GROWING A CdTe LAYER ON A SILICON SUBSTRATE AND STUDYING THE ELECTOPHYSICAL PROPERTIES OF THE CREATED HETEROSTRUCTURE AND INFLUENCE ON HUMIDITY

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Annotation

In this article, we are talking about semiconductor materials science, creating heterostructures based on cadmium telluride films obtained on a Si substrate and obtaining contacts on the created system. The morphology of the obtained films, the number of elements in the films, their distribution, and the size of polycrystalline particles were studied using modern instruments. The change in the volt-ampere characteristics of the obtained heterostructures depending on the humidity has been studied.

Keywords: materials science, semiconductor, fundamental, metals, silicon, mechanical engineering, cadmium tellurium, solid solution, technology, vacuum electronics, moisture, sensor, epitaxial layer, diffusion

Introduction

At present, in semiconductor equipment, fundamental materials such as silicon (Si), germanium (Ge), which are typical representatives of semiconductors, and semiconductor compounds A^3B^5 and A^2B^6, for example, arsenide gallium (GaAs), gallium phosphide (GaP), indium antimonide (InSb), cadmium telluride (CdTe), cadmium sulfide (CdS) and a number of other compounds and their solid solutions are used. In some cases, they can be replaced by one or the other, but in many cases it is not possible to replace them with one another.

It is also worth noting that A^3B^5 and A^2B^6 compounds and their solid solutions are relatively expensive materials.

Based on the above, in the future, researchers' interests are focused on the study of bulk and film heterostructures composed of different semiconductors.

Basically, if these heterostructures are based on silicon (Si), whose electrophysical and photoelectric properties are sufficiently studied, this interest will undoubtedly be of great importance. The field of application of film and volume semiconductor heterostructures can be the creation of various sensors [1-4], for example, humidity sensors that monitor humidity in the environment or in the process of growing or storing agricultural products, respectively.

The relevance of the topic. Cadmium telluride and cadmium sulfide are one of the promising materials that have a bright future in the creation of semiconductor devices (nuclear radiation detectors, photoreceptors, and sensors of all kinds) within A^2B^6 compounds. Si-CdTe and Si-CdS systems film heterostructures are of special importance as a new object of study from the point of view of the physics of semiconductor solar cells. It should be noted that silicon is the most common element in the Earth's crust.]At present, the technology of obtaining and purifying silicon is well developed, so silicon is the main material for the microelectronics and electronics industry. Combining the advantages of the semiconducting properties of cadmium telluride and cadmium sulfide with silicon is an urgent task, and in particular, the creation of heterostructures with an ideal band diagram between cadmium telluride, cadmium sulfide, and silicon opens up new opportunities in semiconductor device engineering.

METHODS AND RESULTS

Obtaining a wide class of compounds and solid solutions of silicon-based semiconductor materials undoubtedly plays an important role in semiconductor physics and semiconductor device engineering.

Therefore, in this work, using the method of vacuum deposition on various types of poly and monocrystalline silicon substrate, a telluride cadmium film layer is obtained at narrow pressure of ~ 10^{-4} and a heterostructure is created based on it. The thickness of the sole is 350-400 microns [5-6].

The X-ray structural analysis of the CdTe layer on the silicon substrate was conducted, as well as electrophysical and photoelectric properties, moisture sensitivity studies were conducted, and the results were analyzed.

The technological conditions for growing a telluride cadmium layer on a silicon substrate by vacuum sputtering (the temperature of the substrate and the source to be sputtered, the temperature interval, the distance between the substrate and the source, the ratio of the source and alloying primes material, and other parameters)

