INVESTIGATION OF MICRO-MECHANICAL PROPERTIES OF STOMATOLOGIC MATERIALS

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Abstract: **Investigation of the physical-mechanical characteristics of stomatologic materials (ceramics for crowns, silver amalgam, cements and materials on a polymeric basis) properties by the modern methods and correspondence their physical-mechanical properties to the physical-mechanical properties of native teeth is represented. The universal device "Micron-Gamma" is built for this purpose. This device allows investigate the physical-mechanical characteristics of stomatologic materials (an elastic modulus, micro-hardness, destruction energy, resistance to scratching) by the methods of continuous indentation, scanning and pricking. A new effective method as well as its device application for the investigation of surface layers of materials and their physical-mechanical properties by means of the constant indenting of an indenter is realized. This method is based on the automatic registration of loading (P) on the indenter with the simultaneous measurement of its indentation depth (h). The results of investigations are presented on a loading diagram P=f(h) and as a digital imaging on the PC. This diagram allows get not only more diverse characteristics in the real time regime but also gives new information about the stomatologic material properties. Therefore, we can to investigate the wide range of the physical-mechanical properties of stomatologic materials. "Micron-Alpha" is the digital detection device for light imaging applications. It enables to detect the very low material surface relief heights and restoration of surface micro topography by a sequence data processing of interferential data of partially coherent light also. "Micron-Alpha" allows: to build 2D and 3D imaging of a material surface; to estimate the quantitatively characteristics of a material surface; to observe the imaging interferential pictures both in the white and in the monochromatic light; to carry out the investigation of blood cells, microbes and biological macromolecules profiles. The method allows restore 3D topography of a material surface in a real time regime. The information about the material surface at partially coherent light is contained in the visibility of interferential strips. The distinctive features of device are: the non-contact electromagnetic loader; the differential size of depth of indenter introduction into the sample, that has allowed considerably reduce a rigidity of construction; a small weight and dimensions; job in a real time regime; low cost.**

DEVICE " MICRON – GAMMA"

"Micron-Gamma" (Fig. 1) is the device for research of physical-mechanical properties of material boundary layers by indenter continuous forced and scanning, topographical and metal graphical methods.

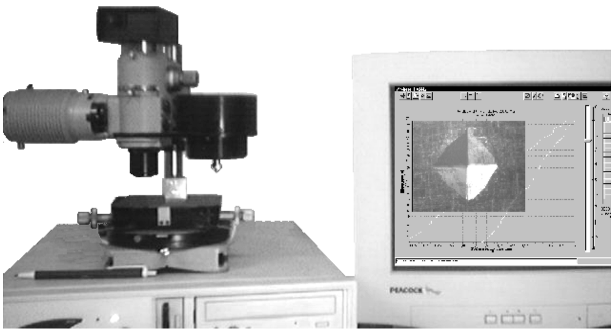

Fig. 1. Device "Micron-Gamma".

Performances:
Loading range (P), *mN*……..........…..…...../10 - 5000
Penetration depth (h), *μm*. ……… . 0,01 – 200
Loading rate (V), *mN/c*………………..… 0.1 – 1000
Time under loading, *min* ………………………..0 - 10
Scanning range, *mm* ….…..........………...….......30×30
Scanning rate, *μm/c*……..........………...…....10 – 100

The indenter continuous forced method is based on automatic measuring and registration of indenter force and indenter penetration depth. Results are presented in the form of graphic diagrams and a database.

It is possible to carry out test for determination of microhardness, to study specifics of material microdeformation according to kinetics of indenter penetration, to register material microcreep, to measure material elasticity.

The scanning method (Fig. 3.) is based on continuous registration of resistance forces to movement of indenter introduced into surface. Statistical characteristics of material local micro volumes resistance to contact deformation are determined; the complex estimation of boundary layer condition along scanning path is made.

In particular it is possible to determine average strength along scanning path, to estimate dispersion and heterogeneity of strength properties, to model elementary acts of friction and deterioration processes.

