

The development of new technologies based on ferromagnetic films is important in many areas of everyday life, for example in telecommunications, information technology, and medicine. In particular, this applies to spintronics and magnonics. Spintronics is the control of electrons exploiting their charge and their spin; and magnonics is the manipulation of spin waves (collective precessions of their magnetic moments). The rapid development of these fields is because multiple applications have been found, and they are either already implemented or at the testing phase. The wide range of application includes areas such as transmission and processing of information, magnetic field sensors, and logical devices. Rapid progress in these areas is possible due to extensive material studies. A spectacular example of this is the very recent experimental realization of Dzyaloshinski-Moriya interaction (DMI) induced skyrmion formation even though the DMI has been studied since the 1960s. Skyrmions are objects of nanometric size exhibiting a whirl spin configuration with chirality determined by the DMI. Because of their stability and small size, they are a promising medium for processing and recording information on currently unreachable data storage densities. Thanks to DMI, spin waves that have the same wavelength but opposite propagating direction will have different frequencies. This allows for the control of spin wave emission in desired directions. Due to the aforementioned advantages and a wide range of applications, the DMI is intensively studied in many renowned laboratories. Currently, it is very important to develop methods that allow the propagation of spin waves in waveguides of any shape and the skyrmions movement along specific paths without deflection in the presence of currents. Very recent theoretical reports show that the desired effects can be achieved in ferromagnetic thin films with spatially distributed DMI. However, so far there is no effective method allowing local modification of the DMI. We expect that DMI modifications can be generated by changes in the microstructure of the interface between the ferromagnetic and the surrounding layers. In ferromagnetic films, the DMI has interfacial character, therefore using our previous experience in the field of structural modification through ion bombardment, we expect that this technique will also allow for the modification of DMI. Therefore, the scientific goal of this project is to describe and explain the influence of ion bombardment on the DMI. The final goal is to achieve local modification of DMI by focused ion beam (FIB) or ion bombardment through masks.

Based on our previous research and literature reports, for this investigation we have selected layered systems exhibiting: strong DMI, low damping of magnetization precession, and perpendicular magnetic anisotropy (where the magnetization favors directions perpendicular to the plane). This choice provides the opportunity to develop a technology for the fabrication of new magnetic materials required in spintronic and magnonics, which here will be investigated experimentally and with Monte Carlo and micromagnetic simulations. These specialized calculation methods will allow not only to interpret experimental results but also to select material parameters, which in turn will determine the choice of material to be used in the proposed experiments of this project.

The subject of the project is included in the National Smart Specializations program (Advanced Multifunctional Smart Nanostructural Materials to be Applied in Electronics, Optoelectronics, Sensorics, Information Technology, Photonics and Communication, and their Technologies) and it is in the mainstream of material research of thin films conducted in leading research centers around the world.