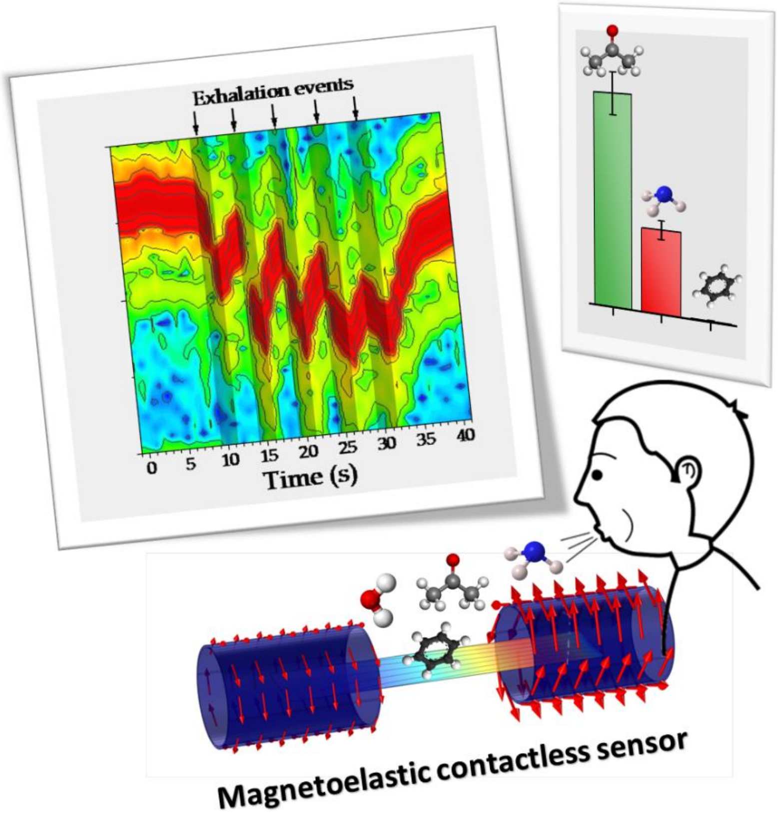

Figure 1 Graphical abstract

Index Terms — Remote sensing; Gas sensor; Breath analysis; Magnetoelastic resonance; Soft magnets; 27 Polyvinylpyrrolidone; Nanofiber; Humidity; Biomarkers; Diabetes.

Coercivity development in FeNiPC ribbons as a possible precursor for novel sustainable permanent magnets

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Tetrataenite is an $Fe_{50}Ni_{50}$ ordered phase ($L1_0$) with potential as a sustainable alternative to common rare-earth-based magnets based on its excellent magnetic properties, with an estimated theoretical maximum energy product $(BH)_{max}$ of about 42 MGOe [1]. Reported to be found naturally only in some meteorites [2], the large-concentration synthesis of pure $L1_0$-FeNi, in realistic time scales, remains an exciting challenge for scientists.

This work is starting from $Fe_{40}Ni_{40}P_{13}C_7$ amorphous ribbons, prepared by melt-spinning, with the goal of promoting atomic mobility when starting from an amorphous state and controlling the crystallization process [3]. The composition of the precursor was corroborated by Energy Dispersive X-ray spectroscopy (EDX) measurements. The as-spun ribbons were encapsulated in an Ar-sealed ampoule and annealed at different temperatures (370-430 ºC) for different times (12 days and 1 h).

Figure 1(a) shows X-ray diffraction (XRD) patterns for the as-spun ribbons (amorphous), a 12 days annealed (370ºC) sample and a 1 hour annealed (390ºC) sample. XRD intensity peaks of $Fe_{50}Ni_{50}$, $FeNi_2P$ and Fe_3C were detected for the annealed samples. Room temperature hysteresis loops for selected samples are shown in Figure 1(b), including an inset of the second quadrant. A coercivity of 475 Oe, reached after 12 days annealing (370ºC), agrees with the value reported by J. Kim *et al*. after application of a long-duration annealing process [3]. Our study shows the possibility of reducing the annealing time from 12 days to 1 h, and not only matching coercivity but improving it further, by a slight increase in the annealing temperature. In particular, annealing at 390ºC for 1 h has led to a coercivity of 757 Oe. This enhanced coercivity might be due to the beginning of formation of the $L1_0$ FeNi phase. Further work is in progress to provide a solid proof and discern the synthesis mechanism of this promising permanent magnet phase under viable synthesis conditions.

