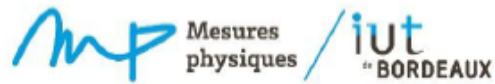


Table of Content in a report: the outline - MP S3 2022 **KEYS**

Work in groups of 3-4 students. Here is an extract of a former student's internship final report.

From its abstract, introduction and conclusion, build a balanced outline with meaningful titles.



Second-year student in Applied Physics and Measurement Engineering.

Internship report

Development and characterization of Magnesium-based materials for implant application.

Internship carried out from April 15 to June 25 2022.



Company: Helmholtz-Zentrum Hereon,
Institute of Metallic Biomaterials,
Department of Functional Magnesium Materials,

Internship tutor: Dr.

Abstract

Nowadays, more and more people are practicing extreme sports increasing risks of fractures. It is necessary to adapt and make convenient bone and ligament consolidation. For that, the company Helmholtz-Zentrum Hereon develops and characterizes magnesium staples to restore a fractured bone or a broken ligament. Those staples have the property to degrade in the human body so there is no need for the implant to be removed after having repaired the fracture. To fulfill its functions, the implant material must have specific properties. As a matter of fact, many researches and studies were done on plenty of magnesium alloys. The material microstructure and its behavior during thermo-mechanical and degradation test had to be investigated. During the internship, we focused on the microstructural observation of the alloys. To do that, samples were created directly from raw material by extrusion. Then, it was polished and observed by optical and scanning electron microscope (SEM). Those investigations were furthered by electron backscattered diffraction analyze for specific samples. All of those measurements had the aim to evaluate the composition of the alloy, its properties and the impact of the extrusion process on the material structure. Then, the samples will be investigated at the synchrotron accelerator to determine its thermo-mechanical properties, and will sustain degradation tests in the bio laboratory.

My internship took place in the company Helmholtz-Zentrum Hereon in Germany. This limited liability company is dealing with the preservation of a sustainable world. In fact, they generate knowledge and they research new technologies for the benefit of the climate, the coasts and the people. They go through experimental studies, modeling, artificial intelligence and make a link between basic scientific understanding and practical applications. The site of the company in Geesthacht is dealing especially with materials and coastal environment researches. On this site is the Institute of Metallic Biomaterials that covers the Department of Functional Magnesium Materials. This Institute welcomed me during 10 weeks. The team develops and characterizes materials for medical implant that could be implanted and degrade in the human body in order to restore fractured bones or ruptured ligament. They investigate the manufacturing process, the exact shape, the detailed chemical composition and the resulting microstructure in order to obtain the best material for implant application.

As human life expectancy is increasing, and more and more people go in for high-risk sports, the risks of bones fractures or ligament break increase. As a matter of fact, it became necessary to develop novels materials for medical implants based on magnesium so it could degrade in the body and do not need to be surgically removed. Thus, bones or ligament consolidation would become more convenient for patient and save time for doctors.

How do you investigate the microstructure of materials to develop magnesium staples for human implant application?

The Magnesium material is an alkaline-earth metal enough inert to the air to be used in the industry as a pure metal or a constituent of an alloy. The magnesium is a material facing a great future in the biomedical field thanks to its properties. In effect, according to the website Lenntech [1], the magnesium has the lightest density of all metals ($1,81 \text{ g/cm}^3$ at 20°C) and the capacity to degrade in the body. Alloyed with other elements, its properties evolve and get better. It is very profuse in nature and is found in very large quantities in many rock ores. It is the third more abundant metal in the earth crust. Actually, it is a very used material in the mechanical, biomedical and industrial field mainly because of its lightweight.

To get the best alloy with the properties needed for a biomedical implant, it is necessary to investigate many different magnesium based alloys. The purpose of the internship was to investigate and characterize six different magnesium alloys with as-cast and extruded samples using different technics and process. In the first part, the investigations were focused on 6 magnesium alloys analyzed with as-cast samples. Those samples were polished and their microstructure was observed by an optical and a scanning electron microscope. In the second part, the purpose was to evaluate the impact of the extrusion process on two specific magnesium alloys. For that, the raw material was extruded and then samples were created for microstructural observation. Those observations were completed with an electron backscattered diffraction analysis for some particular samples. Finally, after those microstructural characterizations, the samples will sustain thermomechanical tests realized with the synchrotron source in Hamburg.