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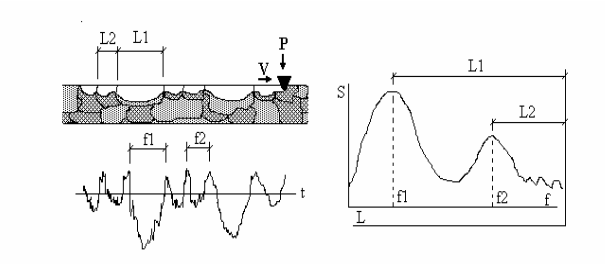


Fig. 3. The scanning method panel.

The topography method (Fig. 4.) is based on scanning of surface by indenter under minimal load with the subsequent processing of profile records. Parameters of surface roughness ($R_z, R_{max}, R_a, S, S_m, t_p$) are recorded; the three-dimensional profile of surface is presented.

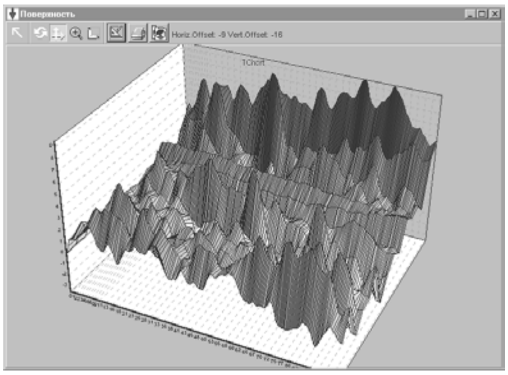
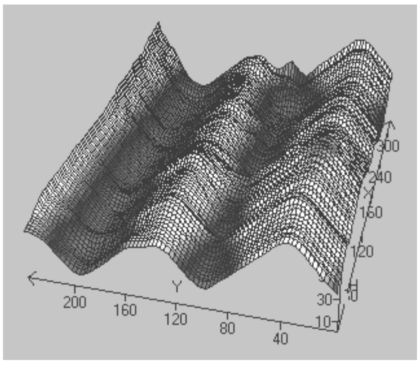


Fig. 4.The topography method panel.

The microscopic metalographic method (Fig. 5) is grounded on registration of the image by means of optical microscope with a built-in digital video camera and with automated video-display processing. The method allows to realize targeted injection, to carry out quantitative analysis of the image, grain-boundary structures and porosity analysis, phase and nonmetallic particles estimation, to record processes of destruction and cracking in dynamic as well as to design three-dimensional model of the surface profile on the basis of four (eight) images.



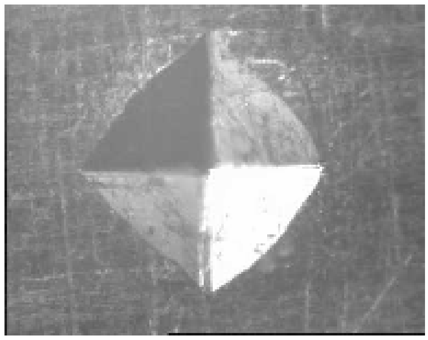


Fig. 5. The microscopic metalographic method pictures.

Distinctive features of device are multi functionality; operation in real time; small weight and dimensions; non-contact electromagnetic loader; differential meter of indenter introduction depth relative to specimen surface that has allowed to reduce rigidity of construction considerably.

DEVICE ” MICRON – ALPHA”

“Micron-Alpha” is the non-contact high resolution profilometer. "Micron-alpha" is used for restoring of surfaces micro topography by the method of a sequence processing of the interference data in partly coherent illumination.

“Micron-Alpha” allows:
Plot 2D and 3D images of a surface;
Estimate characteristics of a surface;
Carry out the metallographic researches.
Observe interference figures both in the white and in the monochromatic lights.

Technical characteristics:
Scanning area (X,Y),µm...……………………300x110
Horizontal resolution (X,Y)), µm. ………………...0,25
Maximum height of relief (Z), µm ………………….50
Vertical resolution (Z), nm…………………………..10
Image zoom,………………………………………..500
Time of picture reception, min………………….. 0,1-5

"Micron-Alpha" allows to carry out the investigation of the blood cells, microbes and biological macromolecules profiles also. The method allows restore 3D topography of a material surface in a real time regime. The information about the material surface at partially coherent light is contained in the interferential strips.

"Micron-Alpha" can be successfully applied for material technologies, industry, microelectronics, medicine and in research laboratories.

Figure 8 shows 3D images of a surface and profiles of the different stomatologic seal samples was obtained by the device “Micron-Alpha”.

