18 months post-doctoral position available

Controlled Synthesis of Iron Silicides and Germanides Nanocrystals : Towards the Next-Generation of Nanomaterials for Energy and Electronics

Laboratoire de Physique et Chimie des Nano-Objets (http://lpcno.insa-toulouse.fr)
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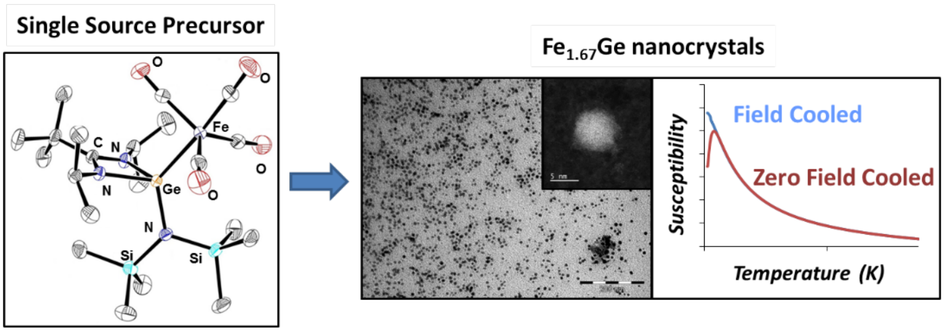
***Project* :** Metal silicides and germanides have been vital building blocks in the construction of modern life (computers, optoelectronics, and photovoltaics).[1] Key to their success is the ability to possess a whole host of compositions and phases, giving rise to highly unique magnetic and optoelectronic properties.[1-2] For example, the Si-rich β-$FeSi_2$ phase has a narrow direct band gap, and is a promising candidate for photovoltaics and fiber communication.[2] Similarly, Iron germanide phases (Fe_3Ge, FeGe…) attract much attention because they display various interesting magnetic properties : for instance, the cubic FeGe one is the only material showing the formation of skyrmions (vortex-like spin-swirling object) at room temperature, making them ideal for next-generation memory storage.[2] Currently metal silicide and germanide nanomaterials are typically synthesized via physical based methods that require harsh conditions (T ~ 900 – 1200 ^{o}C) and expensive equipment. Furthermore, these methods are limited in their control over key parameters such as size, shape, composition, phase, and yield.[1] To truly exploit these unique materials in next-generation optoelectronic and photovoltaic applications, the control over key parameters mentioned above (size, shape, composition, phase, and yield) must be realized. Solution based approaches, when harnessed correctly, are well known for their precise control over size, shape, composition, phase in nanomaterials. For iron silicide and germanide there is only a single report of their synthesis in solution, both of which had limited control over size, shape, composition, and yield.[3] We have recently, described the synthesis of unprecedented high quality iron germanide (β-phase $Fe_{3.2}Ge_2$) NCs (Figure).[4] This success relies on the use of rationally designed organometallic single source precursors which produce $Fe_{3.2}Ge_2$ NCs in the softest conditions ever reported. The strategy that we intend to explore will be based on the thermolysis of a second generation of high energy precursors in order to synthesize under mild conditions iron silicides and germanides nanocrystals (NCs) that have controlled-composition, -size, -surface, and -shape. The control of these structural and morphological characteristics is of central importance since, at the nanoscale, they profoundly impact the physical (optical, magnetic and transport) properties. The characterization and study of the physical properties using a wide range of techniques typically employed in molecular and material chemistry (IR, NMR, UV-Vis, photoluminescence spectroscopies, single crystal and powder X-ray diffraction), magnetic measurements (VSM) and electron microscopy (TEM, SEM).



In this project, we will develop high quality iron silicides and germanides using solution-based approaches. From the initial experiments and using a second generation of precursors, we hope to develop generalized, facile, synthetic routes to these important materials. Produced nanomaterials will be extensively characterized using a host of chemical and material techniques including (electron microscopy, NMR, XRD, magnetic measurements and absorbance/emission spectroscopy).

References

1) Vaughn II D. D., Schaak R. E. ***Chem Soc. Rev.*** 2013, *42*, 2861.
2) He Z., Xiong S., Wu S., Meng M., Wu X. ***J. Am. Chem. Soc***. 2015, *137*, 11419.
3) Vaughn II D. D., Sun D., Moyer J. A., Bianchi A. J., Schiffer P., Schaak R. E. ***Chem. Mater.*** 2013, *25*, 4396.
4) Sodreau A., Mallet-Ladeira S., Lachaize S., Miqueu K., Sotiropoulos J.-M., Madec D., Nayral C., Delpech F. ***Dalton Trans.*** 2018, *47*, 15114

Profile of the candidate: The candidate is expected to have a PhD in materials chemistry, with expertise in organometallic synthesis and a strong background in the use of a wide range of characterization techniques. More generally, the candidate needs to be highly motivated and capable of performing research in an autonomous and rigorous way. Given the multidisciplinarity context of the project, the candidate is expected to have excellent team working skills and a very good level in English. He (she) will also be involved in the dissemination of the research, through publications and presentations at national and international conferences. Moreover, the selected candidate will participate to the supervision and training of the undergraduate and graduate students involved in the project.

Application procedure:
Please provide a CV, a cover letter and the names of 2 references.
For queries about the position and/or the project, please contact Céline Nayral (cnayral@insa-toulouse.fr) and Fabien Delpech (fdelpech@insa-toulouse.fr). Ph : +33 5 61 55 96 50
The net monthly salary is between ~1900 and 2200 euros depending on the experience.
The preferred starting date is October, 2019. This can be postponed until late fall (especially for young candidates who have to defend their thesis in the fall).

Scientific environment: The project will be carried out in the Laboratoire de Physique et Chimie des Nano-Objets which the key characteristics is to bring together physicists and chemists who are all involved in the synthesis, the assembly, the study of the physical properties and the modelling of nanocrystals. In the framework of this project, three research groups of the LPCNO are involved: "Nanostructures and Organometallic Chemistry" (NCO), "Quantum Optoelectronics" and "Nanomagnetism". The post-doctoral fellow will perform the everyday work in the "Nanostructures and Organometallic Chemistry" group. It is specialized in designing new synthesis methods of metallic, semiconductor and oxide NPs starting from organometallic precursors (in solution and under mild conditions) and is one of the leading groups in this field at international level. Over the last 5 years, the group has published more than 170 articles in international journals and 5 patents. It focuses its interests on one hand, on the growth control and surface chemistry of NPs (shape control, self-organization, surface ligands), and on the other hand, on the influence of the surface chemistry on NPs chemical (catalysis) and physical properties (magnetic, optical, electronic). These basic researches find direct applications in various domains such as oncology, microelectronics, energy and catalysis. They contribute to meeting major current scientific and societal challenges such as the fight against cancer, the development of more environmentally friendly materials, CO_2 conversion and energy storage.