The panel of 2D/3D parameters adjustment.

Introduction.

The data obtained by scanning probe microscopes may be presented as 2D and 3D images.

A choice of colour palette, lighting simulation and other functionalities are common for 2D and 3D representations. Let's say that 2D the representation in essence is 3D with the strictly given orientation of a surface related to observer (top view). Therefore in "Callisto" the adjustment of 2D and 3D parameters of representations are combined in one panel. The panel consists of three basic menues:

Geometry - for adjustment of geometrical parameters of a surface;

Polygon - for representation of a surface as a set of flat coloured primitives (triangles).

Lines - for representation of a surface as a set of coloured lines directed along X and Y axes.

The adjustments realized in described panel are related to the currently active window containing 2D or 3D surface representations.

In a case, when 2D representation is active, the "**Lines**" adjustments are ignored. In this case only the "**Zscale**" regulator and "**Background Colour**" windows are used only.

2D and 3D representations used in "Callisto" (Fig. 5), are based on OpenGL technology. The majority of adjustments is directly connected to the said technology, therefore it is not considered in detail. Any user action are simultaneouslu changed the 2D and 3D representations of the image.

In the bottom part of the panel there are two buttons for saving of parameters in a file and their restoration by loading a file of parameters.
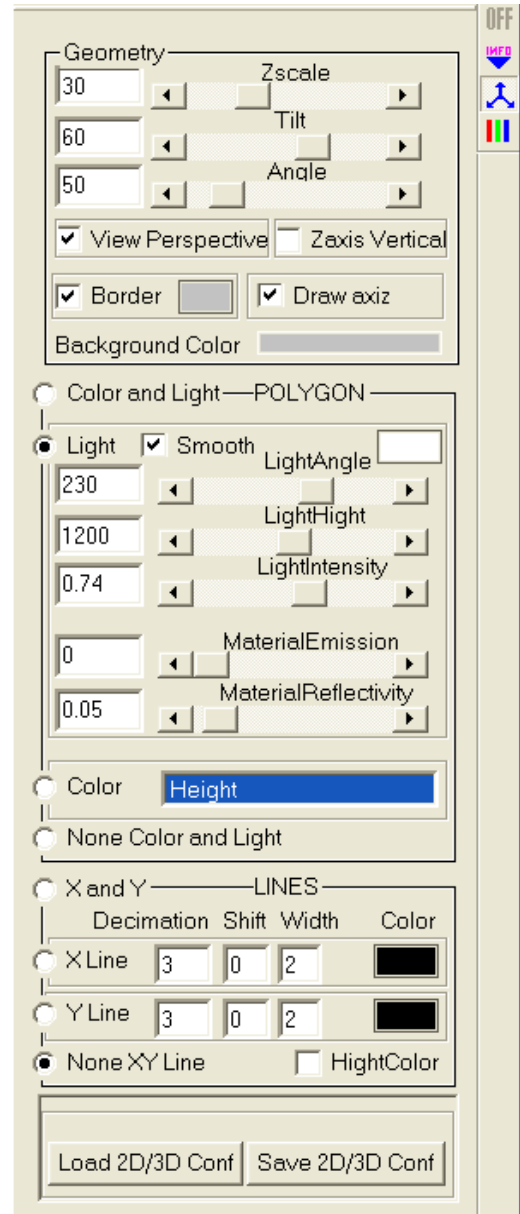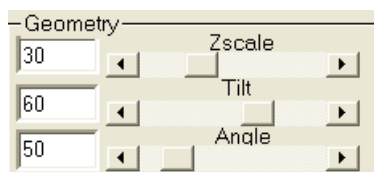
Рис. 1. Внешний вид панели параметров 2D/3D изображения.

The assignment of 2D/3D representation control elements.

Managing elements of Geometry menu.

