

## **OPINION**

for dissertation work

for acquiring the scientific degree "Doctor of Sciences"

in the area of higher education 5. Technical sciences

professional field 5.6. Materials and Material Science

specialty "Material Science and Technology of Machine Building Materials"

Author: Assoc. Prof. Eng. Tsanka Dimitrova Dikova

Topic: "Properties of additively manufactured dental materials"

Member of the Scientific Jury: Assoc. Prof. Roussi Minev Minev, PhD, MEng

### **1. Subject and state of the art of the dissertation**

The topic of dissertation work is related to materials and process chains for preparation of dental medicine objects by digital 3D technologies. It also covers the study the applicability of the new materials used in terms of their mechanical and other properties and the geometrical characteristics of the prostheses, orthodontics systems and other entities of dentistry. This is one of the fastest growing areas of technology science at the interface of medicine and engineering, with many open issues about the accuracy of the build objects and materials properties. Numerous specialized scientific journals exist in this area, as well as international projects and networks. Important attention is also devoted to this issue through the National Scientific Fund (for example, project DFSI B02 / 19 "3D Printing and its Application in the Prosthetic Dental Medicine"). Therefore I believe that the topic and subject of the dissertation is in no doubt up-to date.

### **2. Methodology of the study**

The interdisciplinary character of the problem requires a combination of physical experiments and computer simulations. Measurements of geometrical characteristics, density, hardness, strength, adhesion, tribo-corrosion assessments were performed. A microstructural analysis was carried out and methods for determining the chemical composition were used. Numerical modeling of some of the mechanical tests has been done and a specific "bending in chewing" simulations have been performed.

I believe that the spectrum of methodologies that were used is adequate, productive and in relation to the research tasks. The methodological procedures were correctly implemented.

### **3. Contributions of the dissertation**

#### **3.1 Scientific contributions**

##### **3.1.1 Formulating a new theory**

The influence of the optical properties of the specific dental polymers on the accuracy of the objects obtained by the use of 3D printing has been determined and explained.

3.1.2 Demonstration by the use of new means of significant new aspects of already existing scientific areas problems, theories, hypotheses and others.

The influence of the increased roughness of dental alloys on the adhesion of permanent metal ceramic prostheses is determined and explained.

### 3.1.3 New methods

Methods and devices for (i) assessing the fitting accuracy of dental structures subjected to bending that simulate real conditions; (ii) testing the adhesion strength of ceramic and composite coatings; (iii) assessing the nature of the disintegration of a porcelain-based dental alloy coating by a specific criterion.

## 3.2 Scientific-applied contributions

### 3.2.1 Creating new classifications, methods, constructions, technologies, etc.

Development of technological chains for preparation of prostheses and other dental devices.

### 3.2.2 Obtaining and proving new facts

The mechanism of disintegration of porcelain and composite coatings on Co-Cr dental alloys, produced by two alternative methods (casting and SLM - Selective Laser Melting) has been identified.

The influence of the optical properties of the photopolymers on the roughness of the obtained structures is investigated. The significance of the initial and final stage of the building process on the geometrical stability of the surface formation has been shown in the study.

The elasticity modulus of specific dental materials are determined: porcelain and composite. The adhesion of the coatings was tested by the tensile test methodology, which proved to be more informative and allowed to extend the spectrum of the studied materials.

It has been found that the crack formation limit in bending of Co-Cr dental bridges cast by conventional or layered technology is close to the crack formation limit in bending of SLM dental bridges made of Co212-f alloy.

Tribo-corrosion resistance in artificial saliva of SLM Co-Cr objects was measured. It was proven that SLM Co-Cr objects are more stable compared to the castings.

### 3.2.3. Obtaining confirmation facts

It has been shown that stereolithography and multilayer printing provide a higher accuracy and low roughness of dental plastics compared to the conventional processes.

It has been found that the hardness of the SLM Co212-f and cast Biosil-F alloys changes in a different way after baking a two-sided porcelain coating on them.

It has been shown that the roughness of dental materials obtained by 3D printing or SLM is 2 to 4 times higher than that of conventionally made materials.

It has been confirmed that the precision of fitting of permanent plastic and alloy prostheses made by layered technologies is higher than that made by conventional technology. Although the measured "gap" is uneven it is still within the functional limits of the dental devices.

The typical microstructure of Co-Cr dental devices cast on 3D printed models has been investigated and described.

## 3.3 Applied contributions

Technological chains preparation of casting models through specific 3D printing systems were studied. Exemplary parameters and set-ups for their production were recommended for use in dentistry.

Calibration coefficients for 3D preparation of dental systems were determined and algorithms for designing high-precision virtual models of prosthetic structures were investigated.

#### **4. Publications and citations of the work**

Total publications on dissertation - 24

In standalone authorship (world databases) - 3 (1 chapter of a book and 2 articles)

In standalone authorship (published in other scientific journals and conferences) - 2

In co-authorship (world databases) - 11

In co-authorship (published in other journals and conferences) - 8

Citations in world databases - 9

Citations in publications of other journals and conferences - 3

On the basis of the above data it can be concluded that the results of the thesis of Prof. Dikova have gained international publicity among the scientific society.

#### **5. Authorship of the results obtained**

Based on my personal impressions and the data in the previous section, I believe that Dr Dikova's authorship is indisputable. Much of the publications are in standalone authorship, and in another, she is the first author. She is also the head of a scientific project and is supervising researchers.

#### **6. Remarks and comments on the dissertation**

I have no principal remarks on the work. I can recommend to use universal test pieces and methodological approaches in the future studies of the dimensional accuracy and surface characteristics of 3D layered objects.

#### **7. Conclusion**

I believe that the submitted thesis corresponds to the requirements of the Law on the Academic Staff Development in the Republic of Bulgaria. The results achieved give me the reason to propose that the scientific degree "Doctor of Science" be granted to Assoc. Prof. Eng. Tsanka Dimitrova Dikova in the area of higher education 5. Technical sciences, professional field 5.6. Materials and Material Science, specialty "Material Science and Technology of Machine Building Materials"

11.06.2019

Signature:

/Assoc. Prof. Roussi Minev, PhD, MEng/