Post-doctoral Fellowship - Fapesp

Field of knowledge: Physics

Project title: Magnetic properties of confined nanostructures: metallic and insulating rare-earth doped nanoparticles prepared by Laser Ablation and Chemical Syntheses

Working area: Condensed Matter Physics

Number of places: 1

Start: 2019-10-01

Principal investigator: Carlos Rettori

Unit/Instituition: IFGW/Unicamp

Deadline for submissions: 2019-08-25

Publishing date: 2019-07-24

Locale: Rua Sérgio Buarque de Holanda, 777, Campinas

E-mail for proposal submission: rettori@ifi.unicamp.br

Summary

This project is conducted by the Optics and Magnetic Properties of Solids Research Group – GPOMS hosted at the University of Campinas's Gleb Watahin Institute of Physics (IFGW-UNICAMP) in São Paulo State, Brazil. Part of the Thematic Project registered under grant number 2017 / 10581-1 (Principal Investigator: Pascoal G. Pagliuso), the project aims to prepare nanostructures and nanomaterials via chemical synthesis (bottom-up) [1, 2] as well as by the physical method of Laser Ablation or LA (top-down)[3]. The nanoparticles (NPs) will be studied by optical, microwave, radio frequency spectroscopies and magnetometry, among other structural and electron microscopy techniques. The post-doctoral researcher will be dealing with preparation and characterization of metallic and intermetallic NPs (Au, Ag, Cu, Pt, etc.), and insulating rare-earths $4f^n$ doped $NaY_{1-x}M_xF_4$ NPs (with M: Gd, Er, Yb, Dy, Eu, etc.).

Introduction and Justification

The Crystal Electric Field (CEF) effects on diluted rare-earths in NPs are unexplored today, therefore, the study and characterization of their magnetic properties by means of ESR and Magnetic Susceptibility complemented by structural (XRD) and electron microscopy (TEM, SEM) techniques are extremely important.

An example of materials of interest where CEF plays important role is the $4f^n$ rare-earth doped $NaY_{1-x}M_xF_4$ NPs, which display the upconversion (UC) phenomenon largely explored lately because of its application for solar cells to absorb the IR part of the visible spectrum[4, 5]. Particularly, the most efficient materials for displaying UC are the $4f^n$ rare-earth doped ABF_4 (A: Na^{+1}, Li^{+1}, K^{+1}, etc., B: Y^{+3}, Gd^{+3}, La^{+3}, etc.) in the hexagonal phase P6m/3[6]. The UC is a non-linear

phenomenon involving two or more absorbed photons that may lead to new devices with great potential for technological applications.

Objectives

Insulating NPs of $NaY_{1-x}M_xF_4$ doped with rare-earths $4f^n$ (M = Nd, Gd, Dy, Er, Yb, Tm) will be prepared by a chemical synthesis (thermal decomposition) in the presence of surface controllers in order to supervise the nucleation and NPs growth. Eventually, core/shell NPs may be also prepared, as much as nanocrystals in self-assemblies composites[7]. Metallic and intermetallic NPs doped with rare-earths will be prepared by the Laser Ablation method where the doped metallic starting materials will be obtained by means of arc-melting furnace. The magnetic properties of the obtained NPs will be compared with their corresponding bulk magnetic properties.

Working Plan

1st semester: Familiarization with the project related literature. Fabrication and structural characterization of the $4f^n$doped $NaYF_4$ (bottom-up) and undoped metallic (top-down) NPs in order to optimize the current methodologies.

2nd semester: Optical spectroscopy of the insulating NPs prepared by the chemical route. Preparation and structural characterization of Er-doped Au NPs by arc-melting and LA techniques.

3rd semester: Magnetic characterization of the bulk and NPs materials by SQUID (magnetometer), and ESR. Perform experimental data analyses and interpretation. Disseminate the results through reports and presentations for meetings, national and international scientific events.

4th semester: Disseminate the results through publications in international peer-reviewed scientific journals. Report the scientific activities.

Methods

The insulating and metallic NPs will be prepared by chemical (bottom-up) and physical (top-down) routes, respectively. The different characterizations will be carried out by Dynamic Light Scattering (DLS), transmission (TEM) and scanning (SEM) electron microscopies in Brazil's National Nanotechnology Laboratory – LNNano (affiliated with the National Energy and Materials Research Center, CNPEM), atomic force (AFM), X-Ray diffraction (XRD), X-Ray Fluorescence by total reflection (TXRF), Infrared spectroscopy (FTIR), Electron Spin Resonance (ESR) and SQUID magnetometry.

About the fellowship

This opportunity is open to candidates of any nationalities. The selected candidate will receive a FAPESP's Post-Doctoral fellowship in the amount of R$ 7,373.10 monthly and a research contingency fund, equivalent to 15% of the annual value of the fellowship which should be spent in items directly related to the research activity.

References

[1] J.M. Vargas, W. Iwamoto, L.M. Holanda Jr, S.B. Oseroff, P.G. Pagliuso, and C. Rettori. *Journal of Nanoscience and Nanotechnology* 11, 2126-2131 (2011). G. G. Lesseux, W. Iwamoto, A. F. García-Flores, R. R. Urbano, and C. Rettori. *Journal of Applied Physics*, 115, 17E128 (2014). **http://dx.doi.org/10.1063/1.4867126**.

[2] A. F. García-Flores, J. S. Matias, D. J. Garcia, E. D. Martínez, P. S. Cornaglia, G. G. Lesseux, R. A. Ribeiro, R. R. Urbano, and C. Rettori. *Physical Review B*, 96, 165430 (2017) **http://dx.doi.org/10.1103/PhysRevB.96.165430**.

[3] Vincenzo Amendola and Moreno Meneghetti. *Physical Chemistry Chemical Physics*, (2013) 15, 3027. **http://dx.doi.org/10.1039/c2cp42895d**.

[4] J. F. Suyver, J. Grimm, M. K. van Veen, D. Biner, K.W. Krämer, and H. U. Güdel, J. Lumin. 117, 1 (2006).; X. Ye, J. E. Collins, Y. Kang, J. Chen, D. T. N. Chen, A. G. Yodh, and C. B. Murray, *Proceedings of the National Academy of Sciences*, USA 107, 22430 (2010).

[5] Y. Shang, S. Hao, C. Yang and G. Chen, Nanomaterials, 2015, 5, 1782–1809; X. Huang, S. Han, W. Huang and X. Liu, *Chemical Society Reviews*, 2013, 42, 173–201; A. C. Atre and J. A. Dionne, *Journal of Applied Physics*, 2011, 110, 034505.

[6] B. Zhou, B. Shi, D. Jin and X. Liu, *Nature Nanotechnology*, 2015, 10, 924–936.

Link site Fapesp: http://fapesp.br/oportunidades/3037/