Objective of the project

The project aims to optimize the synthesis, analyse structurally, and spectroscopically investigate new inorganic tellurate-type optical materials, specifically $BaLaLiTeO_6$ and $BaLaNaTeO_6$ in the form of polycrystalline powders, both un-doped and doped with Nd^{3+} or Yb^{3+} ions. A parallel objective is to check the sinterability and determine whether these cubic structures can serve as new transparent ceramic materials. The selection of these materials is justified as they demonstrate exceptional suitability for incorporating optically active rare earth metal ions (RE^{3+}). The tellurates proposed in this project are also part of the large family of perovskite compounds. Such structures are currently widely studied due to their versatile applications in modern solid-state science, holding great promise as new semiconductors, superconductors, and luminescent materials.

Description of the reasons for choosing the research topic

Transparent ceramics are considered innovative materials because they result from a high level of proficiency in often complex manufacturing processes. Even though the first truly transparent alumina-based ceramics emerged in the 1960s, recent developments in ceramic processes have significantly improved their performance and expanded the range of available compositions. It is now possible to finely control their composition and microstructure, particularly their grain size and residual porosity, and ultimately their functional properties. The development prospects for these materials are numerous and largely rely on the flexibility of ceramic processes. This allows for the development of new compositions, including non-cubic crystalline systems through processes that favour grain orientation, as well as the production of large, complex-shaped pieces with properties equivalent to or superior to those of single crystals and glasses.

Transparent ceramics like sapphire (Al_2O_3) for optical devices, YAG (yttrium garnet, $Y_3Al_5O_{12}$) for optical materials (e.g., lasers, LEDs, scintillators), and PZN–PT (lead zinc niobate–lead titanate, $PbZn_{1/3}Nb_{2/3}O_3$–$PbTiO_3$) for electro-optics address many of the challenges faced by traditional single crystal materials. Growing single crystals requires sophisticated facilities and is very time-consuming, resulting in expensive products that are only practical where cost is not a major concern. Additionally, single crystals are often difficult to machine for specific applications due to shapes determined more by their crystal structure than by processing conditions. Other issues with single crystals include the challenge of large-scale production and the mechanical brittleness of some materials. In this context, transparent ceramics are becoming increasingly important. Transparent ceramics offer several advantages over single crystals, such as cost-effectiveness, scalability, shape control feasibility, and improved mechanical properties.

Research Description

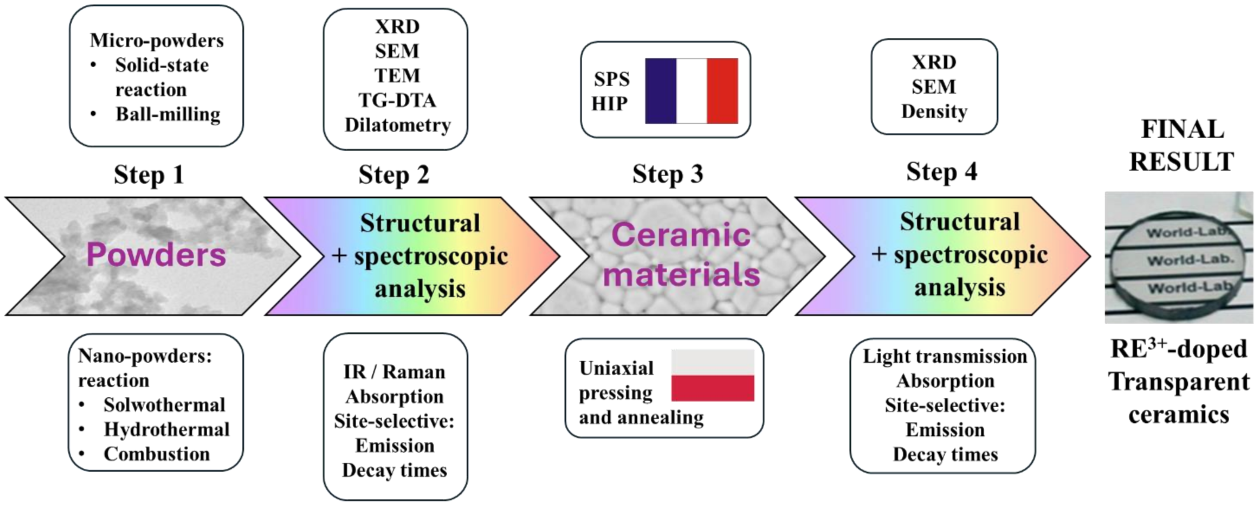

Fig. Project Layout Diagram

The most anticipated outcomes

The primary outcome of the project is the introduction of tellurate-type $BaLaLiTeO_6$ and $BaLaNaTeO_6$ as a novel category of transparent ceramics. This advancement opens new possibilities for researchers to explore their potential applications. The perovskite-type structures of BLLT and BLNT, proposed within this project, offer facile ion substitution within the lattice. Introducing both divalent and trivalent ions enables the exploration of a wide range of application properties, such as Eu^{2+} (for LEDs), Ce^{3+} and Pr^{3+} (for scintillators), and Nd^{3+} and Yb^{3+} (for near-infrared lasers), among others.