FINAL REPORT

INDIVIDUAL FELLOWSHIPS

Project n°: **PIEF-GA-2008-220166**

Project Acronym: **CAMMISP**

Project Full Name: ***Characterization of Applied Magnetic Materials for Industrial Scale Products***

Marie Curie Actions

IEF Final Report

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1. FINAL PUBLISHABLE SU MMARY REPORT

For a strong European Research Area it is necessary to allow European nanotechnologies industry to strengthen its competitiveness and to stay competitive with the rest of the world, which is investing massively in the field of nanotechnologies. Therefore, there is a demand in Europe to improve the entrepreneurial character of researchers in nanotechnology related field. To accomplish this goal there must be an advanced educational system able to educate a diverse and multi-disciplinary skilled research workforces that is capable to turn new fundamental knowledge into novel competitive technologies, in addition to an effective research infrastructure capable of competing at world-class level. Such an educational program could provide at the same time a fertile ground for the scientific exploration of novel physical phenomena that could eventually lead to novel materials and applications.

This is the key aspect this proposal addressed by means of novel and inter-disciplinary research training. The diagram shown in Fig. 1 summarizes the proposal's goals and long-term perspectives.

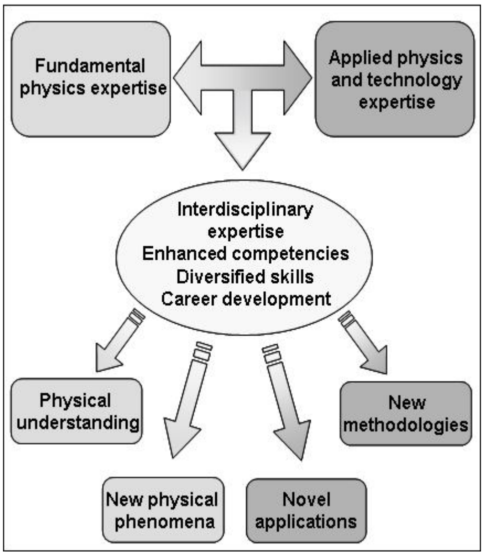

Fig.1 Schematic of project's educational and research goals and

More specific, applied nano-magnetism has become a very timely, relevant and strategic field of nano-science and nano-technology all over the world. The fundamental technology change towards using ferromagnetic layered structures with perpendicular magnetic anisotropy as storage media (perpendicular magnetic recording, PMR) that worldwide hard disk drive industry has recently started, is generating a tremendous interest in the development of novel materials as well as characterization methodologies for PMR applications.

The project was hereby build on Dr. Vavassori longstanding expertise and proven track record in fundamental aspects of nano-magnetism especially: magnetic microscopy, non-destructive magneto-optical measurements as well as the development of advanced experimental tooling including time-resolved magnetometry using fast laser techniques. Within the framework of the here proposed program, his well established fundamental background was complemented with an interdisciplinary and technology-related research profile, by training him in the fields of characterization methodologies for technologically relevant materials, in particular magnetic materials related to magnetic recording.

The enhancement of competence and skill diversification of the beneficiary, the present proposal's aim, had been progressively achieved through three main steps:

- (i): establishment of complementary interdisciplinary expertise at an advanced level in the field of technological relevant materials for magnetic recording and, more specifically, for PMR applications;
- (ii): establishment of interdisciplinary and inter-sectorial expertise at an advanced level on the characterization methodologies utilized for PMR materials;
- (iii): test of effectiveness of presently used methodologies by addressing some of the most urgent problems in PMR materials characterization.

In the first step (Months 1-6), Dr. Vavassori had been introduced to the detailed aspects of the underlying physics and the scientific challenges related to PMR materials, such as, competing interactions, due to the presence of competing inter-grain interactions. In addition Dr. Vavassori acquired key knowledge of materials issues such as: materials processing and magnetic properties of hard disk drive recording media, as well as their technological demands.

In the second step, Dr. Vavassori learned (Months 6-12) about key aspects of already existing methodologies employed for recording materials characterization, with particular emphasis on the data analysis methodologies available for retrieving key recording media parameters, which are of crucial interest for PMR technology applications. In details, Dr. Vavassori was trained on the ΔH(M,ΔM)-Method, which is nowadays considered to be the state-of-the-art methodology to retrieve the intrinsic switching field distribution of the media grains, which is of crucial interest for PMR technology applications.

During the last part of the project (Months 12-24) Dr. Vavassori devoted his efforts to the design of a set up based on magneto-optic Kerr effect (MOKE) in polar geometry (p-MOKE), specially designed for low noise, fast , and robust PMR materials characterization at the nano-scale. In addition Dr. Vavassori set up the public domain OOMMF micromagnetics modeling package in order to carry out simulations of PMR materials. The comparison of the predictions of different implementations of ΔH(M,ΔM)-Method against more realistic calculations based on micromagnetics, provided with hints for improving the existing ΔH-Method data analysis scheme.

As a result of this novel educational and research training project, Dr. Vavassori gained a solid understanding of state-of–the-art magnetic recording technologies, in particular the technological challenges related to materials issues and materials testing. In addition, he acquired the necessary familiarity with industrial applications related aspects as: product planning, product reliability, patent issues, management and time management skills, as well as negotiation strategies.

Concerning data analysis methodologies, Dr. Vavassori acquired the necessary knowledge of advanced methodologies utilized for PMR materials with particular emphasis on the ΔH(M,ΔM)-Method, which is nowadays considered to be the state-of-the-art methodology to analyze data for PMR technology applications.

In terms of scientific and technologically relevant achievement, the main result was the identification, through the comparison with micromagnetic simulations and extensive materials characterization activity, of directions for improving the ΔH(M,ΔM)-Method to cover a broader range of inter-granular interactions, as the inclusion of locally varying inter-granular exchange coupling.

This result was achieved thanks to the set up of a new experimental tool based on p-MOKE that allows for a low-noise, fast and robust PMR materials characterization at the nano-scale.

The enhancement of competence and skill diversification, encompassing fundamental physics and applied technology aspects, acquired by the beneficiary during this research training and career development program decisively support Dr. Vavassori in attaining a leading independent position in the European research environment as a part of a structured and long-term professional development plan. The added knowledge gives Dr. Vavassori the ability to quickly assess the technological impact and value of a research topic and will put him into an excellent position to build an entirely new research program in the field of applied materials for large-scale industrial applications with a high potential of generating technology transfer (e.g., technological spin-offs) in relationship with European industry, which can substantially contribute to European excellence and competitiveness in the field of applied nano-magnetism.

Additionally, the key knowledge was transferred to the host institution, CIC nanoGUNE Consolider, and thus enables to consolidate world-leading expertise in this research field within one EU-based research center. One of the objectives of the present project is to allow nanoGUNE to maintain its world-wide leadership position in the development and research of characterization tools for magnetic recording materials, which would also be applicable on the industrial scale. This strengthens nanoGUNE's ability to maintain collaborations with world-wide operating industrial partners, and may allow for commercial joint ventures or spin offs based upon new products in characterization tooling. Such a development would provide a direct economic benefit and return to the European Union and highlights the crucial role that EU administered research investments play.

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