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TiNi Fixed Dentures with a Ceramic Coating

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Abstract

The work presents the study of a ceramic material that would provide a satisfactory bond of the commercially available ceramics to Titanid alloy. Polished sections of Titanid alloy and ceramics supplied by various manufacturers were examined. The desired intermediate opaquer layer was fabricated from the following raw ingredients: potassium feldspar originating from Krasnoyarsk deposit and chemically pure barium oxide BaO, sodium carbonate Na_2CO_3, zinc oxide ZnO, hydroxyapatite $Ca_5(PO_4)_3(OH)$, and titanium oxide TiO_2. The adhesion strength of Triceram dental ceramic to Titanid alloy with the use of the transitional ceramic opaquer appeared to be fairly high and ranged from 35 to 45 MPa.

1 Introduction

The strength of bond between ceramic coating and a metal framework is one of the critical factors affecting durability of metal ceramic dentures [1]. Titanid - a titanium-based alloy-is a novel material in metal ceramic dental prosthetics. It has a thermal linear expansion coefficient (TLEC) different from that of currently available dental ceramic materials intended for titanium alloys, which poses a real adhesion problem [3]. So finding a solution to ceramic coating of a nickelid titanium framework is a challenging task.

The aim of our study is to come up with a ceramic material that would provide a satisfactory bond of the commercially available ceramics to Titanid alloy.

2 Results and discussion

To that the aim, polished sections of Titanid alloy and ceramics supplied by various manufacturers were examined in polarizing reflected light of an Axioscop 40 Pol microscope. Thermal linear expansion coefficients of Titanid and our proposed intermediate layer ceramic material were measured in a DIL 402 dilatometer. The chemical composition of ceramic opaquers under study was analyzed using an S-115 spectrophotometer and the microelemental analysis was performed with a DFS-8/2 diffraction spectrograph. An MIPI-100K installation was used to assess the strength of bonding of Triceram ceramic to Titanid alloy via our developed opaquer material.

It was found that of all the specimens under study Triceram ceramic formed thethinnest oxide layer of homogeneous thickness after sintering (Fig. 1).

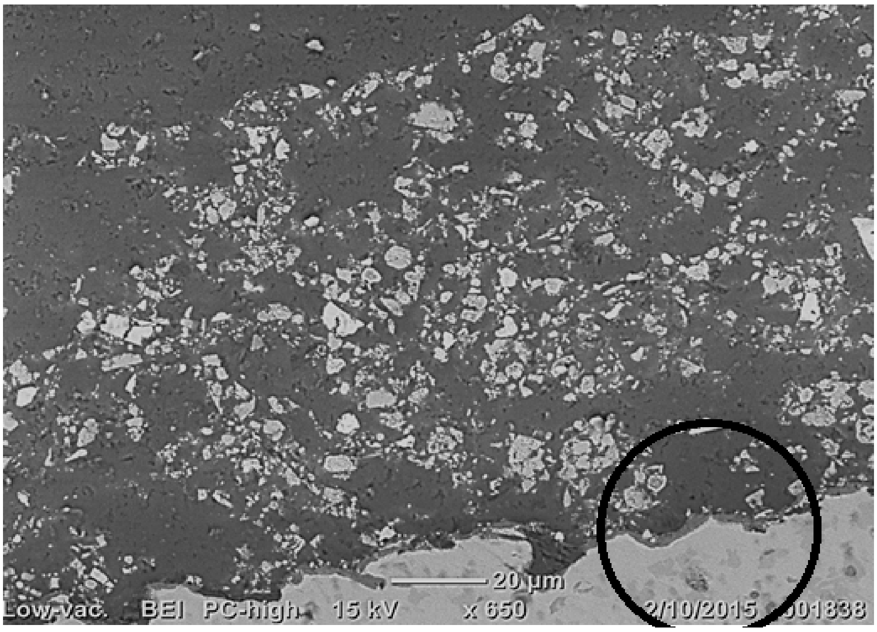

Fig. 1. Microstructure of the contact area between Triceramopaquer and TiNi surface. Electron microscopy, x650

Electron microscopy images of the metal-Triceramopaquercontact area revealed extended 1.5 to 8.0 µm-wide sections of ceramic detachment and weak attachment. This is associated with insufficient adhesion of the coating and accounts for its multiple defects.