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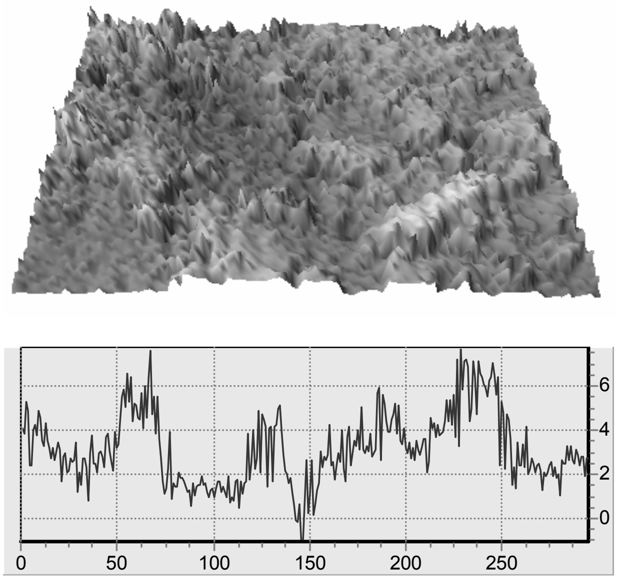

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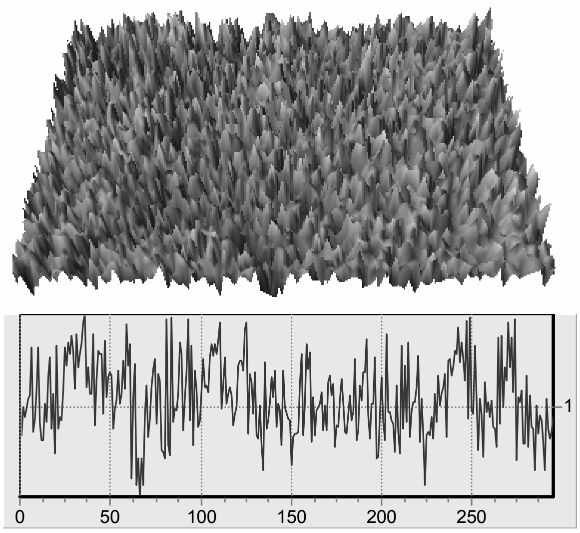

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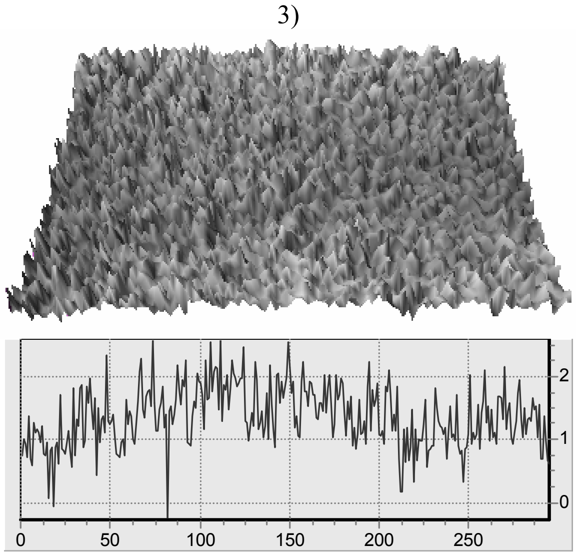

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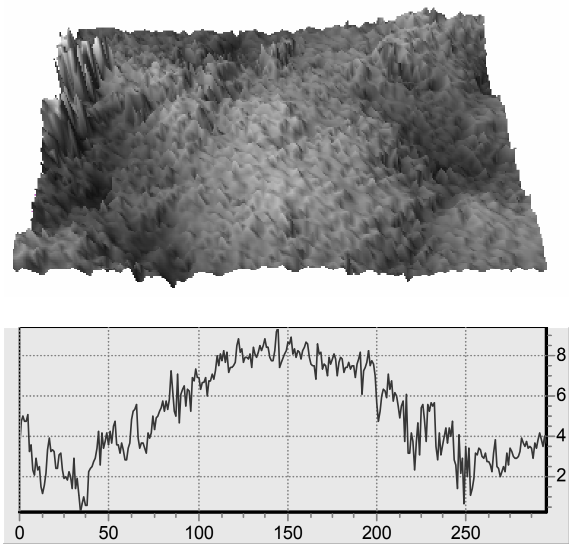