- Regulators changing the Z (vertical) scale of surface emulation on the screen, tilting the surface emulation related to observer and rotating the surface emulation around the Z axe. For more convenient control the said operations are duplicated with the help mouse:

- The forward movement of a mouse at pressed left button results in change of virtual surface tilting;

- In - plane movement of a mouse at pressed left button results in turn of a virtual surface around the Z axis;

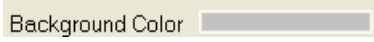- The forward / backward movement of a mouse at pressed right button results in change of Z scale;
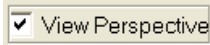
 - the selector, allows to set a perspective projection for the 3D representation.

 - the selector, allows to fix the Z axis in vertical position independently on XY plane tilting.
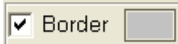
 - set the border of surface visible. Set up of the border colour.

 - image background colour.

Control elements of "Polygon" menu.

The switch "**Color_and_Light/Light/Color/None_Color_ and_Light**" - allows to adjust 2D or 3D representation in case the surface is emulated as a set of flat coloured primitives (triangles).

Light – the surface illumination by a light source with the given parameters. This mode most corresponds to our look at surfaces in real life (Fig. 5, a).

Color – the mode, at which the each point of a surface is coloured according to its height above a surface (fig. 5, c). The conformity is set with the help of the colour palette menu . This mode does not allow to get good contrast of images. Basically "**Color**" mode is used in a combination with illumination (fig. 5, b, e) and representation of a surface as set of lines or grid (fig. 5, d).

Color_and_Light – the combination of two modes described above. It allows to add "depth" in "**Light**" representation (fig. 5, b, e). The mode is most effective in a case, when an additional information may corresponds to topography of a surface. For example, in a contact mode of scanning it may be the torsion of a probe. In dynamic mode (short-term contact) it may be the phase shift image. Thus by loading an additional file and choosing it from the list we are getting "mixed" image where the colouring of the surface is corresponds to its local properties (Fig. 3, g).

Remind that three of above described modes are based on representation of a surface as a set of small flat triangles.

None_Color_and_Light – mode, which does not allow to represent a surface as set of flat primitives. This regime is related to visualization of a surface as set of lines or grid at the appropriate choise of the **X_and_Y/X_Line/Y_Line/NoneXY_Line** switches (Fig. 5, f, g).
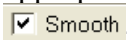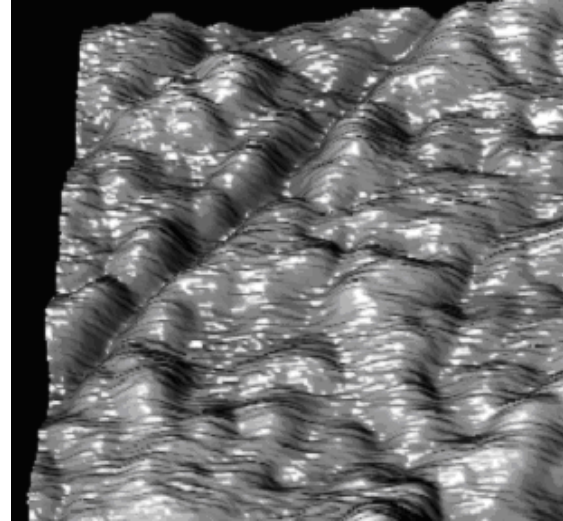
 - the selector, allows to smooth roughnesses between two lines of a surface. Gives appreciable effect (Fig. 2) in lighting emulation mode for the images having about 512x512 pixel size.
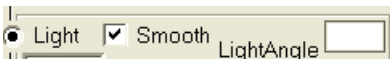
 - the button allowing to choose the colour of a light source during illumination of the virtual surface.
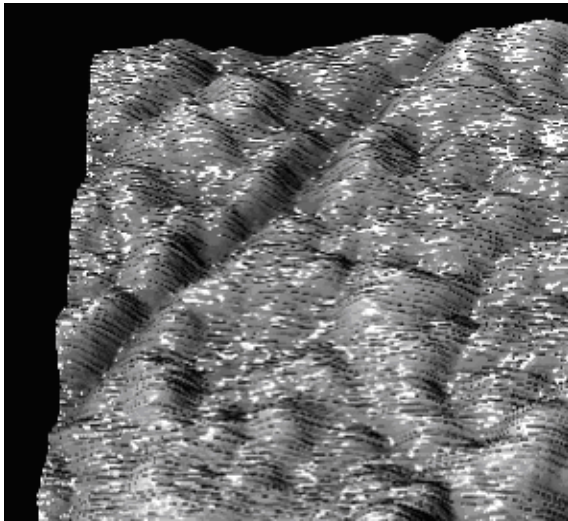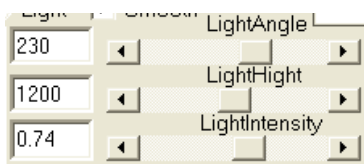
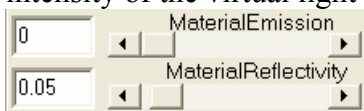<center>a)   b)</center>