The thermal linear expansion coefficient of Titanid was found to be 11.4 x 10-6K-1while that of Triceram was about 8.3 x 10-6K-1. To ensure a reliable bond of Triceramopaquer to Titanid surface, a ceramic material is required that would have a TLEC somewhere between those two values.

To fabricate the desired intermediate opaquer layer we used the following raw ingredients: potassium feldspar originating from Krasnoyarsk deposit and chemically pure barium oxide BaO, sodium carbonate Na_2CO_3, zinc oxide ZnO, hydroxyapatite $Ca_5(PO_4)_3(OH)$, and titanium oxide TiO_2. The potassium feldspar composition was as follows: K_2O – 14.7%; Al_2O_3 – 18.49%, SiO_2 – 63.8%, Na_2O – 2.06%, Fe_2O_3 – 0.53%. Crucibles with the charge were loaded into a high-temperature furnace where the ceramic charge was processed at 1370 єC. The frit was then kept at 900 єC to promote formation of leucite crystals (Fig. 2). After cooling the crucibles we obtained a glass ceramic frit of leucite composition which was then ground in a PULVERISETTE -7 planetary mill.

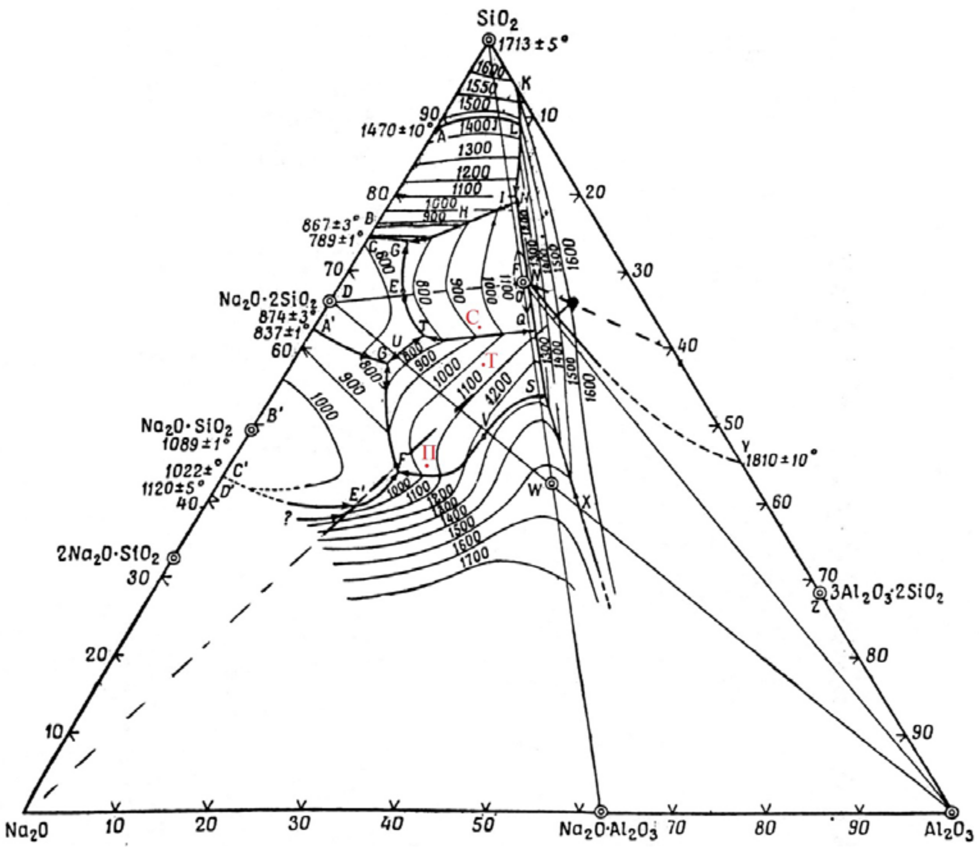

Fig. 2. AtriplesystemNa2O-Al2O3-SiO2 (Schairer, Bowen), pointC - «Ceramco 3», pointT - «Triceram», pointП – obtained ceramic material