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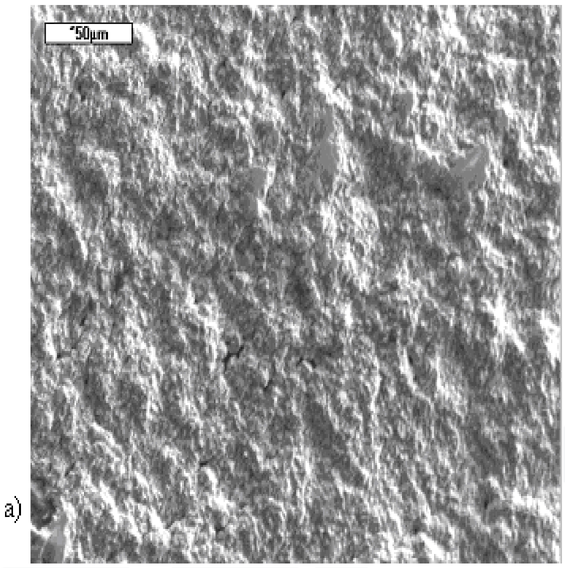
were determined experimentally. Before growing, both poly and mono-silicon substrates were subjected to appropriate mechanical and chemical processing. Therefore, both n-type and p-type silicon substrate were used as substrate.

In our opinion, the use of Si-CdTe-heterostructure is a promising system for the creation of various semiconductor devices and devices, including humidity sensors.

The compositional distribution of chemical elements on the surface of the obtained layer was studied. The analysis was carried out using an EDS LINK ISIS (energy - dispersion spectrometer) on a Jeol-JXA-8900 microanalytical complex, with a measurement error of ±2%. The test condition is V=20kV, I=10nA. Standards are pure Si, Te and Cd. The measurement results and microphotographs are presented in Fig. 1.



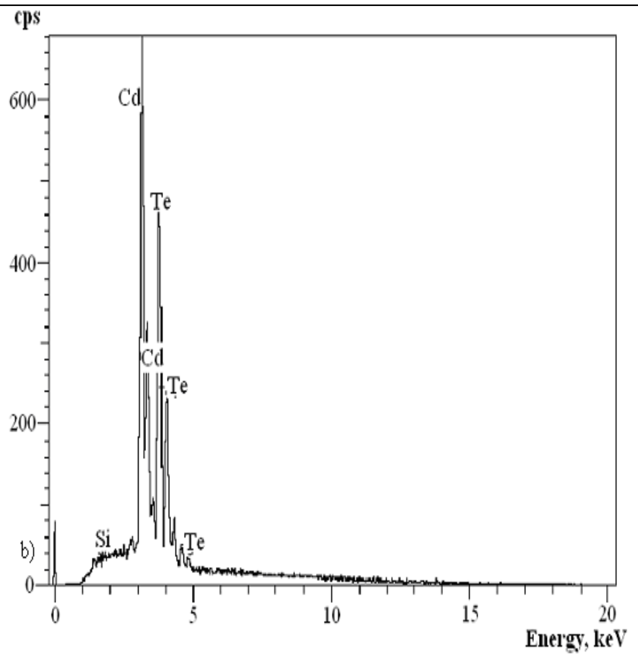


Fig.1.a - picture. Photomicrograph of the layer surface	**Fig.1.b** - picture. Distribution spectrum of layer elements on the surface obtained from measurements

In order to clearly understand the obtained layers, the results of studies of the surface of the layer, the relief view of the layer taken from the side, 3D photography, and the sizes and distribution of polycrystalline particles in the layer are presented in the atomic force microscope "Agilent Technologies 5500 AFM - Mode III - complete set BA210" (Fig.2).

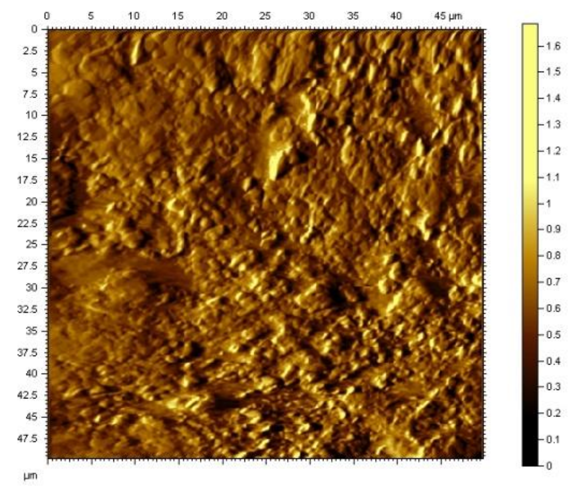


Fig. 2a. Topography of a polycrystalline film grown on a Si substrate (top view)

