CREATION, RESEARCH AND SUBSEQUENT USAGE OF NANOPARTICLES FLUIDS FOR ELECTRONIC COMPONENTS COOLING

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Electronic devices consume electrical energy which is partly transformed into heat energy. As a result, their temperature rises. Temperature rise above the allowable has the negative impact on the parameters and in most cases it can damage them. Semiconductor devices (hereinafter referred to as chips) are especially temperature sensitive. In this case the physics is powerless and it is difficult even theoretically to create semiconductor chip, which will be long-term stable over 100 °C temperature.

The heat removal, allocated in electronic devices and systems has especial value. Thermal streams in powerful electronic systems, for example, in transferring and receiving modules of radars, in powerful laser diodes, in processors of powerful computers and servers, etc. reach values 5 – 10 MW / m^2. In the future thermal streams will even more increase and will reach 20 – 30 MW / m^2. Nowdays, the density of power integrated circuits and micro processors are increasing very intensively and in the future will continue.

In order to settle the problem of heat scattering and removal, there is a need to create new types of heat conductors and to prove that they can successfully remove and scatter powerful heat flows from heating surfaces.

The presented research is dedicated to this problem – so-called thermic siphon method is used to cool modern nanoelectronic devices and equipment.

Thermic siphon is a locked in a cycle of heat exchanger that works through joint action of heat convection and gravity and does not require additional energy. Nowdays thermic siphon heat exchangers are created for Intel Corporation's 45 nm processor's individual structural elements cooling and for the AMD processor's 30 nm transistors cooling. In this or similar types of nanoelements heat removal is the main problem and objective [1].

Apart from thermic siphon principle, in nanotechnology so-called heat pipes method is used. Mass and heat transfer is managed by convection and capillary forces caused by temperature differences. In heat transfer, heat transfer via heat pipes was first demonstrated in the United States – in Los Alamos's Laboratory [2, 3]. Heat pipes are irreplaceable in space technology. Important and interesting as well ares porous materials, which are actually nanostructures because pores' transverse dimensions are changing from 10^{-9} – 10^{-6} m range.

Research of liquids consisted of nanoparticles (further nanoliquids) is a separate section of nanotechnology. Nanoliquids are described as fluids which are engineered as colloidal suspensions of nanoparticles in a basic fluid. The nanoparticles used in nanoliquids are typically made of metals, oxides, carbides or carbon nanotubes.

One of the most common types of nanoliquids is surface-active substances (SASs) aqueous solutions and suspensions. SASs can cause liquids to reduce the surface tension coefficient, which increases the liquid fluctuation, i.e. their ability to penetrate into nano porous as well as in a liquid during phase transformations. Therefore, the use of nanoliquids in heat exchanger is highly practical. This effect can be observed during even very low concentrations (**Figure 1**), e.g. 5 – 50 ppm, of SAS [3].

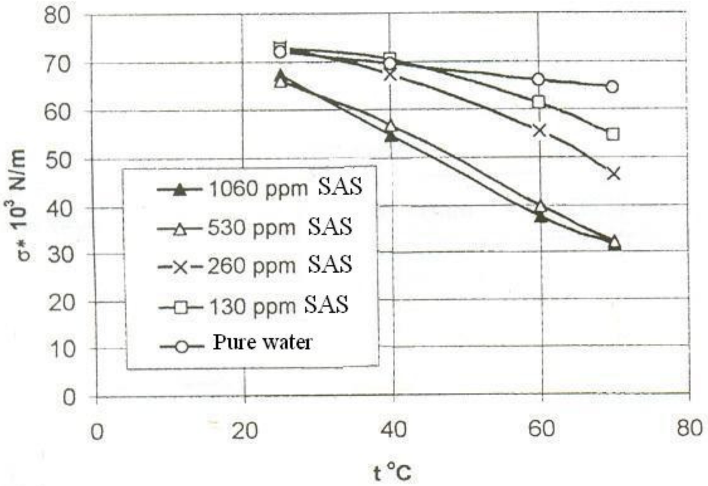

Figure 1. Surface tension as a function of temperature at various concentrations of surface-active substances.

