SUSTAINABLE MATERIALS, PROCESSES AND SYSTEMS FOR ENERGY TRANSITION

I.N.RI.M. - Advanced Metrology for Materials, Sustainable Process and System for energetic transition

Funded By	I.N.RI.M. - ISTITUTO NAZIONALE DI RICERCA METROLOGICA [P.iva/CF:09261710017]
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Context of the research activity	This Thematic Grant includes 2 research Topics (listed below), with a specific title and proponent Supervisor/s. The applicants have the possibility to identify the specific topic they are interested in. Topic 1: Investigating the broadband magnetic behavior of Fe-based composite materials Topic 2: Development and characterization of plasmonic gas sensing devices with integrated microporous gas-storage layer.
	Topic 1: Investigating the broadband magnetic behavior of Fe-based composite materials The proposed research aims to experimentally and theoretically verify the validity of methods, procedures, and configurations adopted for the measurement of the properties of soft magnetic composite materials (e.g. Mn-Zn and Ni-Zn type ferrites, composites formed from sintered iron powders, materials produced by additive manufacturing, ...) in the DC - GHz frequency range. The objectives include highlighting the correlations between chemical composition, microstructure and magnetic response (mainly, energy loss, W, and magnetic permeability, μ) at broadband of the material, and identifying the physical mechanisms governing the observed behavior. The following instrumental set-up, available at INRIM laboratories, will be used for measurements: 1) A Ballistic Permeameter and a Vibrating Sample Magnetometer (VSM) for measuring the normal magnetization curves and DC Hysteresis Cycles up to ~ 1.4 MA/m on bar and sphere samples, respectively; 2) A Digital Wattmeter-hysteresisgraph for AC characterisation of toroidal samples up to the MHz range 3) A Vector Network Analyzer with transmission line for measurements up to 1 GHz of toroidal samples.

Objectives	Fluxmetric measurements at high frequencies (f > 10 kHz) will be performed at polarization values Jp up to a few hundred mT. For any kind of magnetization process identified, particular emphasis will be placed on the role of eddy currents, or spin damping dissipation mechanisms, contributing to increased energy losses. Topic 2: Development and characterization of plasmonic gas sensing devices with integrated microporous gas-storage layer. The research activity will focus on the development of gas sensing device based on plasmonic enhancement of IR absorption or Raman spectra of target gases, e.g. CH4 and CO2, in the ppm and ppb range. Different activities will contribute to this aim. A vast part of the research activity will focus on the development of different microporous materials (e.g. polymers with intrinsic microporosity, metallorganic frameworks, polyaromatic frameworks, micro-porous alumina, etc.) through different synthetic routes and their morphological, physico-chemical and functional characterization. The main characterization methods may include electron microscopies, X-ray spectroscopies, optical spectroscopies and scanning probe microscopies. The synthesis and fabrication of the porous framework will be integrated onto a solid chip sensing device for low gas concentrations by optimizing the deposition/growth conditions. Clean-room fabrication of metallic micro and nanostructures will be used to develop the plasmonic platforms in association with the modeling of the plasmonic enhancements with finite element methods calculations (COMSOL), guiding the choice of the materials and the engineering of the metallic structures with dimensions suitable to match the infrared and/or Raman vibrations of the analyte. This research topic is funded by INRiM and co-proposed by INRiM and UPO.

Skills and competencies for the development of the activity	Topic 1: Knowledge of materials science, phenomenology of electromagnetism, measurement science (metrology), energy. Good knowledge of the English language, spoken and written. Willingness to collaborate with industry and carry out experimental work as well as theoretical modeling. Topic 2: Previous background in Chemistry, Materials Science, Physics or related Engineering degrees is required. Good communication skills in written and oral English are required. The knowledge and/or experience in at least one of these topics is appreciated: synthetic chemistry, materials characterization, FEM simulations, micro and nanofabrication methods, FTIR analysis, Raman spectroscopy, and/or plasmonics. For additional information, please contact: Topic 1: Enzo Ferrara, INRiM, e.ferrara@inrim.it Topic 2: Eleonora Cara, INRiM, e.cara@inrim.it, Giorgio Gatti, UPO, giorgio.gatti@uniupo.it