BULLETIN OF STOMATOLOGY AND MAXILLO-FACIAL SURGERY OF
Vol. 19, No. 2

DOI: 10.58240/1829006X-2023.19.2-90

# CRYSTALLINE OXIDE CERAMICS AT VARIOUS STAGES OF THE TECHNOLOGICAL PROCESS COMPARATIVE CHARACTERISTICS OF THE TECHNOLOGICAL PROCESS

Hakobyan Anna,[1] Vanyan Nvard,[2] Zulumyan Anna,[3] Eranyan Mery,[4] Saghatelyan Lilit [5]

[1] Lecturer, Department of Prosthodontics, Yerevan State Medical University after M. Heratsi, Armenia
[2] Associat professor, Department of Prosthodontics, Yerevan State Medical University after M. Heratsi, Armenia
[3] Associat professor, Department of Prosthodontics, Yerevan State Medical University after M. Heratsi, Armenia
[4] Lecturer, Department of Prosthodontics, Yerevan State Medical University after M. Heratsi, Armenia
[5] Lecturer, Department of Prosthodontics, Yerevan State Medical University after M. Heratsi, Armenia

**Corresponding author: Hakobyan Anna; Lecturer, Department of prosthodontics, Yerevan State Medical University after M. Heratsi, Armenia;*
*Phone: (+374) 91 42 54 76*
*e-mails: anushik-76@mail.ru*

***Received:*** *Feb. 15, 2023;* ***Accepted:*** *Mar. 14, 2023;* ***Published:*** *Apr. 15, 2023*

**Abstract**

The article discusses research about microstructure of crystalline oxide ceramics at stages of the technological process. It is proved that the introduction of stabilizing substances into the composition of oxide ceramics leads to homogenization of the basic substance and to smoothing between crystal contacts. This leads to hardening of the ceramic.

***Keywords:*** *zirconium dioxide, crystalline oxide ceramics, technological stages of ceramics production, aluminium oxide*

## Introduction

Ceramic is a biocompatible and inert material and has a high degree of intraoral stability. Therefore, they can be safely used in the oral cavity. However, ceramics are brittle and break easily.[1]

Most high-performance ceramic products are based on oxides, nitrides, carbides and borides of high purity with a carefully controlled composition. High performance ceramics can be divided into two main categories; structural and functional ceramics. Typical structural ceramics - aluminum oxide ($Al_2O_3$), zirconia ($ZrO_2$), silicon nitride ($Si_3N_4$) and silicon carbide (SiC). However, Ceramics based on $Al_2O_3$, $ZrO_2$ and SiC also often used as functional ceramics. Other functional ceramics of technological interest are barium titanate ($BaTiO_3$) and lead zirconate titanate ($Pb(Ti,Zr)O_3$). To combat this weakness, ceramics are usually particle-reinforced, supported by metal, or made exclusively from polycrystalline material.

All-ceramic materials clearly have quality characteristics through biocompatibility, mechanical strength, low heat transfer and consistently high aesthetics.[2]

Ceramic materials exhibit creep deformation at temperatures above about half their melting point.

Non-contact 3D scanning and digital computer modeling with subsequent milling are not only adapted to friction surfacing, but also provide high accuracy of the edge section of the carcass material.
Various clinical studies prove the optical stability of all-ceramic systems, a high level of biological and functional indicators.[3]
Polycrystalline zirconium oxide, which does not contain glass, is a reliable and effective innovative system that allows obtaining clinically stable results with minimal complications. Improved material strength, improved aesthetics and high biocompatibility give zirconia ceramics great potential for use in a wide range of promising clinical applications.[4]
Microstructural changes of polycrystalline oxide porcelain occur at all stages of the technological process, be it chemical synthesis, grinding, cleaning from mixtures, introduction of stabilizing additives, pressing or firing.
Moreover, the physical-mechanical profile of these glasses (strength, resistance to bending) is determined not only by the crystal structure, but also by the phase transformation under loading.[5-9]
Electron microscopic studies will provide clinically important data on the microstructure of polycrystalline oxide porcelains, which will clarify the optimal limits of the technological process of material processing and will improve the clinical efficiency of all-ceramic structures.[10-16]

## Objectives

To evaluate the microstructure of polycrystalline oxide glasses at different stages of the technological process.

