DIGITAL MICROSCOPE ANALYSIS OF CHEMICALLY CLEANED SILICON SURFACE

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Abstract. *In the article, the process of chemical degradation of the surface of semiconductors, which is widely used in the field of photoenergy, was studied with the help of a digital microscope. The team of the Department of Digital Electronics and Microelectronics has developed a modern digital microscope based on microcontrollers. This microscope allows you to display the sample with a magnification of up to 510 times and see a high-quality image on the screen. Using a microscope, the condition of the nanoclusters formed on the silicon surface was studied by treating it with various abrasives in order to make it appear on the surface. In order to make the peaks clearly visible on the silicon surface, the composition of the selected filler was determined and put into practice.*

Keywords: *microscope, chemical cleaning, semiconductor, nanocluster, silicon.*

Electronics has practically entered all spheres of human activity. Today, the further development of science and technology, the economic growth of society, as well as the solution to the huge problems of ecology and energy facing humanity in the 21st century cannot be imagined without the application and use of electronic industry products in the wide production [1,2]. Especially the development of modern information technology requires the creation and use of modern, durable, high-speed microelectronic and nanoelectronic devices with electrical capacity and systems based on them. Nanoelectronics is the next revolutionary stage in the development of microelectronics, which is based on the quantum mechanical properties of nanoscale structures [3-5]. When talking about nanoelectronics, first of all, it is necessary to understand that the wave property of electrons is used as an information carrier. Nanoelectronics has not only shown that it is possible to create small electronic devices, but also that it is possible to create devices that are tens of thousands of times smaller and many times faster than existing electronic devices. It can be said that a deep and comprehensive study of the basic properties of the physics of nanostructures and nanoelectronics will open new facets of the possibility of such amazing objects. The physics of semiconductors and the structure of integrated microcircuits, as well as the basis of their creation technology processes, do not allow to fully use their functional capabilities and solve the problems of their development. But nowadays, the opportunities to do this in scientific and educational laboratories of higher education are increasing. Some of the unique electron microscopes that are available are increasing the possibility of active use anytime, anywhere and in the educational process in general. Together with the team of the Department of Digital Electronics and Microelectronics, we have developed a modern digital microscope based on microcontrollers.

The main parameters of the digital microscope are listed in Table 1. The microscope is directly connected to the computer and allows for continuous display, storage and transmission of the studied images and processes (Fig. 1).

Figure 1. The appearance of a complex integrated microcircuit on a computer.

Table 1.

Basic parameters of the microscope.

№	Parameter name	Value (type)	Unity
	Magnification level	510	time
	View image	Display	
	Transfer of information	USB	
	Save data in image file format	JPEG	
	Save data in the form of a video file	MP4	
	Power supply	USB	5 V
	Lens-to-Specimen Distance (Focusing Distance)	3	mm
	The maximum distance of the lens from the surface	4.75	sm
	Accuracy of pushing in the horizontal plane	0.002	mm
.	Sample surface	90.25	sm^2
.	Control type	Mechanic	
.	Number of control levers and buttons	5	pcs
.	Lighting system	LED	
.	Sample lighting conditions	2	condition
.	Total height	24	sm
.	Total length	24.5	sm
.	Total width	18	sm
.	Weight	3.590	kg

Chemical cleaning of the surface of semiconductors and metals, which is widely used in the field of photoenergy, was analyzed using this digital microscope (Table 2).

Table 2.

Metall	Formula	Decay rate , Å/min
Titan (Ti)	HF 0,5% solution	500; 20 ^{o}C
Titan – Wolfram (Ti-W)	H_2O_2, 30%	200–1000; 20–60 ^{o}C
Cuprum (Cu)	H_2SO_4: H_2O_2: DI 1:1:100 H_3PO_4: H_2O_2: DI 1:1:50	> 3000; 20 ^{o}C 3000; 20 ^{o}C
Chrome (Cr)	$(NH_4)_2Ce(NO_3)_6$	250; 20 ^{o}C
Nickel (Ni)	H_2SO_4:HNO_3:DI 3:1:1	2000; 20 ^{o}C

When choosing the composition of corrosives and determining the optimal concentration of components, it is necessary to pay attention to the purity of the acids and other chemical reagents used. All reagents must have a high level of purity, guaranteed by the manufacturers, because the initial reagents are the existing mixtures, from which caustic solutions are prepared.