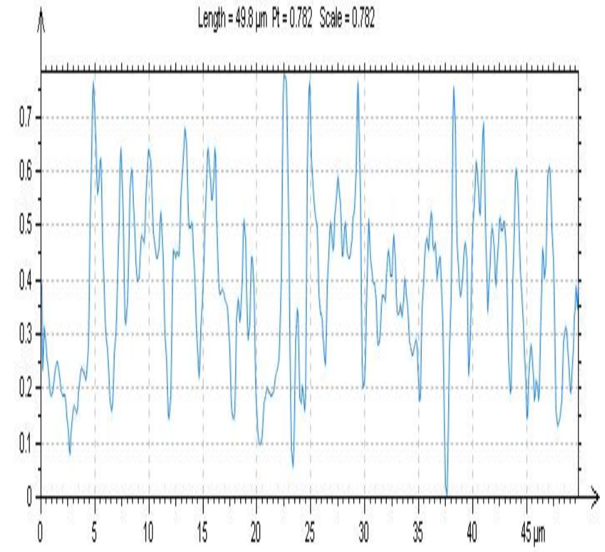


Fig. 2b. Side view of a polycrystalline film grown on a Si substrate

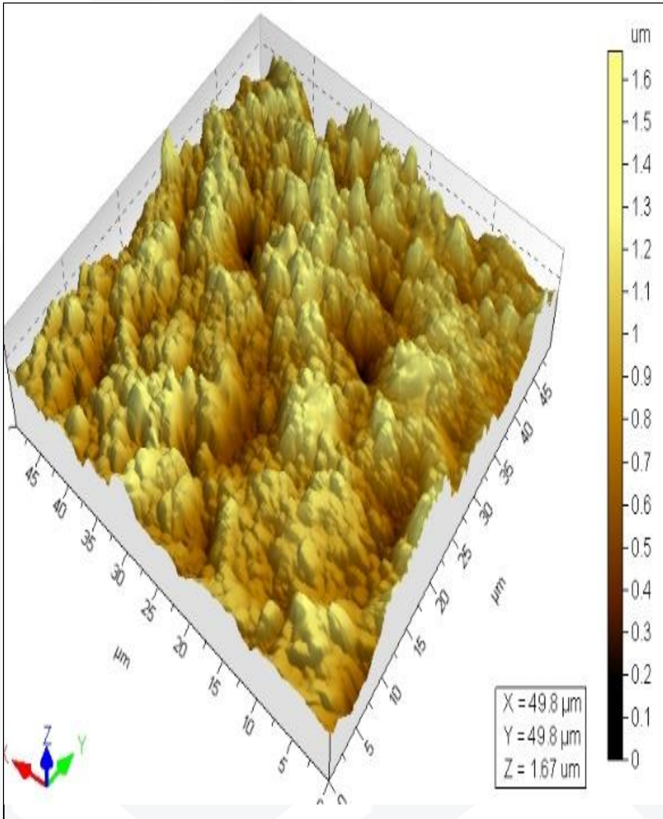


Fig.2.d. 3D view of a polycrystalline layer grown on a Si substrate

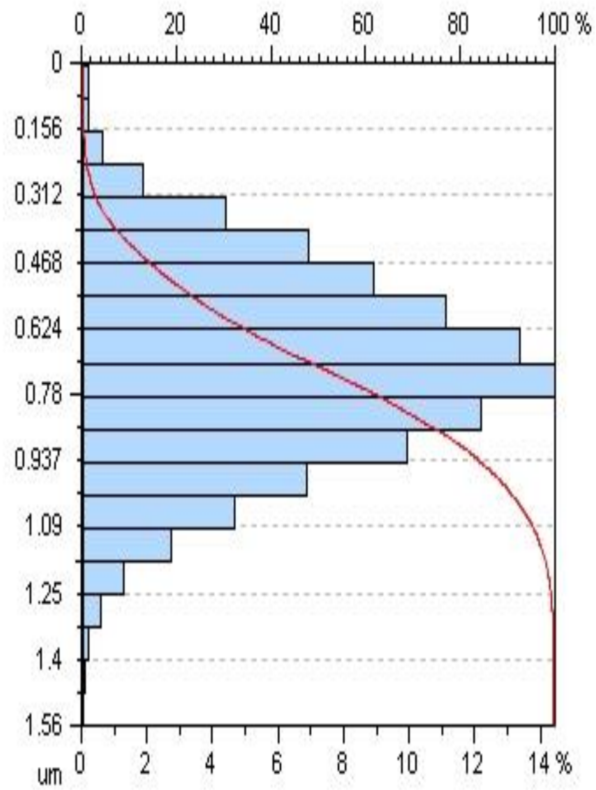


Fig. 2e. Size distribution of grown polycrystalline grains (largest size 780 nm)

Measurements were made at several points. From the measurements of chemical elements as a function of the thickness of the layer, it can be seen that the results obtained from measurements carried out in all directions are almost the same, the average deviation is more than 5%.

The results of the investigations show that a solid solution of silicon-telluride with cadmium is formed in the area of 3-4 microns thick in the transition layer. During the growth of the layer, tellurium diffuses into the ~1.0-1.5 μm surface layer of the silicon substrate. In turn, it diffuses into the epitaxial layer with a thickness of ~ 1-1.5 μm. This phenomenon, in this case, ensures the growth of the CdTe-layer on the Si-substrate by coordinating the crystal lattice and other physical-chemical parameters of the silicon base and the growing layer.