## Materials and methods

According to the chemical and structural composition, we have identified four types of materials under study: unrefined, without stabilizing additives, zirconium dioxide:

- pressed polycrystalline zirconium stabilized with yttrium
- alumina from a natural deposit
- extruded aluminum oxide (99.5% $Al_2O_3$)

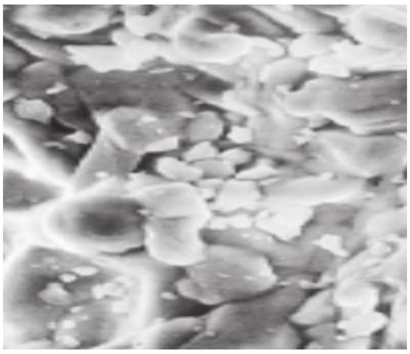
The study was carried out using a Pictoval microscope, the studied materials were magnified 3500 times.

## Results and Discussion

The following criteria for the evaluation of the microstructure of polycrystalline oxide glasses are based on research:

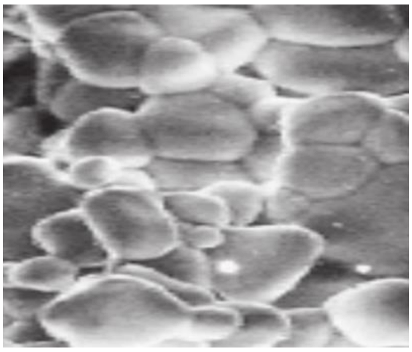
- phase homogeneity
- structural saturation with crystals
- placement of crystals
- type of crystal borders

This method allows not only to obtain a visual image of the microstructure, but also to determine the density of the investigated material.



*Picture 1. Dioxide of unrefined zirconium without stabilizing additives*

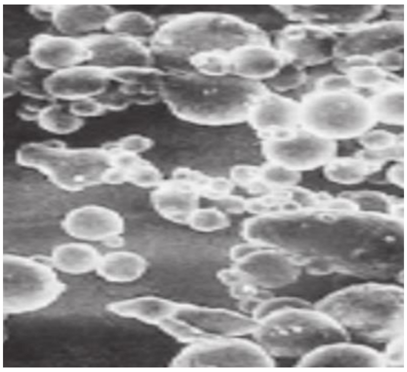
Phase heterogeneity is observed. Multiple conglomerates are present.



*Picture 2. Pressed polycrystalline zirconium, yttrium stabilized*

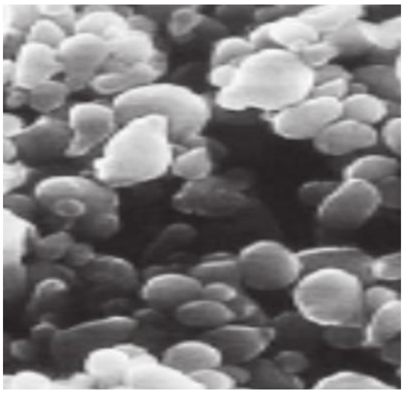
The homogeneity of the phases is obvious, the structure of the material is homogeneous, the crystals have a distinct ovoid shape.

**Hakobyan A, Vanyan N, Zulumyan A, Eranyan M, Saghatelyan L. Comparative characteristics of crystalline oxide ceramics at various stages of the technological process. *Bulletin of Stomatology and Maxillofacial Surgery*. 2023;19(2):90-94. doi: 10.58240/1829006X-2023.19.2-90**



*Picture 3. Aluminum oxide from natural deposits*

Phase inhomogeneity is present, the amount of aluminum oxide crystals is small, a disproportionate local clustering of crystals is observed. Crystals do not have a specific shape.



*Picture 4. Pressed aluminum oxide (99.5% $Al_2O_3$)*

A pronounced phase homogeneity, homogeneous microstructure is observed. Aluminum oxide crystals have an elongated shape. The boundaries of the crystals are smooth, without sharp touches.

It is obvious that the absence of stabilizing additives in the zirconium dioxide material will not contribute to the ordered crystal microstructure in case of firing and pressing.

Chemically synthesized aluminum oxide has the ability to undergo transformational changes at various stages of compression and firing, when oval crystals become elongated. In that process, internal energy is generated, which ensures the stability of the crystal structure.

Expressed homogeneity of phases, homogeneous microstructure is observed. Aluminum oxide crystals have an elongated shape. The edges of the crystals are even, without sharp strokes.

