Luminescent materials have entered our everyday life. They can be found in lamps, traffic lights, computer screens, cell phones, in labels for goods, are used in medical applications, airport security check devices, and many more. Indeed, they have become indispensable and much of society's convenience and welfare depend on them. No wonder that the development and use of luminescent materials have truly exploded in the past decade stimulated by the challenging requirements of technological applications spanning domains from solid-state lighting, optics and photonics, energy conversion and storage to well as labeling, detection, and imaging in biomedicine. The production of luminescent materials and related devices also is the basis for a large industrial sector.

There is and there will be a strong demand for functional luminescent materials in the single crystal forms. Synthetic crystals are high-tech materials that possess a high degree of purity, perfection, extreme hardness, superior thermal and electrical conduction, and are engineered for the desired application. Crystal chemistry strategies are the basis for the tuning and understanding of material properties, as well as the discovery and structural design of new luminescent materials for emerging applications.

Perovskite phase ($LnMO_3$) and garnet phase ($Ln_3M_2M_3O_{12}$) (Ln=Y, Lu, Tb lanthanide and M=Al, Ga, Sc metal elements) single crystals show physical and chemical properties closely related to the structure, composition and synthesis methods. The flexibility of garnet and perovskite structures allow for extreme variations in the designing phase and composition concerning the applications. Activated with optically active ions (e.g. Ce^{3+}, Eu^{3+} or Pr^{3+}) form a class of highly efficient luminescent materials with a remarkably rich history of applications ranging from cathode ray phosphors, lasers and color correction phosphors in fluorescent tubes to their more recent application as scintillators, afterglow materials and color converters in white light-emitting diodes. Generally, the large ionic radii mismatch between Ln^{3+} and M^{3+} ions favors perovskite phase formations, whilst mild ionic radii mismatch stabilizes the garnet phase. The control of this feature enables a smooth transition from the perovskite phase to the garnet phase. However, the knowledge on the transition from perovskite phase to garnet phase, and thus, thermodynamical equilibrium, is limited i.e. boundary between garnet and perovskite phase formation is not determined for single crystals. To successfully design luminescence materials for target applications, detailed knowledge on the thermodynamical equilibrium between perovskite and garnet phase single crystals related to chemical composition is required. Indeed, in the field of single crystals growth from the melt, still, there is a gap in the systematic research on factors governing the transition from perovskite to garnet phase. Therefore, this project aims to fill a lack of knowledge in the research on perovskite and garnet phase single crystals and eutectics equilibria (i.e. to reveal the relationship between a target phase and corresponding factors, such as composition, cation ionic radii mismatch and temperature). Such fundamental knowledge will allow predicting which chemical compositions might be crystallized in the perovskite or garnet phase as well as eutectic systems. Then, it will permit to design of a single crystal with demand luminescence, scintillation, and photo-conversion features for a target application. Consequently, novel multifunctional crystals and single-crystalline films might be discovered for emerging applications.

The micro-pulling down (µ-PD) method is a perfect tool for single crystal growth. This technique enables a fast (5-10 h) and cheap (use of raw material around 1g) crystal growth and is suitable for solidification congruently and incongruently melting systems and eutectic composite systems. The ability to crystallize practically 100% of the melt is an additional advantage. The growth rate up to 5 mm/min is much faster than in most growth methods (e.g. Czochralski or Bridgman) and very convenient for the rapid analysis of new crystal compositions. Moreover, several compositions in the form of single-crystalline films will be prepared by the liquid phase epitaxy (LPE) method. All synthesized perovskite and garnet single crystal and single-crystalline thin film compositions will be characterized in terms of their structural, luminescent, scintillation and photo-conversion properties. Finally, the features of both µ-PD and LPE technological methods for producing luminescent materials will be demonstrated. Luminescent and scintillation and photoconversion properties of selected crystals and films will be compared.