Flávio Marcelino Borges, Maurício Aparecido Ribeiro, André Vitor Chaves de Andrade, Alexandre Camilo Jr, Augusto Celso Antunes, Sandra Regina Masetto Antunes, *UEPG - PR - Brasil*, João Batista Marimon da Cunha, *UFRS - RS - Brasil* ■ Zirconium silicate, or zircon, is largely used as mineral raw-material for pigment in the ceramic industry due to its property of accommodating a great number of ions in the crystalline structure as a host. It also presents high chemical stability and superior resistance to dissolution during enamel annealing. When doped with materials such as vanadium, praseodymium and iron, zircon presents different color tonality due to concentration of each element. Regarding Fe ions doping incorporated to the structure, the coral tonality is obtained. This study deals with Fe doped zircon at 1%, 5%, 10%, 15% e 20% concentrations, through the conventional ceramic process of oxide mixture. The material used was ($ZrSiO_4$) Zirconium silicate and (Fe_2O_3) Iron oxide. Samples were treated with isopropyl alcohol and left in oven at 120^{o}C until the alcohol evaporation was complete. Next, they were turned into powder, drained in a 200 mesh sieve and calcinated at 1150^{o}C for 4 hours. The sample characterization was carried out through X-ray diffraction and Mössbauer spectroscopy. X-ray diffraction made possible to identify the clear formation of zircon with a certain displacement of the lattice parameters due to interdiffusion of reduced iron atoms in the zirconium silicate crystalline structure. However, part of the oxidized iron supplied for the solid solution keeps its integrity which is revealed by the magnetic sextet obtained by hyperfine characterization. Results also show that the α - Fe_2O_3 concentration increases with the increase in Fe concentration.

MAGNETIC MATERIALS AND APPLICATIONS II

[12/05/09 - P065]
Magnetization dynamics measurements in thin films at frequencies up to 24GHz, Alexandre da Cas Viegas, *Laboratório de Filmes Finos e Superfície, Departamento de Física, UFSC, Florianópolis, SC*, Antonio Marcos Helgueira de Andrade, *CESNORS-UFSM, Frederico Westphalen-RS*, Marcio Assolin Corrêa, *Escola de Ciências e Tecnologia-UFRN, Natal-RN*, Ricardo Barreto da Silva, *Centro de Ciências Exatas e Tecnológicas, UNIPAMPA, Caçapava do Sul-RS*, Rubem Luis Sommer, *Centro Brasileiro de Ciências Físicas, Rio de Janeiro-RJ* ■ In this work we describe the apparatus and results of dynamical characterization of soft magnetic thin films in the range of 10MHz up to 24GHz using a Rhodes&Shwarz network analyzer. Magnetic permeability and magnetoimpedance measurements are achieved for a complete hysteresis cycle actually for fields up to 250 Oe. The range of frequency and RF power used makes possible investigate a large variety of dynamical effects including domain wall dynamics, ferromagnetic ressonance phenomena as well non-linear ones. The permeability spectra are obtained from the scattering parameter S11. The sample holder consist of a grounded coplanar wave guide (CWG) with characteristic impedance matched as close as 50Ω as possible, and line width smaller than 200μm, in order to produce relatively high fields on its surface. The sample is placed on top of the CWG where suffer the effect of the RF magnetic field. The CWG is produced using high frequency low losses dielectrics substrates covered with cupper thin films by lithographic procedures or micro-machined systems. Characteristic impedance are depending of dimensions and dielectric properties and are calculated using TXline or AppCad software. A calibration procedure is performed before start the measurements in order to assure cables and sample holder correction of phase shifts and attenuation of the line. Preliminar results of permeability measuresments in multilayers of soft PyCu and PyAg materials with different number of bilayers are reported and ferromagnetic resonance phenomena observed.

