High-Entropy Alloys (HEAs) are next-generation advanced materials characterized by unique properties, designed to perform under demanding conditions. Their key feature is a complex chemical composition, typically consisting of five or more elements. Due to the high configurational entropy in their structure, HEAs stabilize simple phases while suppressing the formation of intermetallic phases, resulting in uniform and reliable properties.

The magnetron sputtering technique, particularly in its pulsed mode, represents one of the most advanced methods for producing multi-component coatings. By precisely controlling parameters such as discharge power, intrinsic and modulation frequencies, and gas pressures, this method allows for the production of homogeneous, amorphous, or nanocrystalline coatings with exceptional properties.

This project focuses on the synthesis of high-entropy alloys composed of refractory and non-toxic elements, including titanium (Ti), zirconium (Zr), molybdenum (Mo), niobium (Nb), copper (Cu), tungsten (W), and tantalum (Ta). The scientific objective is to investigate the application of pulsed plasma generated during magnetron sputtering processes—specifically pulsed magnetron sputtering (PMS) and high-power impulse magnetron sputtering (HiPIMS)—to control and optimize the structure and properties of HEA coatings.

The project aims to develop a synthesis technology for HEA coatings that enables the production of materials with tailored phase compositions, structural features, and functional properties. A detailed analysis will assess the influence of plasma ionization states, pulse frequencies, and energy delivery on the formation of metastable phases and nanostructures in multi-component coatings of the Ti-Zr-Mo-Nb-M system (where M = Ta, Cu, W). Advanced characterization techniques—including SEM, HRTEM/STEM (morphology, topography), XPS, EDS (chemical composition), and X-ray diffraction (phase composition)—will be employed to study the structural and phase states of the coatings. Furthermore, the mechanical, tribological, and corrosion resistance properties of the coatings will be thoroughly evaluated. Based on these results, the project will establish correlations between process parameters, layer structure, phase composition, and functional properties.

The synthesized HEA Ti-Zr-Mo-Nb-M alloys (where M = Cu, W, Ta) have potential applications in the energy and biomedical industries. These coatings can protect surfaces from wear, enhance the durability of turbine components, and be used for medical implants requiring biocompatibility and exceptional strength. HEAs deposited via PMS plasma surface engineering represent the future of advanced material technologies, offering unique physicochemical properties and opening new possibilities for the design of high-performance functional coatings.