Fig. 2. Surface representation in case the **Smooth** option is OFF (a) and ON (b).

 - Regulators allowing to set up an angular position, height and intensity of the virtual light source.

 - Regulators allowing to set up surface light emission and reflectivity.

 - List of "connected" images for current active 2D or 3D of representation. Allows to choose one of the images for using at formation of a colour palette for topography. In this case colouring of sites of the basic (topography) image will correspond to the chosen second image. The conformity is set with help of the colour palette panel. . An example of visualization of the "mixed" image of TiN surface is showed at Fig. 3. The images were obtained in dynamic (short-term contact) scanning mode. The phase shift was recorded simultaneously with topography. Thus, the mixed image allowed to show the difference in superficial energy and visco-elastic properties of the surface related to topography.
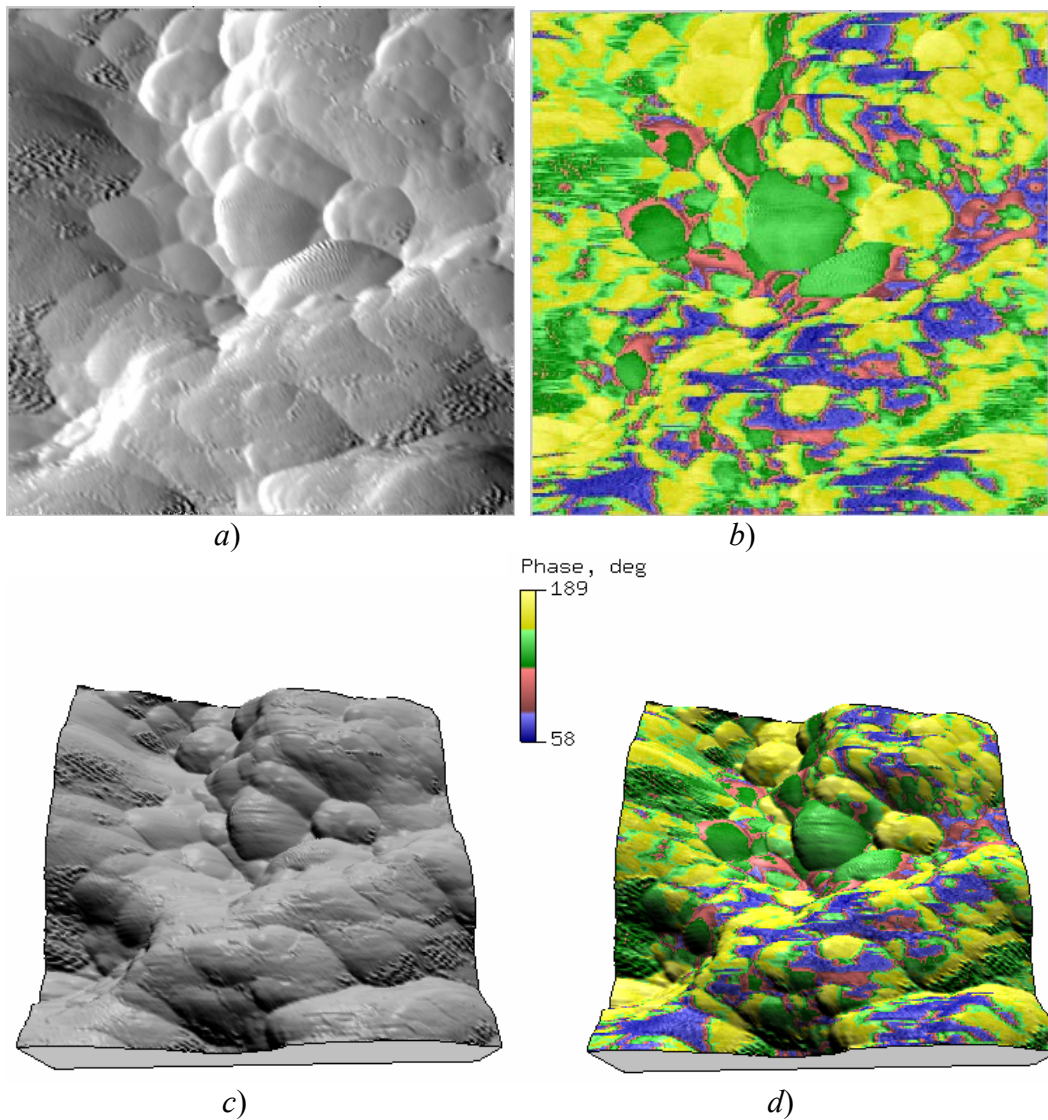
a)   *b)*