[12/05/09 - P066]
Study of the anisotropies distribution on the magnetic amorphous wires and ribbons via magneto impedance effect, C. B. R. Jesus, *Dep. de Física, Universidade Federal de Sergipe, São Cristóvão - SE*, C. T. Meneses, J. G. S. Duque, *Núcleo de Física, Universidade Federal de Sergipe, Itabaiana - SE* ■ The giant magnetoimpedance (GMI) effect is a classical electrodynamics phenomenon where an interaction among a circumferential field generated by an AC current, an externally applied magnetic field and the magnetization of a soft magnetic material leads to strong changes in circumferential magnetic permeability and, consequently, in the frequency-dependent impedance. Once this effect reflect the changes in the magnetic permeability via skin depth it has been observed that GMI is sensible to an external stress (tensile and/or torsion). Magnetoimpedance effect has been observed in a wide variety of soft magnetic materials, such as wires, ribbons, glass coated microwires and thin films. In this work, we have investigated the anisotropies distribution and its influence on the dynamic of the magnetization process on Co-based wires and ribbons through magnetoimpedance effect. In this sense, 8 cm long Co-based amorphous magnetic wires and ribbons have been used to measure giant magnetoimpedance curves as function of external magnetic field, driving frequency and external tensile and/or torsion stress. A theoretical model taking account a Gaussian distribution of magnetization easy axes has been used to fit the experimental data. The experimental results obtained in the as-cast wires and ribbons show a strong dispersion in the magnetization easy axes which is decreased for increasing the external tensile stress.

[12/05/09 - P067]
Magnetoimpedance in nanostructured wires, M. J. P. Alves, J. Gomes Filho, R. L. Sommer, *CBPF, Rua Dr.Xavier Sigaud 150, Rio de Janeiro, Brasil*, A. C. D. Viegas, *Universidade Federal de Santa Catarina, Florianópolis 88040-900, SC, Brasil* ■ Magnetoimpedance is a the change of the impedance of a magnetic material when simultaneously subjected to a slowly varying magnetic field and a *ac* field associated to an high frequency probe current. The effect

depends strongly on the effective transverse permeability that controls the magnetoimpedance through the skin depth. There are several methods to produce magnetoimpedance based sensors and among them, electrodeposition is a low cost technique that has been widely used to prepare nanostructures based on magnetic materials. In particular, cilyndrical films of NiFe, NiFeRu, NiFeMo, CoP, CoNiFe, etc. have been deposited on a non-magnetic inner core conductor (Cu, BeCu, Ag, etc.) in order to produce manetoimpedance based sensors. These structures eventually exhibit very high magnetoimpedance ratios $MI = 100 \times (Z(H) - Z_{Hmax})/Z_{Hmax}$ and very interesting Z vs.H curves. On the other hand planar structures made of sandwiched FM / M / FM layers were found to exhibit even better MI ratios, although smaller than the theoretical limit of 3000%. In this work we investigate the magnetic properties and magnetoimpedance of cylindrical Py films and $(Py/Cu)_n$ multilayers deposited over a Cu central wire with diameter $100\mu m$. The impedance was measured in the GHz frequency range. The results are discussed in terms of the anisotropies present in the samples and simulated using a combined Spinu-Smit & Belgers approach.

[12/05/09 - P068]
Barkhausen noise studies along the stress-strain curves of magnetic metals and alloys, D. E. González-Chávez, R. L. Sommer, *Centro Brasileiro de Pesquisas Físicas (CBPF/MCT)* ■ The Barkhausen effect is a series of jumps in the magnetization of a material when the magnetizing field is gradually varied. These jumps result in the well known Barkhausen noise (BN) at the secondary coil's leads in any magnetic circuit with a ferromagnetic core. The BN time series carry information on the interaction of the magnetic domain walls with the metallurgical defects present in the material under study. The parameters obtained from the BN time series can be used as Non Destructive Technique for studying the effects of static or cyclic mechanical stress applied to e.g. structural steels used in the oil industry. In particular, the mechanical degradation or aging of the material due to this stress is accompanied by a change in the BN characteristic parameters, e.g. RMS value, Power spectrum at different points of the hysteresis curve, etc. Even with the large amount of work published in this subject, the correspondence between the measured BN signal and the microstructure of the studied material is not conclusive and, sometimes, the results seem to be contradictory from author to author. The objective of this work is to improve both, the experimental setup and the numerical methods to get relevant information from raw Barkhausen data, in order to obtain clear relationships between mechanical stress or fatigue of a sample and the BN generated. In this step of the work we report results for BN in pure Fe and Ni under stress. The results are discussed in terms of the known stress-strain relations for these materials and the interplay between the metallurgical microstructure and the magnetization dynamics of these materials.

