SECTION VI.
CHEMISTRY

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FORMATION OF THE CdTe-POLISHED SURFACE

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II-VI semiconductor materials, in particular CdTe possess a wide range of physicochemical properties and they are served for creation IR photodetectors, including the multicomponent lines and matrixes, detectors of γ-radiation and optoelectronic elements [1]. The work of such devices depends not only on the physical and chemical characteristics of single crystals, but also on the chemical composition, structural perfection and geometry of their surface, which results in extremely high requirements for their quality. To solve these problems it is necessary to develop the etchant with given properties, such as the rate of chemical dissolution of the material, roughness of the surface. In the process of creating the working elements of the electronic devices, the stage of chemical processing of single crystals is particularly important, the main task of which is to remove the broken layer formed as a result of previous mechanical etching, as well as to obtain high-quality, maximally structurally perfect and homogeneous chemical composition of the surfaces [2]. These problems are successfully solved by chemical etching of semiconductor wafers, in particular by chemical- mechanical polishing (CMP) [3]. The process of CMP is performing on a polishing member which is made of soft natural or artificial fabrics and the etching solution is dropped onto it at a controlled rate. In this case, the chemical dissolution of the surface layers of the semiconductors is due to the initial reagents of the etchants, and polishing member mechanically removes the products of their interaction and the residuals of the material [4].

Single crystals of CdTe which have been grown by Bridgmans method were used for experiments. Preliminary surface treatment of semiconductors consisted of the following steps: grinding of the plates by abrasive powders marks M10-M1 (3-

5 min) → mechanical polishing with diamond paste (3-5 min) → chemical etching to remove the damaged layer (80-100 μm) by the $HNO_3 – HBr – C_4H_6O_6$ etchants compositions → finishing chemical- mechanical polishing by new slow etchants [5].

The etching mixtures were prepared before starting measurements from 40% HBr, 10.9% aqueous solution of $K_2Cr_2O_7$ and ethylene glycol (EG) ($C_2H_4(OH)_2$), and maintained for 2 h to establish the equilibrium of the chemical reaction:

$$K_2Cr_2O_7 + 14HBr = 2CrBr_3 + 3Br_2 + 2KBr + 7H_2O$$

The process of CMP was carried out on a glass polisher covered with a batiste cloth for 2-3 min and a pressure on the sample in 2-3 kPa. Etchant were dropped by a drip method at a rate of 2-3 ml/min at T = 293 K. A certain amount of viscosity modifier – EL was added to the bromine-emerging polishing solution (B) (vol. %): 35 $K_2Cr_2O_7$ – 50 HBr – 15 EG for obtaining low rate of CMP with support a polishing effect. Solution B is characterized by low rates of chemical-dynamic polishing and high polishing properties. It was established that it is possible to change the rate of CMP within the range 19.3-0.9 μm/min with increasing EG content from 0 to 90 vol. % in B.

It was established that to obtain a high-quality polished surface of researched materials, the chemical-mechanical polishing should be done by etchants with concentration of EG in B increases from 30 to 70 vol. % (V_{pol}=9,3-4 μm/min), in the temperature range of 293 – 296 K. At the end of the etching process, the samples must be immediately washed with water solution of $Na_2S_2O_3$ to remove unreacted residues of the etchant from the surface and then a large amount of distilled water.

The morphology of the polished surface have been investigated by atomic force microscopy using a scanning probe microscope NanoScope IIIa Dimension 3000TM and surface compositions was established using a scanning electron microscope ZEISS EVO 50XVP with a resolution of 2 nm. It is established (see Table) that the CMP using the developed etchants contributes to the formation of a super-smooth (R_a ≤ 10 nm), stoichiometric surface of CdTe.

Table 1

Elementary composition and roughness of single crystals surface after CMP

Etchant composition, vol. %	Roughness of surface (R_a), nm	Concentrations of elements (at. %)					
		Cd	Te	C	O	Br	Cr
50 B : 50 EG	2.1	36.71	36.87	26.42	-	-	-

A series of new slow etching compositions with a controlled dissolution rate (0.9-19.3 μm/min) have been developed, that allows them to be used to reduce the thickness of the plates to the specified sizes, to remove thin layers of material and to finish treatment of CdTe single crystals surfaces.

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