

Nanostructured Ternary Alloys: The Role of Laser Ablation in Shaping Composition and Structure

Materials undergoing magnetostructural transformations — meaning that their crystal structure and magnetic properties change simultaneously — have attracted great interest from scientists worldwide in recent years. These unique properties are important not only for fundamental physics and chemistry but also for various modern technologies. Among their remarkable features are temperature- and magnetically-controlled shape memory effects, giant magnetocaloric effects (useful, for example, in advanced cooling systems), magnetoresistance (changes in electrical resistance under a magnetic field), and barocaloric effects related to pressure changes.

In our project, we aim to produce fine alloy particles (submicron and nanometer-sized) by combining chemical and physical synthesis methods. We are particularly interested in alloys with structures typical for so-called Heusler alloys, containing transition metals as well as elements such as silicon, germanium, manganese, iron, or gallium.

The project focuses on three main goals:

- studying how crystallite size and atomic arrangement affect magnetostructural properties;
- applying a modern synthesis technique — laser ablation in solution (LASiS) — to create multicomponent submicron alloy particles;
- analyzing how particle dispersion influences their magnetic properties.

Previous research has shown that even small changes in chemical composition or doping can significantly alter these materials' properties. Our team has extensive experience in nanomaterial synthesis using chemical methods, ball milling, and solid solution preparation. The produced particles are stabilized using surfactants to prevent agglomeration.

A particularly innovative aspect of our project is the use of laser ablation in solution, which enables processing materials with highly complex chemical compositions. The initial alloys will be prepared in an arc furnace by melting pure elements in an argon atmosphere. These will then be processed into nanoparticles.

To thoroughly investigate the properties of the obtained materials, we will use a wide range of advanced characterization techniques, including Mössbauer spectroscopy, X-ray diffraction (XRD), electron microscopy (SEM, TEM), thermal analysis (DSC, TGA), infrared (IR), UV-Vis, Raman spectroscopy, BET surface area analysis, and EDX. Most of these methods are available at our BioNanoTechno Center at the Faculty of Chemistry, University of Białystok.

We also collaborate with a foreign partner from the University of Padova, who will assist us in building the laser ablation setup, and with the Faculty of Physics at UwB, which has expertise in bulk Heusler alloys.

This research will help us better understand how atomic arrangement and particle size influence the properties of these exceptional materials. In the future, this knowledge may allow us to design materials with tailor-made parameters for use in advanced cooling systems, energy conversion, and next-generation electronics.