From the above, we conclude that the stabilizing additives regulate the arrangement of the crystals, excluding the pointed contacts of the crystals, thereby ensuring the evenness and phase homogeneity of the arrangement of the crystals.

**Conflict of interest and financial disclosure**

The author declares that he has no conflict of interest and there was no external source of funding for the present study. None of the authors have any relevant financial relationship(s) with a commercial interest.

**Funding**

The work was not funded.

## *REFERENCES*

1. Jones DW. A brief overview of dental ceramics. *J Can Dent Assoc.* 1998;64(9):648-50. PMID: 9812434

2. Sharkey S. Metal-ceramic versus all-ceramic restorations: part 3. *J Ir Dent Assoc.* 2011;57(2):110-3. PMID: 21661638

3. de Matos JDM, Lopes GRS, Queiroz DA, et al. Dental Ceramics: Fabrication Methods and Aesthetic Characterization. *Coatings*. 2022;12(8):1228. doi: 10.3390/coatings12081228

4. Guess PC, Schultheis S, Bonfante EA, Coelho PG, Ferencz JL, Silva NR. All-ceramic systems: laboratory and clinical performance. *Dent Clin North Am.* 2011;55(2):333-352, doi: 10.1016/j.cden.2011.01.005

5. Alqutaibi AY, Ghulam O, Krsoum M, et al. Revolution of Current Dental Zirconia: A Comprehensive Review. *Molecules*. 2022;27(5):1699. doi: 10.3390/molecules27051699

6. Degidi M, Artese L, Scarano A. Inflammatory infiltrate, microvessel density, nitric oxide synthase expression, vascular endothelial growth factor expression, and proliferative activity in peri-implant soft tissues around titanium and zirconium oxide healing caps. *J. Periodontol.* 2006;77(1):73–80

7. Denry IL, Holloway JA. Microstructural and crystallographic surface changes after grinding zirconia-based dental ceramics. *J. Biomed Mater Res Appl Biomater*. 2006:76(2):440-448. doi: 10.1002/jbm.b.30382

8. Borba M, de Araújo MD, Fukushima KA, et al. Effect of the microstructure on the lifetime of dental ceramics. *Dent Mater.* 2011;27(7):710-721. doi: 10.1016/j.dental.2011.04.003

9. Kaczmarek K, Konieczny B, Siarkiewicz P, et al. Surface Characterization of Current Dental Ceramics Using Scanning Electron Microscopic and Atomic Force Microscopic Techniques. *Coatings*. 2022:12:1122. doi: 10.3390/coatings12081122

10. Li D, Guo JW, Wang X, Zhang SF, He L. Effects of crystal size on the mechanical properties of a lithium disilicate glass-ceramic. *Materials Science and Engineering: A.* 2016;669:332–339. doi: 10.1016/j.msea.2016.05.06810

11. Savushkina S, Gerasimov M, Apelfeld A, Suminov I. Study of Coatings Formed on Zirconium Alloy by Plasma Electrolytic Oxidation in Electrolyte with Submicron Yttria Powder Additives. *Metals*. 2021;11(9):1392. doi: 10.3390/met11091392

12. Li K, Rao J, Ning C. Optimized sintering and mechanical properties of Y-TZP ceramics for dental restorations by adding lithium disilicate glass ceramics. *Journal of Advanced Ceramics*. 2021;10(6):1326-1337. doi: 10.1007/s40145-021-0507-9

13. Zhao T, Lian MM, Qin Y, et al. Improved performances of lithium disilicate glass-ceramics by seed induced crystallization. *Journal of Advanced Ceramics*. 2021;10(3):614-626. doi: 10.1007/s40145-021-0463-4

14. Cattell MJ. Flexural strenght optimization of a leucite reinforced glass ceramic. *Dent Mater.* 2001;17(1):21

15. Beuer F Marginate und innere Passung von CAM-gefrasten Zirkoniumoxid-Einzelkronen bei unterschiedlichen Praparationswinkeln. *Dtsch. Zahnarzti*. 2003;58:517

16. Andersson M, Razzoog ME, Odén A, Hegenbarth EA, Lang BR. Procera: a new way to achieve an all-ceramic crown. *Quintessence Int.* 1998;29(5):285-96. PMID: 9693647

17. van Dijken JW. All-ceramic restorations: classification and clinical evaluations. Compend *Contin Educ Dent*. 1999;20(12):1115-1124, 1126, 1136. PMID: 10850265