Conclusion

To conclude, a large microstructural study had been done on the samples from different alloys. The goal of the research was to investigate and to compare the different microstructures of samples from different magnesium alloys obtained by extrusion or not. To reach that conclusion, the samples needed to be created from raw material extruded or as-cast. It was polished and etched before being analyzed by optical microscope used to observe an overall view of the microstructure and the components. After, it was observed by a scanning electron microscope to further investigate the composition and especially the particles. Some of the samples were also investigated by an EBSD process to look into the orientation and the size of the grains. Finally, with all of these studies, the presence of LPSO phase was noticed in all the samples proving the strength of each alloy. Also, the extrusion process have a real impact on the properties of the material. In fact, the grains of the samples extruded were really smaller than the as-cast samples ones. This has an effect on the strength of the material as small grains allow easily grains boundaries, a way to strengthen the material.

According to the timeline in the Appendix 4, I reached the step "Sample preparation, microstructure, characterization" during my internship. The following step for the team will be to manage thermo-mechanical tests at the DESY center in order to evaluate the behavior of the alloys under constraints. After that, degradation test will occur in the bio laboratory with conditions similar to the human body (temperature, PH level, oxygen level of blood). The most compatible samples will be selected and will be sent in the laboratory in Kiel to be implanted in rat's body. This will be the last step before the concretization of magnesium staples for implant application.

Personally, this internship constitutes my first professional experience and it was very rewarding. In effect, it was very pleasant to be part of a concrete project useful for people and doctors. This internship allowed me to put in practice skills learnt at the University. It was very interesting to see the application of theoretic knowledge and the way it is applied in a professional context. I had the chance to discover new technics and new process of analyze as the EBSD technic, the measurements with the synchrotron source in the DESY Center and the polishing process of magnesium. The biomedical context was totally unknown for me before my arrival but I developed skills about it and especially about the magnesium material and its properties. By using often devices as the optical microscope or the SEM, I became comfortable with it and the quality of my work increased. The internship was also an opportunity to work with people in team on a same project. I learnt by their side how to share my results and how to work with different people according to their specialty. Finally, my English level was improved as I used the English language every day.

Your analysis on the quality of these elements

- *abstract:*

- *introduction:*

- *conclusion:*

Your outline from these elements.

Use the **sub-headings** below to propose a balanced and logical outline. Think of any title for the headings of the two/three main parts that could include these subheadings. You may add sub-sub headings too.

Further examination of the microstructure using the SEM microscope

The Department of Functional Magnesium Materials in charge of the Magnesium-based human implant project

The extrusion process, its consequences and the creation of specific samples for microstructural observation

Tomography measurements to complete microstructural investigations

The temperature role on the strength of magnesium

Sample preparation for microstructural observation

The Institute of Metallic Biomaterials & Materials for structural application and medical implants

Previous investigations on the magnesium material : state of the art

Diffraction measurements under constraint on a MgYZn sample

Analyses of the microstructure with the optical microscope

Table of contents

1. The German company Helmholtz-Zentrum Hereon preserving health in a sustainable way

- 1.1. The Institute of Metallic Biomaterials & Materials for structural application and medical implants
- 1.2. The Department of Functional Magnesium Materials in charge of the Magnesium-based human implant project
- 1.3. Previous investigations on the magnesium material : state of the art
 - 1.3.1. The impact of the extrusion parameters on the magnesium properties.
 - 1.3.2. The temperature role on the strength of magnesium

2. Microstructure of six magnesium-based alloys : characterization with optical microscope

- 2.1. Sample preparation for microstructural observation
- 2.2. Analyses of the microstructure with the optical microscope
- 2.3. Further examination of the microstructure using the SEM microscope

3. Extrusion process : an in-depth study of the alloys $Mg_{1.8}Y_{0.6}Zn$ and $Mg_{1.8}Y_{0.6}Zn_{1.6}$

- 3.1. The extrusion process, its consequences and the creation of specific samples for microstructural observation.
 - 3.1.1. Heat treatment and extrusion process
 - 3.1.2. Interpretation of the extrusion values and its impact on the following investigations
 - 3.1.3. Transformation of the extruded bars into samples for microstructural investigations
- 3.2. Analyses of the microstructure images and comparison to the previous ones
 - 3.2.1. Microstructural observation with the optical microscope
 - 3.2.2. Further investigations on six specific samples using the EBSD technique
 - 3.2.3. Final microstructural observation using the SEM microscope

4. Final mechanical measurements with synchrotron radiation source at DESY Center

- 4.1. Diffraction measurements under constraint on a MgYZn sample
- 4.2. Tomography measurements to complete microstructural investigations.

Conclusion	
Bibliography	
List of acronyms.....	
List of figures	
List of appendices	