The scientific objective of this study is to explore the mechanisms of microstructure formation of single α(Mg) and dual α(Mg)+β(Li) phase Mg-Li-Ca alloys produced by laser powder bed fusion (LPBF) to control their mechanical and corrosion properties with a particular focus on application in regenerative biomedicine. An important feature of Mg alloys is their biodegradability, which may be a critical point in the production of newly developed bone implants, which due to time duration can be fully replaced by newly formed tissue. Such a solution will minimize the number of surgeries that are necessary to remove non-resorbable Ti and steel implants. Although Mg alloys exhibit a Young modulus (about 45 GPa) similar to human bone (7-30 GPa), their formability due to the hexagonal crystal lattice (hcp) is limited. Alloying Mg with Li can be an alternative way to overcome fabrication obstacles. The use of Mg-Li alloys can also significantly reduce the weight of implants. Nevertheless, too fast degradation of the Mg-Li alloys produced by ingot metallurgy usually results in a premature disintegration of mechanical integrity and local hydrogen accumulation, which limits their clinical bone repair application. Furthermore, hcp-structured metals are hard to deform due to limited slip planes activated at room temperature, and this causes difficulties in fabrication of elements with complex shapes using traditional routes.

Tailoring the microstructure of single α(Mg) and dual α(Mg)+ β(Li) phase Mg-Li alloys by additive methods due to a high cooling ratio should significantly improve their corrosion and mechanical properties. Therefore, within this project, we will attempt to fabricate fully densified Mg-Li alloys using laser powder bed fusion (LPBF). Moreover, Ca will be added to increase the biocompatibility and osseointegration of the alloys. As a result, ultrafine grained single α(Mg) structured Mg-Li-Ca and ultrafine grained dual α(Mg)+β(Li) structured Mg-Li-Ca alloys will be produced. The developed materials will give us – in a world first – broad knowledge about the mechanical, corrosion and biological performance of Mg alloys alloyed with Li and Ca, which will be a strong background for further design and evaluation of single α(Mg) and dual α(Mg)+β(Li) phase Mg-Li alloys to obtain fully biofunctional materials. Furthermore, the results will be compared with materials prepared by ingot metallurgy.

The systematic work involves the production of Mg-Li-based alloys with a single phase α(Mg) structure and dual α(Mg)+β(Li) structure by LPBF (Fig.1). For this purpose, the custom-made powders will be fabricated, and the parameters of ultrasonic atomization will be chosen as accurately to avoid Li oxidation or evaporation. The powders will be used for consolidation via LPBF. LPBF parameters will be adjusted to minimize defects such as porosity or crack initiation during materials fabrication. Once materials with maximum density will be fabricated, tests will be carried out to understand the formation of materials' microstructure and the resulting biological, corrosion and mechanical properties. In the final step, to consider the produced materials as biomaterials, attention will be paid to the correlation between the degradation properties and the biological behaviour of the material.

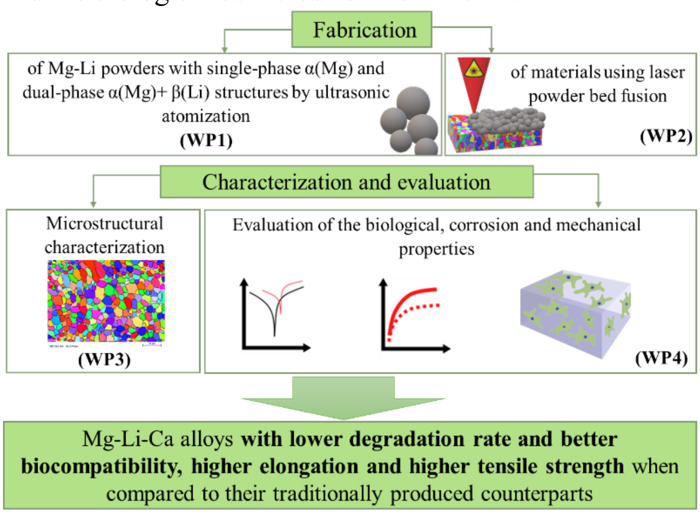

Figure 1 Flowchart of the project

As a result of the project a wide knowledge of the properties of Mg-4Li-0.5Ca and Mg-8Li-0.5Ca fabricated via laser powder bed fusion will be gained, and this will allow as to get a deep understanding of the microstructure formation and its influence on the functional properties of the alloys in terms of biomedical use.