## ԲԱԶՄԱԲՅՈՒՐԵՂԱՅԻՆ ՕՔՍԻԴԱՅԻՆ ՃԵՆԱՊԱԿԻՆԵՐԻ ՍՏԱՑՄԱՆ ՏԵԽՆՈԼՈԳԻԱԿԱՆ ԳՈՐԾԸՆԹԱՑԻ ՏԱՐԲԵՐ ՓՈՒԼԵՐԻ ՀԱՄԵՄԱՏԱԿԱՆ ԲՆՈՒԹԱԳԻՐ


Հակոբյան Աննա,[1] Վանյան Նվարդ,[2] Զուլումյան Աննա,[3] Երանյան Մերի,[4] Սաղաթելյան Լիլիթ [5]

[1] Երևանի Մ. Հերացու անվան պետական բժշկական համալսարանի Օրթոպեդիկ ստոմատոլոգիայի ամբիոնի դոցենտ, Հայաստան

[2] Երևանի Մ. Հերացու անվան պետական բժշկական համալսարանի Օրթոպեդիկ ստոմատոլոգիայի ամբիոնի դոցենտ, Հայաստան

[3] Երևանի Մ. Հերացու անվան պետական բժշկական համալսարանի Օրթոպեդիկ ստոմատոլոգիայի ամբիոնի դասախոս, Հայաստան

[4] Երևանի Մ. Հերացու անվան պետական բժշկական համալսարանի Օրթոպեդիկ ստոմատոլոգիայի ամբիոնի դասախոս, Հայաստան


**Hakobyan A, Vanyan N, Zulumyan A, Eranyan M, Saghatelyan L. Comparative characteristics of crystalline oxide ceramics at various stages of the technological process. *Bulletin of Stomatology and Maxillofacial Surgery*. 2023;19(2):90-94. doi: 10.58240/1829006X-2023.19.2-90**

[5] Երևանի Մ. Հերացու անվան պետական բժշկական համալսարանի Օրթոպեդիկ ստոմատոլոգիայի ամբիոնի դասախոս, Հայաստան

**Ամփոփում**

Հոդվածում քննարկվում է տեխնոլոգիական պրոցեսի տարբեր փուլերում օքսիդ կերամիկական զանգվածների միկրոկառուցվածքի ուսումնասիրությունը:Հաստատվում է, որ կայունացնող նյութերի ներմուծումը օքսիդ կերամիկայի բաղադրության մեջ հանգեցնում է բազային նյութի համասեռացման և միջբյուրեղային շփումների հարթեցման՝ դրանով իսկ դրականորեն ազդում է օքսիդային կերամիկայի ամրության բնութագրերի վրա:

## СРАВНИРЕЛЬНАЯ ХАРАКТЕРИСТИКА КРИСТАЛЛИЧЕСКИХ ОКСИДНЫХ КЕРАМИК НА РАЗЛИЧНЫХ ЭТАПАХ ТЕХНОЛОГИЧЕСКОГО ПРОЦЕССА

Акопян Анна,[1] Ванян Нвард,[2] Зулумян Анна,[3] Еранян Мери,[4] Сагателян Лилит [5]

[1] Доцент кафедры ортопедической стоматологии Ереванского государственного медицинского университета, Армения
[2] Доцент кафедры ортопедической стоматологии Ереванского государственного медицинского университета, Армения
[3] Преподаватель кафедры ортопедической стоматологии Ереванского государственного медицинского университета, Армения
[4] Преподаватель кафедры ортопедической стоматологии Ереванского государственного медицинского университета, Армения
[5] Преподаватель кафедры ортопедической стоматологии Ереванского государственного медицинского университета, Армения

**Резюме**

В статье обсуждается исследование микроструктуры оксидных керамических масс на различных этапах технологического процесса.Обосновывается,что введение в состав оксидной керамики стабилизирующих веществ приводит к гомогенизации основного вещества и сглаживанию межкристаллических контактов, тем самым положительно сказываясь на прочностных характеристиках оксидных керамик.

**Hakobyan A, Vanyan N, Zulumyan A, Eranyan M, Saghatelyan L. Comparative characteristics of crystalline oxide ceramics at various stages of the technological process. *Bulletin of Stomatology and Maxillofacial Surgery*. 2023;19(2):90-94. doi: 10.58240/1829006X-2023.19.2-90**