The volt-ampere characteristic and humidity sensitivity of the received heterostructure were measured. A Schottky barrier (barer Schottky) was created by injecting indium into the p-Si-pCdTe- heterostructure in a vacuum (Fig. 3). A heavily doped 500Å layer was deposited on top of the CdTe- layer. In this case, the temperature of Si-CdTe was kept in the range of 90-120°C

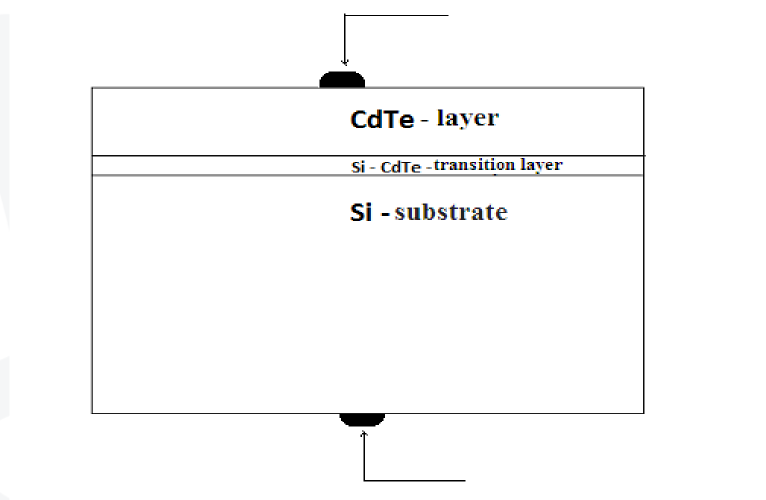


Fig. 3. Approximate side view of the contacted heterostructure

CONCLUSION

The sensitivity of the structure to humidity can be observed from the data obtained from the VAX measurements made on the heterostructure created on the basis of the pair ***Si*** and ***CdTe***. If these studies are completed and perfected, it will be possible to create humidity sensors that are widely used in various sectors of the economy, including agriculture.

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