The thermal linear expansion coefficient of our transitional ceramic opaquer was measured to be 10,6 x 10-6K-1, which falls in the range between Titanid alloy and Triceram ceramic making the difference between them less of a problem. When fused to Titanid alloy, the obtained transitional ceramic opaquer exhibited a most homogeneous structure in the contact area. The material showed no anomalous structures, i.e. no potential centers of deformation such as chips and fractures. So no detachment is observed when using transitional glass-crystalline pre-opaqueing material. The higher quality of the composite system is due to homogeneity of the obtained material being free from large crystal fragments and due to improved adhesion ensured by penetration of nickel and titanium ions into the glass-crystalline layer (Fig. 3).

The adhesion strength of Triceram dental ceramic to Titanid alloy with the use of the transitional ceramic opaquer appeared to be fairly high and ranged from 35 to 45 MPa.

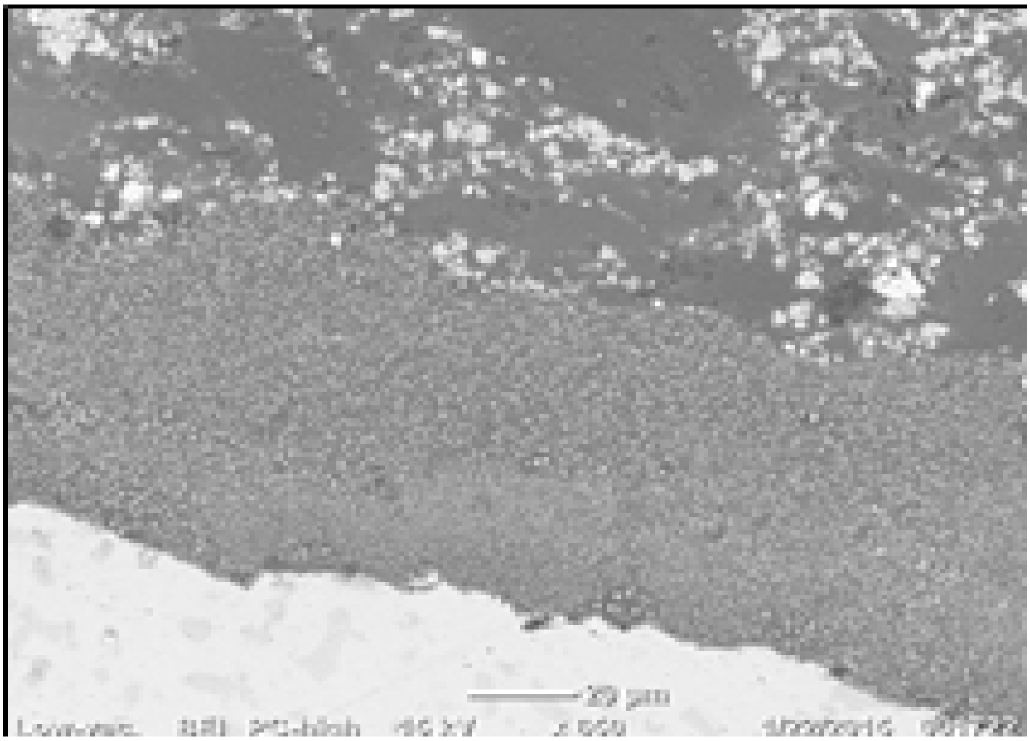

Fig. 3. Micrograph of the composition:metal (TiNi) – intermediate layer –Triceramopaquer –Triceram dentin –Triceram enamel, X650.

Application of a transitional ceramic layer between Triceram ceramic and Titanid alloy makes it possible to fabricate metal-ceramic dentures to meet the existing state-of-artstandards and extend the application potential of this material to include diabetes mellitus patients [4].

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