Phase, deg
189

58

c)   *d)*

Fig. 3. Different representation of the TiN surface modyfied during sliding friction, obtained in dynamic mode of scanning:
(*a*) - 2D topography representation; (*b*) - 2D phase shift representation; (*c*) - 3D of topography; *d*) – mixed image (topography – **Light**, phase - **Color**).

Control elements of "Line" menu.

The switches **X_and_Y/X_Line/Y_Line/NoneXY_Line** allowed to set 3D representation of the surface topography as set of lines directed along X and/or Y axes (Fig. 5, *d, f, g, h*).

X_and_Y/X_Line – the lines directed along orthogonal axes makes a grid.

X_Line/Y_Line – the lines directed along one of **X/Y** axes only**.**

NoneXY_Line – no lines visible.
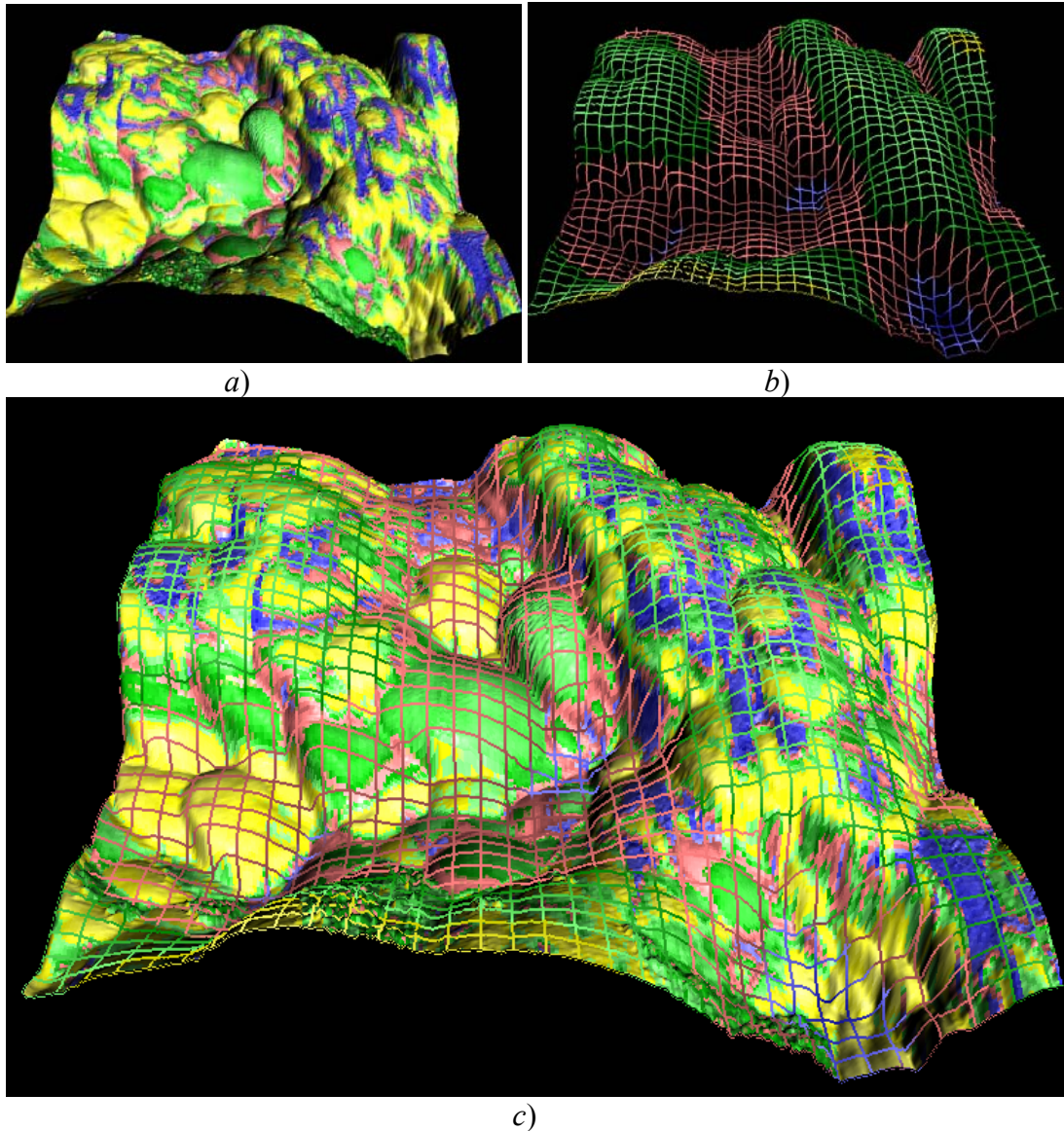
a)   *b)*

c)

Fig. 4. Different representation of the TiN surface modyfied during sliding friction, obtained in dynamic mode of scanning: (*a*) – mixed image (topography – **Light**, phase - **Color**), (*b*) – representation of topography using grid (topography - **Color**), *c*) – result of mixing of two representation described above (the surface is represented as set of flat primitives and grid).