[12/05/09 - P069]
The GMI Impedance Phase Characteristics, Focusing on its Dependence with the Frequency of the Excitation Current, E. Costa Silva, C. R. Hall Barbosa, E. Costa Monteiro, *Post-Graduation Program in Metrology/PUC-Rio - RJ - Brazil*, L. A. P. Gusmão, *Electrical Engineering Department/PUC-Rio, RJ, Brazil* ■ The Giant Magnetoimpedance Effect (GMI) has been studied since the 90s. However, most of the research efforts concentrate on the impedance magnitude characteristics, which variation is usually expressed by GMI (%). The Laboratory of Biometrology of PUC-Rio, in partnership with the Department of Physics of UFPE, conducts research on magnetic transducers for biomedical applications, based on the GMI effect or, more specifically, in a variant of that, known as Longitudinal Magnetoimpedance (LMI). These studies indicate that the impedance phase characteristics are in many ways better than the magnitude characteristics, allowing, for example, the construction of more sensitive transducers (10 to 100 times better).

The present work has examined the variables that affect the behavior of the impedance phase of the GMI effect as a function of an external magnetic field to which the samples are submitted. Thus, were considered the length of the samples (1 cm, 3 cm, 5 cm and 15 cm) and frequency (100 kHz to 10 MHz), DC level (0 mA to 100 mA) and amplitude (0,1 mA to 20 mA) of the excitation current.

This manuscript focus on the dependence of the impedance phase with the frequency of the excitation current in ribbon shaped GMI alloys ($Co_{70}Fe_5Si_{15}B_{10}$), describing an effect experimentally observed. It suggests, for a given condition of the samples, the existence of two optimal frequency values where the sensitivity, expressed in degrees by Oersted, is maximum and approximately equal. Consequently, for other values of the frequency the sensitivity has smaller values. As a future work, the dependence of these maxima with the length of the ribbons will, also, be outlined.

It is expected that the GMI impedance phase characteristics become more studied, given their important features and applicability, so in the future the physics community will be able to model and explain the presented behaviors, such as the presence of two frequency values where the maximum sensitivity of the impedance phase is obtained, what is not seen on the impedance module characteristics.

[12/05/09 - P070]
Dynamics of magnetization and Magnetoimpedance in Py/Cu Nanostructures Electrodeposited on Si (100), A. M. C. Castro, J. Gomes Filho, R. L. Sommer, *Centro Brasileiro de Pesquisas Físicas (CBPF/MCT)*, A. D. C. Viegas, *Universidade Federal de Santa Catarina (UFSC)* ■ Nanostructured magnetic materials based on sandwiched layers of permalloy ($Py = Ni_{81}Fe_{19}$) and copper (Cu) can provide excellent response to magnetic fields of high frequencies and therefore, they are excellent candidates for use in sensors based on the magnetoimpedance effect. On the other hand nanostructures deposited on silicon (Si) substrates, allow the development of integrated sensors, i.e. the sensor element and correspondent electronics on the same substrate. The electrode-

position technique has been widely used to produce thin films because it allows the control of the of nucleation and growth modes by adjusting the deposition potential and the composition and pH of the electrochemical bath. Additionally, the electrodepositon technique allows the production of alloys and multilayers in flat or non flat surfaces, always with low costs when compared with techniques based on system for ultra-high vacuum, e.g. sputtering, molecular beam deposition (MBE), etc. In the present work we investigate the effects of the electrodeposition parameters film thickness on the magnetic properties and magnetoimpedance of single-layered permalloy films as well as on Py/Cu multilayers, both, deposited on $Si(100)$. The results are discussed in terms of the usual models for magnetoimpedance and permeability of nanostrutured materials.

[12/05/09 - P071]
Magnetic and Magnetoimpedance Properties of Electrodeposited NiFeCr/CuCr Multilayered Systems, J. Gomes Filho, K. Cezilla, R. L. Sommer, *Centro Brasileiro de Pesquisas Físicas (CBPF)*, A. D. C. Viegas, *Universidade Federal de Santa Catarina (UFSC)* ■ Multilayered structures based on soft ferromagnetic (FM) materials may exhibit remarkable magnetoimpedance (MI) effects at low saturation magnetic fields and have been extensively studied in recent years. In particular, these structures may have potential application on the fabrication of magnetic field sensors with high sensibility. An important example of a soft magnetic alloy largely used for such ends is permalloy^{TM} (Py = $Ni_{81}Fe_{19}$), in multilayers like Py/M, M = Cu , Au, Ag etc. In the present work, we report our preliminary results on the addition of chromium (Cr), in the form of chromium sulfate ($Cr_2(SO_4)_3$), in a bath used for electrodeposition of Py/Cu multilayers and the correspondent PyCr/CuCr multilayered planar systems are produced on a copper substrate. Such Cr addiction modifies the chemical composition of the magnetic layers as well as of the spacer layers, as a function of the set electrodeposition potentials. As pure Cr exhibits antiferromagnetic (AFM) behaviour at usual room temperature ($T_N = 37.5\ ^oC$), it is expected that such addiction implies in changes on the magnetic and MI behaviour of the multilayered system, including magnetic anisotropies, in particular the appearance of an exchange biased component on the studied effects. In fact, similar effects have been reported in Py/Cr and Py/CrO_2 multilayered systems obtained by high vacuum techniques. Some electrochemical aspects of the compound bath are also presented and discussed.