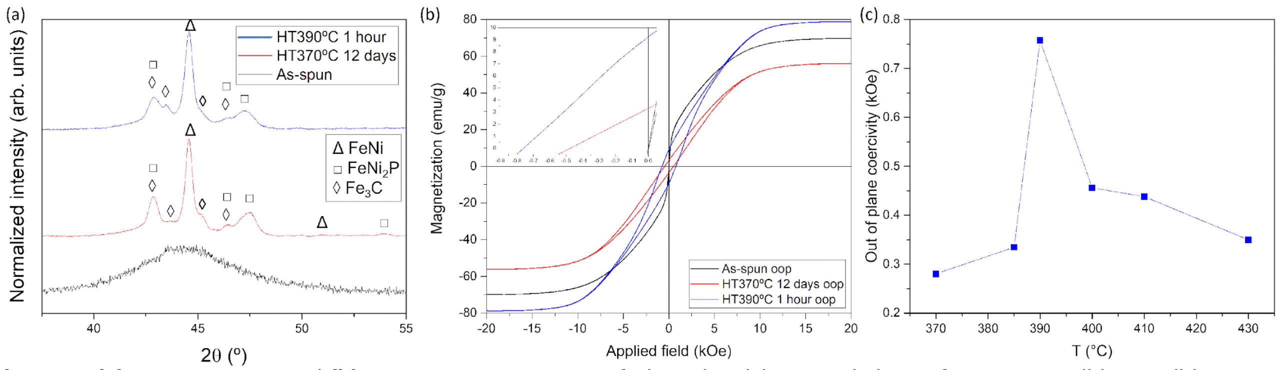

***Figure 1**. **(a)** XRD patterns and **(b)** room temperature out-of-plane (oop) hysteresis loops for: as-spun ribbons, ribbons annealed at 370ºC for 12 days and ribbons annealed at 390ºC for 1 hour; **(c)** Evolution of coercivity vs annealing temperature after 1 h annealing*

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Index Terms — permanent magnets, sustainability, FeNi, melt-spinning.

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Distinguishing local demagnetization contribution to the magnetization process in multisegmented nanowires

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The excellent response of cylindrical magnetic nanowires (NWs) to external stimuli (magnetic, electrical or mechanical), as well as their interesting magnetic properties raising form their high aspect-ratio and curved geometry, position the NWs as promising materials for their use in different fields, ranging from biomedical to spintronics applications [1]. The versatility of these nanostructures is based on the tunability of their magnetic properties by the appropriate selection of the composition and morphology. For instance, the controlled reversal magnetization in cylindrical nanowires have proposed recently as an alternative to the three-dimensional (3D) racetrack memory devices [2]. Besides, the stochastic magnetization switching behavior is attracting attention for the development of neuromorphic devices [3].

In this work, we present a study of the magnetization reversal process in multilayered CoNi/Cu nanowires. The non-standard MFM images obtained under in-plane magnetic field, so called 2D images [4], are correlated with the magnetoresistance measurements and micromagnetic simulations. Thanks to this combined studied, the contribution of the individual segments to the demagnetization process can be distinguished. Results show that the magnetization reversal process in these nanowires does not occur through a single Barkhausen jump, but by several switching corresponding to the magnetization reversal processes of individual CoNi segments in the NW. Moreover, the existence of vortex states is confirmed by their footprint in the magnetoresistance measurements as well as in the magnetic imaging measurements. In addition, the either deterministic or stochastic character of the magnetization process is analysed. We observe different switching fields among the segments due to a slightly variation in geometrical parameters or magnetic anisotropy.

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Index Terms — magnetic nanowires, magnetization reversal processes, magnetoresistance, magnetic force microscopy

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Co-existence of hexagonal close-packed (HCP) and face-centered cubic (FCC) crystal structures Ni nanoparticles embedded in carbonaceous matrices

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Carbonaceous materials that include metallic nanoparticles (NPs) have attracted extensive interest during the last decades, especially those of metals like Nickel organic frame works (NiOF), thanks to its importance in technological applications (i.e., catalysis, batteries, ceramics, etc) [1] However, to control NiOF properties, a correlated analysis of its microstructure and magnetic properties should be done.

To achieve this purpose, we have prepared five samples of 2-methylimidazole Nickel NPs with carbonization temperatures between 400ºC and 600ºC [2]; characterized their crystal structure and microstructure by X-Ray diffraction (XRD) and high-resolution transmission electron microscopy (HRTEM). Additionally, their magnetic properties were studied by SQUID magnetometer through ZFC-FC and magnetization vs. magnetic field ($M(H)$) curves.

The samples exhibit two crystallographic phases of Ni: face centered cubic-FCC and hexagonal compact phase-HCP. Additionally, at the lowest carbonization temperature Ni_3C was also detected. XRD peaks become narrower and symmetrical as the carbonization temperature raises, suggesting that the mean diameter of Ni-NPs increases. The interplanar distances were measured by analysing in detail HRTEM images. These studies corroborate XRD results and the existence of Ni_3C phase on samples synthesized at the lowest and the other carbonization temperatures.

The analysis of $M(H)$ curves recorded at room temperature reveals that saturation magnetization (M_S) is low on samples that contain antiferromagnetic Ni_3C compared to higher values obtained in the samples with FCC and HCP phases. Besides, M_S and mean blocking temperature values (T_B) increase as the carbonization temperature rises as a consequence of the increment of the average NP.

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