

Supervisor Report on PhD Thesis

Faculty: **Central European Institute of Technology**
Student: **Mariano Casas Luna**

Academic year: **2019/20**

Doctoral study program: **Advanced Materials and Nanosciences**
Field of study: **Advanced nanotechnologies and microtechnologies**
Supervisor: **doc. Ing. Ladislav Čelko, Ph.D.**

PhD thesis title: Structure and properties of hydroxyapatite-magnesium composites produced by the means of current assisted infiltration sintering

Evaluation of doctoral thesis:

I met Mariano Casas Luna for the first time during my research stay at the CIITEC-IPN in Mexico in the year 2013. At that year, he defended his master study programme at the IPN and then completed three months research stay in our research group at CEITEC BUT. After he finished his master study, he became a full member of our research group as a PhD student. During his PhD study, he has been involved in three his own topic related projects and other four interdisciplinary research projects.

Mariano's dissertation thesis deals with the highly topical research on new composite materials for biodegradable orthopaedic implants, which in future will enable to avoid the second invasive surgery to remove the implanted material from animal or human body.

To achieve that, Mariano studied several interrelated topics. Firstly, the individual materials for composites formulation were synthesized (HA, TCP and CDHA ceramics) or casted (Mg, Mg-Ca and Mg-Zn alloys). Secondly, the inks of ceramic powder were designed and produced, and the porous ceramic green bodies with different and controlled spatial resolution were 3D printed (robocasted). Thirdly, the ceramic green bodies were sintered, and/or directly infiltrated utilizing the newly developed method, in close collaboration between the CEITEC-BUT and CIITEC-IPN, called the current assisted metal infiltration process. Finally, the produced composites were characterized utilizing the approaches of materials science and engineering, and preliminary biology *in vitro* test. Mariano concluded all the above-mentioned procedures and successfully reached the final goal of the thesis. It should be also noted that Mariano was a part of the research team and as a co-author help to develop the procedure of the current assisted metal infiltration process, which resulted in patent proposed by IPN.

During his PhD study, Mariano successfully learned and enhanced his skills in the problematics of soft-chemistry (wet precipitation method, stable suspensions formulation, chemical analysis, etc.), additive manufacturing (direct ink writing), heat treatment (calcination, casting of magnesium and its alloys, sintering, current assisted metal infiltration, etc.), methods of structural and phase analyses of materials (metallography, LM, SEM, XRD, XPS, etc.), methods of evaluation of materials properties (nano-, micro-, hardness measurements, compressive test, etc.), and selected *in vitro* biology protocol (cytotoxicity). Moreover, he successfully concluded two two-months research stays abroad: (i) at the Helmholtz Centre in Geesthacht in Germany in the research group of Dr. Norbert Hort, an excellent European researcher in the field of magnesium alloys, under his direct supervision, where he dealt with magnesium alloys casting, and (ii) at CIITEC-IPN in Mexico in the research group of prof.

Sebastián Díaz de la Torre, an excellent researcher in the field of powder metallurgy and spark plasma sintering, under his direct supervision, where he made a significant progress on the current assisted metal infiltration technology.

He, as a talented young researcher, acceded to the thesis topic and laboratory works very independently and in an excellent and responsible manner. The written thesis is well ordered, systematic and clear for the scientific audience across the several branches. I also noticed a high formal and stylistic level of the work, except for some minor typos.

The results of the doctoral thesis and Mariano's other work on interdisciplinary projects in which he was involved were published in nine highly reputable impact journals (*Acta Biomaterialia*, *Journal of the European Ceramic Society*, *Ceramics International*, *Metallurgical and Materials Transaction B*, *Journal of the Mechanical Behavior of Biomedical Materials*, *Journal of Composites Science*, *Acta Metallurgica Sinica*, and *JOM*), presented at nine national and international conferences, and published in three conference proceedings (listed in WoS and/or Scopus). Moreover, he is also a co-author of two international patents: (i) Spark plasma synthesis of hydroxyapatite and (ii) Current assisted metal infiltration process.

Overall, I found Mariano the exceptional young talented researcher, a very valuable member of the research team, and an independent hard working and critically thinking person who was always ready to help solving current scientific issues. **I am delighted to recommend his thesis for the defence** leading to the PhD degree.

In Brno, 4th September, 2020

doc. Ing. Ladislav Čelko, Ph.D.

Supervisor of doctoral thesis