 - editing of parameters of lines, allows to set **Decimation**, **Shift** of the first line concerning the basic matrix of the image. The thickness (Width) and colour of lines may be changed as well. - The selector of representation of various sites of a line by a colour palette. Each point of a line is painted by colour, which corresponds to its local height above a surface (Fig. 4, a). The conformity is set with the help of the panel of adjustment of a colour palette . The program allows simultaneously to show both lines and flat primitives in colour. The colour palette for lines and primitives may be various (Fig. 4, b).
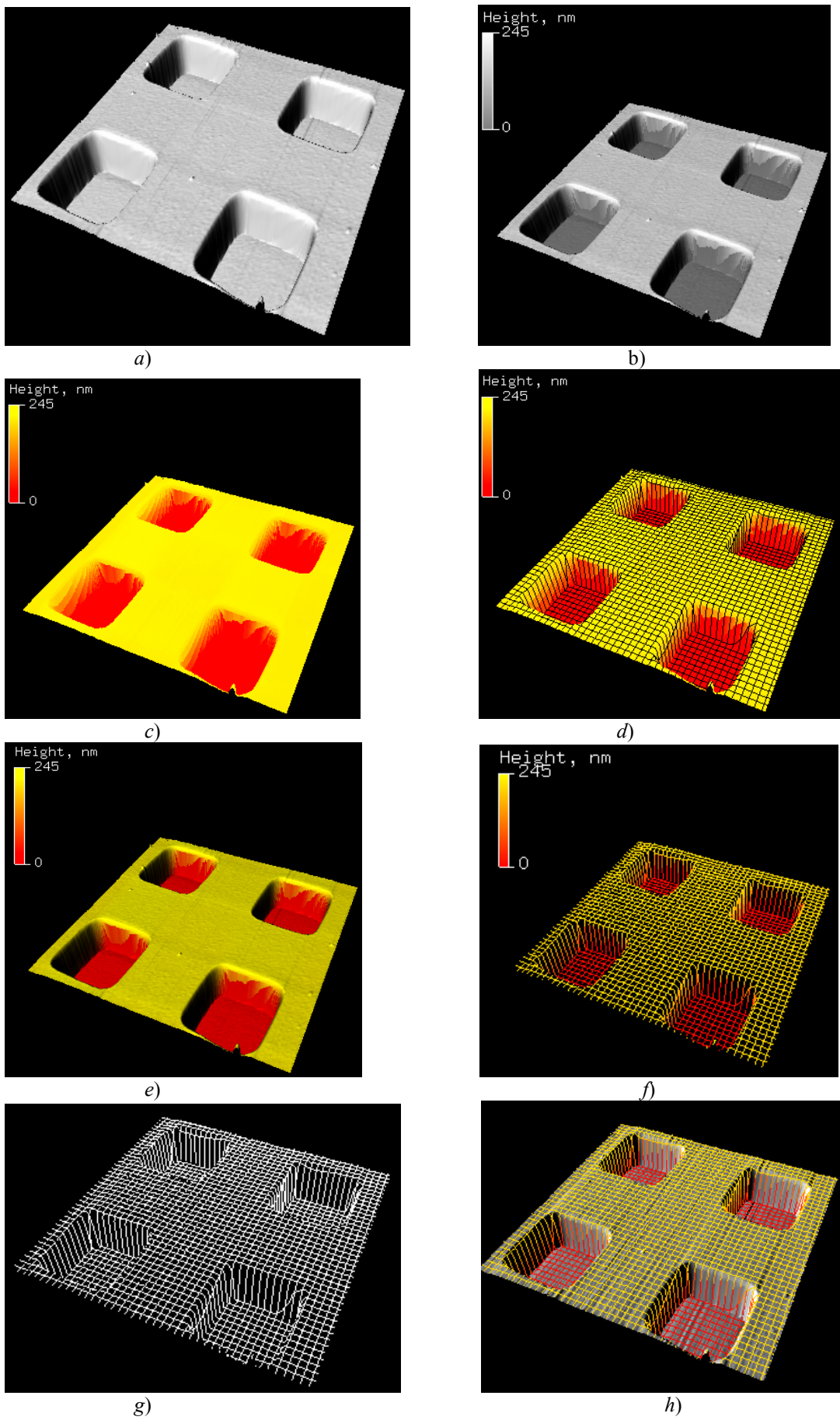
Fig. 5. Different 3D representations of test sample. See description in text.

The panel of colour palette adjustment.

The panel of a colour palette adjustment is intended for installation of a relation between height histogram and chosen colour. Is used for colouring as flat primitives as lines in 2D/3D representations.

The histogram is displayed at the left side of the panel. At the right side the colour markers (at Fig. 6 their amount is 8) are placed. In the bottom part of the panel there are two buttons used for saving of the created colour palette in a file, and its restoration.

At the first opening of the right-side (markers) panel there are only two rectangular markers (black below and white above) are present. They form a scale grey for the just opened image. For changing of colour of a marker it is necessary place the cursor over it the and to press the right button of mouse. Thus the contextual menu allowing to remove the chosen cursor or to change its colour will be opened. The colour of marker may be changed with help of standard dialogue window. If the cursor is placed in an empty space between existing markers it is possible to add a new marker and to choose the colour for it (the right button of mouse is used as well). If the the cursor is placed on the chosen marker pressing of the left button of mouse provides to change a position of a marker in a vertical plane (to nominate the colour of the certain part of histogram).
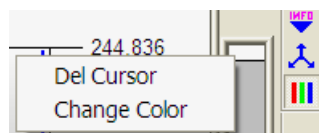
For 2D and 3D representations of one image (the matrixes of data) there are two various palettes are formed.