Opponent report of doctoral thesis of

Ing. Luca Bertolla

MECHANICAL REINFORCEMENT OF BIOGLASS®-BASED SCAFFOLDS

1. Topicality

The open cell ceramic foams are of the technological interest because of their potential use in a number of industrial branches. They still wait for future more extensive applications because the mechanical response is usually below the needed limits. Bioactive glasses have been commercially available for more than 30 years as bone substituting material in orthopaedic applications and in dentistry surgeries. However, the main drawback still impairing the use of bioactive glasses in load-bearing applications is their intrinsic brittleness. In this context, the subject of the submitted thesis is very topical because it focuses on the reinforcement of brittle Bioglass®-based porous scaffolds and the production of bulk Bioglass® samples exhibiting enhanced mechanical properties.

2. The aims of the thesis and their fulfilment

The main aims of the thesis concern the mechanical improvement of bulk Bioglass® and Bioglass®–based porous scaffolds. The planned research represents a broad spectrum of activities ranging from the production of scaffolds by using different kind of slurries, coating of scaffolds by different polymers and their mechanical testing and also FE modelling of foam’s unit cell and coating effect, and last but not least the production of and characterization of boron nitride nanosheets (BNNS) by top-down approach and sintering of bulk Bioglass® and Bioglass®/BNNSs by spark plasma sintering. I can state that the aims of the thesis were fulfilled.

3. Opinion concerning the procedure, the concrete contribution and the applied methodology

The submitted thesis deals with the given problems on 107 pages of text divided into 7 chapters including Conclusions. The author quotes 223 references including his own contributions. In the end of the thesis the author includes the list of his publications –which represents 7 contributions in proceedings of international conferences and 4 papers in impacted scientific journals. The chapter 2 (pp. 15-42) provides a solid background research concerning all fields the thesis is focused on. The chapter 4 (pp. 45-59) describes thoroughly applied methods in all planned research activities, which includes sample preparation, exfoliation of BNNSs, characterization of materials and FEM modelling. The chapter 5 (pp. 60-84) presents vast bulk of results the author achieved in various fields of the planned
research. The results obtained are then discussed in chapter 6 (pp. 85-100) and briefly summarized in the Conclusion (101-102).

With respect to methodology, the submitted thesis is elaborated in a well-considered way and also provides great number of hints in the literature and procedures necessary to achieve the planned goals. Procedures for solving given subject matter concur literary analysis of state of-the-art of given problems and focus on following research areas: production of scaffolds by using different kind of slurries, coating of scaffolds by different polymers, mechanical test of bulk Bioglass®, mechanical test of coated scaffolds, microstructural characterization of scaffolds and fractographic analysis by SEM, production of coating film, mechanical test of coating material, FE modelling of foam’s unit cell and coating effect, production of and characterization of BNNSs by top-down approach and sintering of bulk Bioglass® and Bioglass®/BNNSs by SPS. The author significantly contributed and brought new piece of knowledge primarily in respect to coating of scaffolds by different polymers and mechanical testing of coated scaffolds.

4. Importance for the next development of scientific field and engineering applications

The author collected a great number of results which significantly contribute both to basic knowledge and applied research, respectively, in the given field. E.g. for the first time ethanol-based slurry has been adopted for the production of 45S5 Bioglass® scaffolds. Resulting scaffolds exhibited 3D interconnected structure with higher degree of open porosity in comparison with water-based Bioglass® slurries commonly reported in literature. Both polyvinyl alcohol (PVA) and microfibrillated cellulose (MFC) composite coatings were successfully applied to the scaffolds by dip–coating without reducing the open porosity. It was found that the addition of 5 wt. % of MFC fibres led to a noticeable 10 fold increase of compressive strength. Also tensile strength has been found to be remarkably improved by the PVA/MFC composite coating; the scaffold coating containing PVA with addition of 10 wt. % of MFC exhibited more than 20 fold increase of tensile strength compared to non-coated samples. I appreciate that the author also attempted finite element modelling which demonstrated that the dominant criterion for the strengthening for polymer-coated scaffolds is the extent of coating infiltration into surface defects.

5. Formal lay-out of the Ph.D. thesis

From the formal point of view the doctoral thesis possesses a required level and matches standards imposed upon theses. Figures provide sufficient information and the text is comprehensible both with respect to contents and the used language, respectively. I have found only few misprints in the thesis.

6. Remarks on the thesis and questions

a) In my opinion, data in the Table 14 concerning the slope of linear part of stress-strain curves do not correspond to the plots in Fig. 38a)

b) Influence the defects in the scaffold struts the overall stiffness of the scaffold? Can the coating infiltration into surface defects influence the overall stiffness of the scaffold?
7. The short version of the Ph.D. thesis

The short version of the Ph.D. thesis provides sufficient information concerning the content of the doctoral thesis.

8. Conclusion

I evaluate the submitted thesis positively. Ing. Luca Bertolla proved to be capable of scientific work, to join a scientific team, and to solve a commended problem, respectively. The Ph.D. thesis fulfils both factual and formal requisites imposed on doctoral theses. Hence, I can recommend the submitted thesis for defence and after a successful pass of the defence

    I recommend to award to Ing. Luca Bertolla the title
    Ph.D. in the field of Physical and Materials Engineering.

Brno, December 3, 2015