In the electronic cooling systems critical thermal load is a very important value. During this vapor is blanketing with low heat transfer coefficient and often high surface temperature and limiting in industrial and electronic systems large volume boiling application.

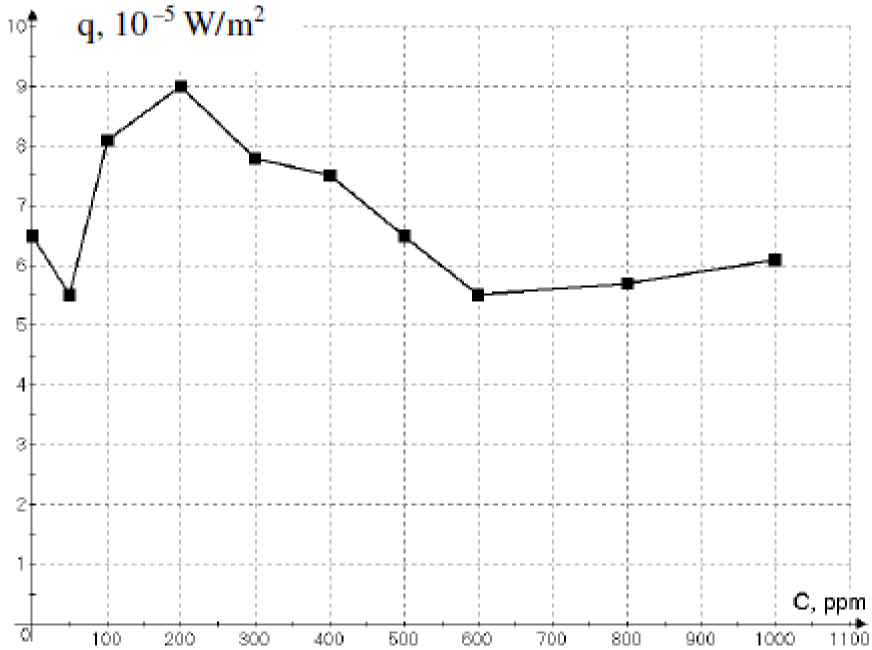

Figure 2. Dependence of nichrome surface critical thermal loads on concentration of natrium dodecyl sulfate.

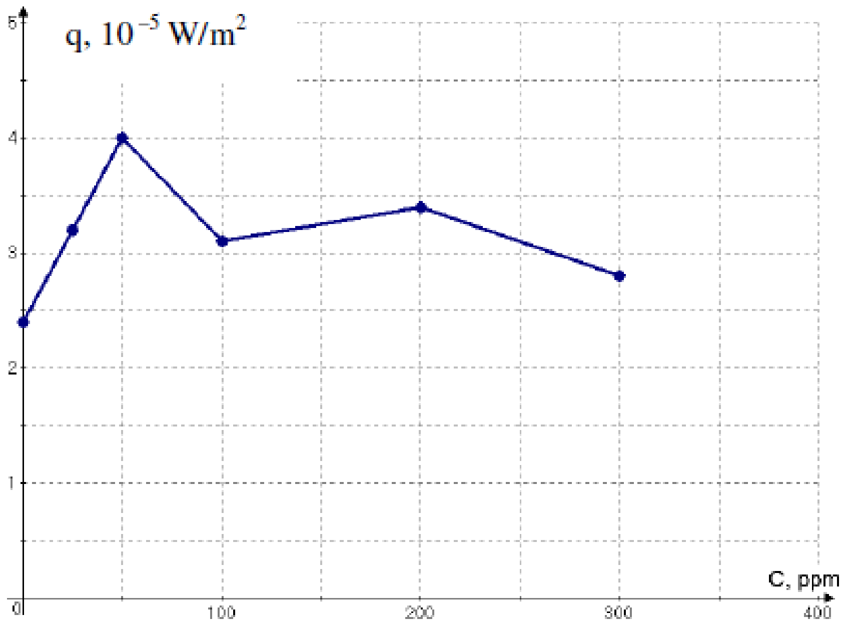

Figure 3. Dependence of nichrome surface critical termal loads on concentration of natrium dodecyl sulfate in freon 113.

