POST-DOCTORAL POSITION (18 MOIS)

This contract is part of CANDYCE project

Project title: Magnetic composites based on YIG or Ce-YIG nanoparticles (CANDYCE)
Project duration: 48 months (october 2024- september 2028)

Post-doctoral subject: « Development and characterisation of YAG nanoseeds»
Keywords: nanoparticles, solvothermal synthesis.

This 18-month contract is funded by the French National Research Agency (ANR) as part of the CANDYCE project. It is part of a collaboration between the PHENIX laboratory in Paris (ANR sponsor), the Institut de Chimie de Clermont Ferrand (ICCF) (Inorganic Materials (MI) team, Luminescent Materials (ML) group) of the Université Clermont Auvergne and the Laboratoire Hubert Curien in Saint-Etienne.

PROJECT SUMMARY

Yttrium iron garnet ($Y_3Fe_5O_{12}$ or YIG), which may or may not be doped with cerium, is a magneto-optical (MO) material with a strong Faraday effect, giving it potential applications as insulators or circulators in integrated optics platforms. Faced with the technological challenge of integrating it into these platforms, this project proposes to develop gold-coated Ce-YIG nanoparticles (NPs) whose size, morphology and functionalisation would be optimised to develop a composite Ce-YIG@Au/alkoxysilane MO material. The NPs (<20 nm), synthesised by a solvothermal process based on YAG seeds ($Y_3Al_5O_{12}$), will be coated with a layer of gold to give them interesting magneto-plasmonic properties. The resulting core-shell particles will then be functionalized on the surface so that they can be dispersed in an alkoxysilane-based sol. The preparation of the NPs will also be optimised to obtain single-domain nano-rods whose shape anisotropy gives a preferred direction to the magnetic moment. By orienting these moments during processing, the final composite will have a magnetic remanence enabling a self-polarised MO material to be obtained. The final composite material will then be inserted into the core of non-conventional photonic devices such as a suspended-core fibre, to produce integrated insulators.

POST-DOCTORAL SUBJECT :

The post-doctoral subject ‘Elaboration and characterisation of YAG nanoseeds’ will be carried out at the ICCF (UCA).

The post-doc's main task will be to develop well-crystallised YAG seeds of controlled size and morphology (5-10 nm). This mission will be carried out in close collaboration with the PHENIX laboratory, in particular thanks to strong interactions between the ICCF post-doc and the PHENIX PhD student.

One of the challenges to be overcome by the post-doc will be to obtain YAG nanogerms smaller than 10 nm (ideally around 5 nm), weakly agglomerated and with a controlled morphology (spherical or acicular particles). These seeds will have to be prepared in the form of stable suspension(s), so that they can be used directly for the growth of YIG/Ce-YIG nanoparticles in an autoclave reactor (doctoral student's assignment).

The planned application requires YIG or Ce-YIG nanoparticles with a diameter of less than 20 nm, if possible acicular, with an ideal aspect ratio of 2:1 (ideal ratio to be optimised). It is very difficult to obtain such particles directly, which is why YAG nanoparticles will be developed to serve as nanogerms for the YIG-Ce-YIG phase. The YAG matrix was chosen because the YAG and YIG phases are isostructural. The development of YAG acicular nanoparticles has been reported very little. In fact, the work carried out to date has resulted in rather spherical nanoparticles with diameters of less than 30 nm. To meet the challenge posed by this project, two strategies will be considered: 1) a **bottom-up strategy** consisting of playing on the synthesis conditions of solvothermal methods to directly obtain YAG nanoparticles ideally smaller than 10 nm and with an ideally acicular morphology; 2) a **top-down strategy** in which submicron YAG particles will be synthesised by the sol-gel process, which is well mastered at the ICCF, before being ground (wet grinding using a planetary mill available at the ICCF).

All the samples obtained will be characterised using conventional techniques: X-ray diffraction (XRD), transmission and scanning electron microscopy (TEM and SEM), Raman and IR spectroscopies. Specific techniques such as SAXS may also be used. All these characterisations will be used to define the optimum conditions for synthesis.

COMPLEMENTARY INFORMATION

***Profile*: PhD in inorganic materials chemistry or in the physical chemistry of materials.**
***Funding*: ANR, gross monthly salary 3080€ over 18 months**

Persons involved in the project and supervising the post-doctoral student

- Audrey Potdevin / audrey.potdevin@sigma-clermont.fr
- Geneviève Chadeyron / genevieve.chadeyron@sigma-clermont.fr

Deadline for applications: 26 November 2024, accompanied by a detailed CV (with letter(s) of recommendation if possible) and a covering letter **(to be sent to the above contacts).**

Desired contract start date: January or February 2025