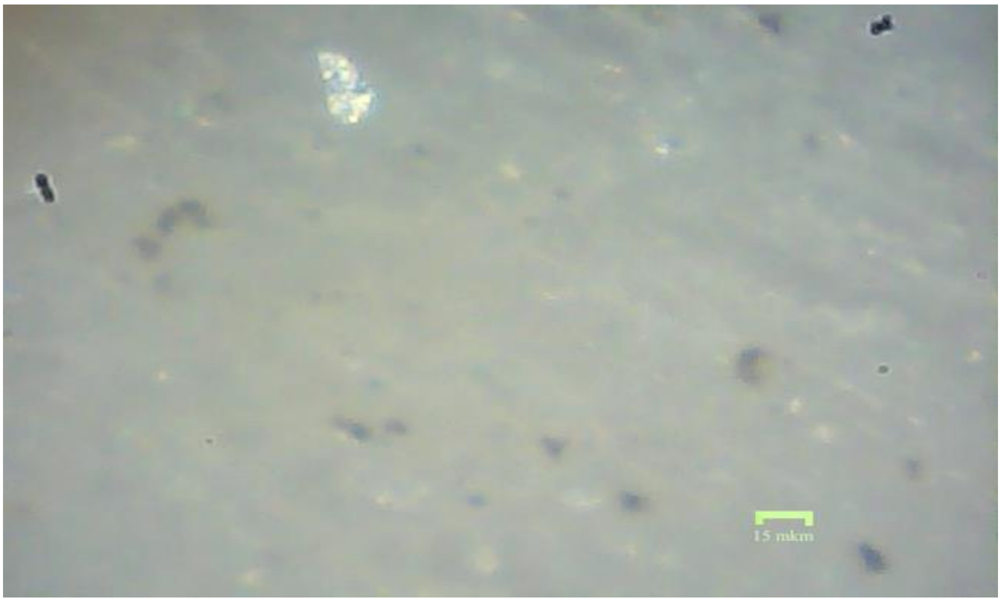

Figure 2. Silicon sample taken directly under a microscope.

The conditions on the surface of silicon can be seen when the composition of the abrasive is made at the following concentration.

1-When the surface of silicon sample was eroded with the contents of HNO_3:HF (2:1) ratio, the degradation time was 2 minutes, the surface of the sample came to the following state (Fig. 3).

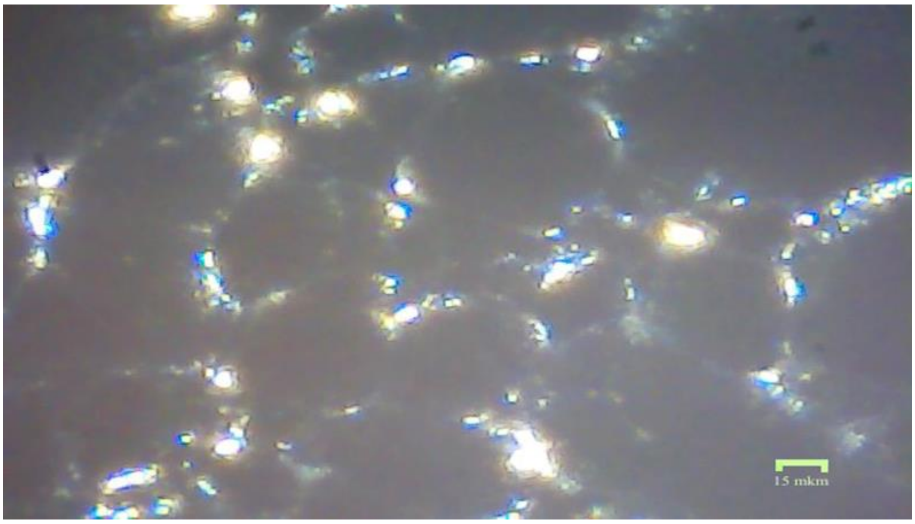

Figure 3. Silicon sample surface after 1st decay.

2-When the surface of silicon sample was eroded with HNO_3:HF:CH_3COOH (5:3:3) ratio, the decay time was 3 minutes, the surface of the sample came to the following state (Fig. 4).