Very few studies have been reported related to the critical heat loads in boiling with addition of surfactants. Only Yang & Ma [4] have researched the critical thermal load during large volume boiling water solution with SAS on a horizontal 0.116 mm wire. Results of these experiments are shown in **Figure 2** and **3**. When surfactant concentration in the water increases, the critical thermal load also increases. Because of the experimental wire surface was of very small size, we can not extend it for other cases as long as critical thermal load is dependent on geometrical characteristics.

Nanoliquids are defined as fluids confined in nanopores or as fluids with colloidal suspension of nanoparticles [5].

There are two fundamental methods to obtain nanoliquids:

1. Single step direct evaporation method – the dispersion of nanoparticles is obtained by direct evaporation of the nanoparticle metal and condensation of the nanoparticles in the base liquid; and
2. Double-step method – first the nanoparticles are obtained by different methods and then dispersed into the base liquid.

In order to setlle our research objectives, the special experimental test bench (**Figure 4**) as to be created where possible values of critical thermal loads on the surface of the two-component nanoliquids can be measured during boiling.

The main parts of the device are large and small vessels. Large vessel with water is designed to stabilize temperature in small vessel. A small vessel is placed at the bottom of the metal plate, which is heated by means of a variable transformer. Here nanoliquids critical thermal loads are formed. Advanced automatic measuring stand is used for automatic experimental measuring.

This experimental stand should be used to research nanofluids critical thermal load during boiling, which consists of the main fluid (distilled water, methyl and ethyl alcohol), surfactant (SAS) from the various solid nanoparticiples with the following concentrations: 50, 100, 200, 300, 400, 500, and 1000 ppm.

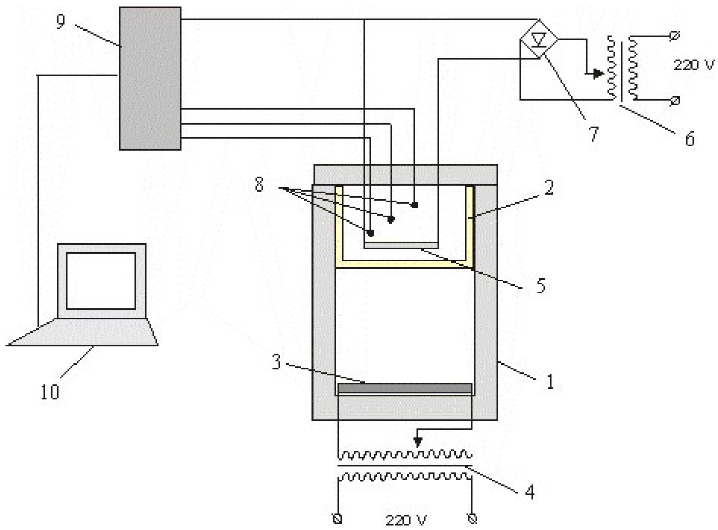

Figure 4. Experimental scheme for researching critical values of thermal loads:
1 – large vessel, 2 – small vessel, 3 – heater, 4 – variable transformer,
5 – heating surface, 6 – variable transformer, 7 – rectifier, 8 – thermocouples,
9 – automatic measuring stand, and 10 – personal computer.

Figure 4 presents the experimental scheme for researching critical values of thermal loads. The results of conducted experiments are shown in above **Figures 2** and **3**. They show the dependence of nichrome surface critical thermal loads on the concentration of natrium dodecyl sulfatewith and without freon, respectively. As it shows the **Figure 2**, if the concentration changes from 0 up to 1000 ppm, the maximum critical load can be obtained during 150 – 250 ppm. While according to the **Figure 3**, if the concentration changes from 0 up to 300 ppm, the maximum critical load can be obtained during 160 – 230 ppm.

Based on the results obtained, we can conclude that:

1. By mixing of refrigeration agents and SAS, it is possible to set up a new refrigeration nanofluids; and
2. It is possible to set up an experimental nanotechnological heat exchanger plant for electronic elements (including the solar energy photoelectronic transformer) cooling.

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