[12/05/09 - P072]
First-order-reversal-curve analysis of Pr-Fe-B-based nanocomposites, D. R. Cornejo, T.R.F. Peixoto, *IF - USP - Brasil*, S. Reboh, P. F. P. Fichtner, *UFRGS - RS - Brasil*, V. C. de Franco, V. Villas-Boas, F. P. Missell, *UCS - RS - Brasil* ■ Ribbons of nominal composition $(Pr_{9.5}Fe_{84.5}B_6)_{0.96}Cr_{0.01}(TiC)_{0.03}$ were produced by arc-melting and melt-spinning the alloys on a Cu wheel. The ribbons show two main phases, one based upon $\alpha - Fe$ and the other upon $Pr_2Fe_{14}B$, and show exchange spring behavior with $H_c = 12.5$ kOe and $(BH)_{max} = 13.6$ MGOe when these two phases are well-coupled. Transmission electron microscopy revealed that the coupled behavior is observed when the microstructure consists predominantly of $\alpha - Fe$ grains surrounded by hard material containing $Pr_2Fe_{14}B$. Then, our results show that soft grains surrounded by hard material also provides a satisfactory microstructure for high-coercivity nanocomposite magnets. A first-order-reversal-curve (FORC) analysis was performed for both a well-coupled sample and an uncoupled sample. Each FORC diagram show two peaks for both the uncoupled sample and for the well-coupled material, associated with two different regions that we have denominated as "hard"contribution and "soft"contribution. The soft contribution arises principally in those grains of $\alpha - Fe$ that are not totally exchange-coupled to the $Pr_2Fe_{14}B$ phase. The hard contribution in the FORC distributions must correspond to the $Pr_2Fe_{14}B$ phase. The peak positions of the soft contribution are identical in the two samples but their relative weights are very different The hard contribution presents nearly identical values of the coercivity in both cases. The localization of the FORC probability suggests demagnetizing interactions between particles. Using the experimental FORC distributions, we may calculate the switching field distributions (SFD) for each sample and the results are consistent with the respective microstructure.

[12/05/09 - P073]
Magnetic and Structural Properties of Finemet Films, Ana Luiza Rocha, *Centro Brasileiro de Pesquisas Físicas*, Felipe Bohn, *Universidade Federal de Santa Maria*, Rubem Sommer, *Centro Brasileiro de Pesquisas Físicas* ■ FeSi based alloys have received great interest because of their potential of applications in a wide variety of micro magnetic devices, including magnetic sensors and read/write heads for magnetic disk memories. In particular, FeSiCuNbB nanocrystalline alloys, commercially known as FINEMET, correspond to a very attractive group of materials due to the fact that they exhibit very soft magnetic behavior, with low losses and high saturation induction and permeability values. The nanocrystalline structure of finemet is obtained by crystallizing the amorphous precursor through an optimum annealing treatment which results in a homogeneous and ultrafine FeSi grain structure with a typical diameter ranging from 10 to 20 nm. These alloys are usually in a non-equilibrium condition, and their structural and magnetic properties depend not only of their composition, but also on the preparation method and the annealing temperature. The crystallization process has not been widely studied in films. In this work, we aim to determinate the optimum procedure to obtain the nanocrystalline phase in Finemet films. We study the structural and magnetic properties in ferromagnetic films produced by magnetron sputtering with nominal composition $Fe_{73.5}Cu_1Nb_3Si_{13.5}B_9$ and various thickness, ranging from 10 to 1000 nm. We submitted a set of amorphous samples to annealing during 1 hour at temperatures varying from 250 °C to 450 °C. The influence of film thickness and annealing conditions on the magnetic behavior and structure of the films were in-