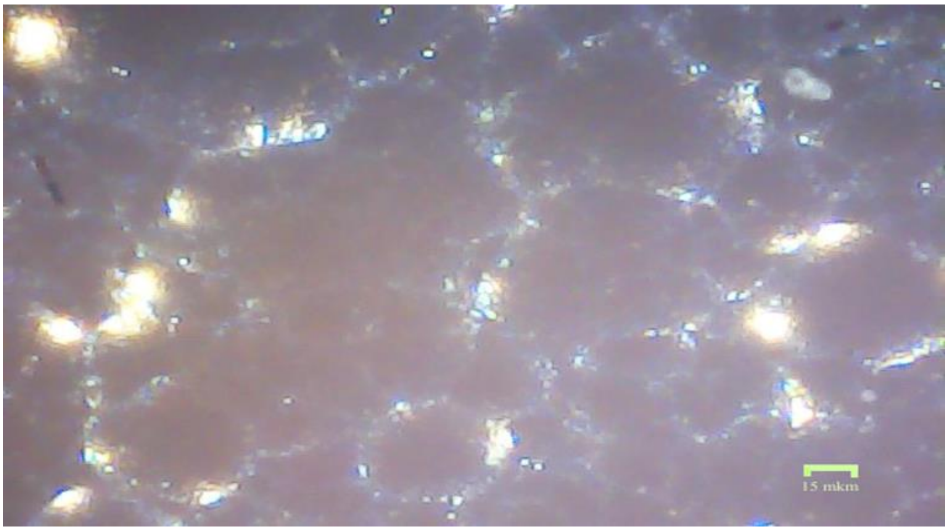

Figure 4. The surface of the silicon sample after the 2nd decay.

3-When the surface of the silicon sample was eroded with the contents of HNO_3:HF (3:1) ratio, the decay time was 15 seconds, the surface of the sample came to the following state (Fig. 5).

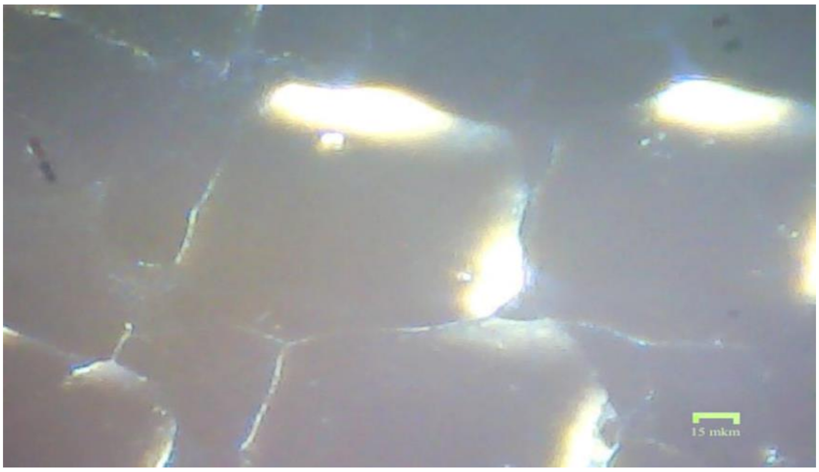

Figure 5. The surface of the silicon sample after the 3rd decay.

4-When the surface of the silicon sample was eroded with the contents of HNO_3:HF:CH_3COOH (3:1:8), the decay time was 4 hours and 30 minutes, the surface of the sample came to the following state (Fig. 6).

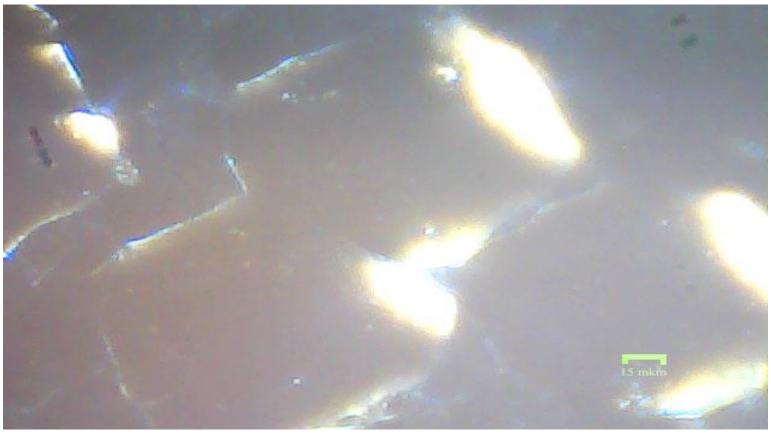

Figure 6. The surface of the silicon sample after the 4th decay.

The nanoclusters formed on the silicon surface were treated with various solvents to reveal them, and their condition was studied using an optical microscope [6-7]. The content of the selected abrasive was determined so that the peaks were clearly visible on the silicon surface. When testing nanostructured materials, they undergo preliminary processing. We can see the surface of the silicon sample with the decaying composition HNO_3:HF:CH_3COOH in the ratio 3:1:8, respectively (decay time 4 hours 30 minutes).

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