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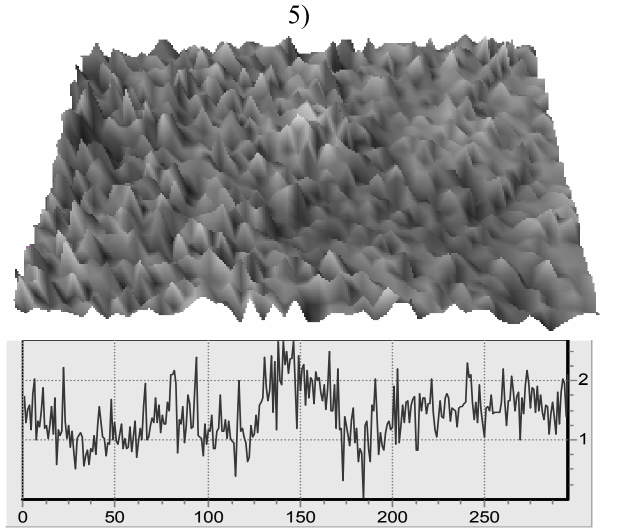

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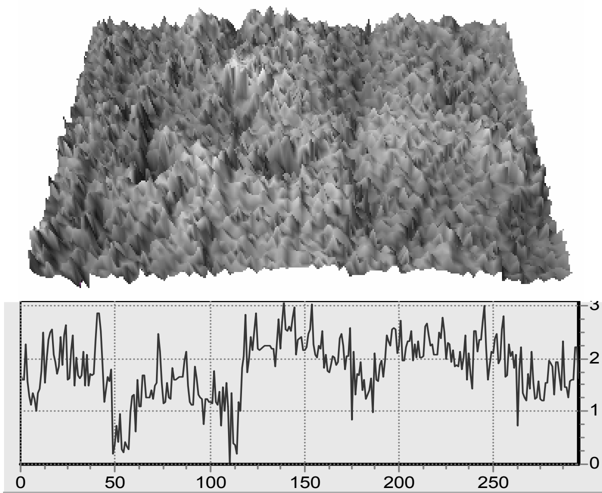

7)

Fig. 8. 3D images of a surface and profiles of the different stomatologic seal samples: 2 – "ECTA" – KIEV; 3 - "Valux Plus" – 3M ESPE; 4 – "Filtek P60"- 3M ESPE; 5 – "Gradia direct" – GC; 6 – "Tetric Flow" – Ivoclar vivadent; 7 – "Dipol" – KIEV.

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Figure 9 shows indentations of the different stomatologic seal samples and enamel are obtained by the device "Micron-Alpha".

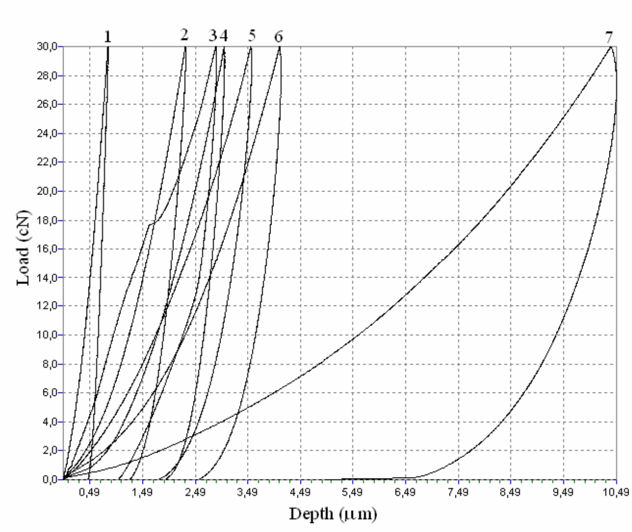

Fig. 9. Loading displacement curve in the measurement process of the different stomatologic seal samples: 1 – enamel; 2 – "ECTA" – KIEV; 3 - "Valux Plus" – 3M ESPE; 4 – "Filtek P60"- 3M ESPE; 5 – "Gradia direct" – GC; 6 – "Tetric Flow" – Ivoclar vivadent; 7 – "Dipol" – KIEV.

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