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O. Bubinets,
postgraduate student
Zaporizhia State Engineering Academy
V. Skachkov,
Candidate of Engineering Sciences**,** Associate Professor at the Department of Metallurgy,
Zaporizhia State Engineering Academy,
Zaporizhia
e-mail: nko@zimz.com.ua

PARTICIPATION OF OXYGEN AND CARBON IN FORMATION OF OXIDATION-INDUCED STACKING FAULTS IN MONOCRYSTALLINE SILICON

It is experimentally established, that density of oxidation-induced stacking faults (OISF) in the boron doped monocrystalline silicon plates, that above, than it is more relation of oxygen atoms concentration to carbon atoms concentration in them.

Key words: silicon, single crystal, oxygen, carbon, oxidation-induced stacking fault.

Single crystals of silicon intended for microelectronics, produced by growing from the melt by the Czochralski method.

By purity monocrystalline silicon very high requirements. The concentration of uncontrollable impurities in it should not exceed $10^{-9\,\%}$.

The impurities in the growing single crystal comes primarily from the melt. This is - a variety of impurities contained in the raw material - polycrystalline silicon semiconductor purity. Directly during growth in melt enters oxygen impurity due to partial dissolution in a liquid silicon quartz crucible walls. Also, the melt comes carbon atoms as a result of their separation elements graphite tooling heated melting chamber. These two prmesi contaminants in silicon single crystals called background impurities, since their entry into the melt can not be excluded when using existing installations Czochralski method. Numerous studies have shown that oxygen and carbon are involved in complex formation processes in a single-crystal silicon [1].

In the manufacture of many devices and virtually all integrated circuits using wafer oxidation operation. In the process of oxidation in the surface areas of the plates along with the introduction of thermal and mechanical stresses are formed oxidation stacking faults (OISF) [1]. This two - dimensional defects, which are a violation of the order of stacking atomic layers. In the crystal lattice of silicon defect packaging often has an interstitial nature and formed by "pasting" of two of the extra between two close-packed atomic planes {111}. Oxidizing stacking faults reduces the dielectric strength of silicon dioxide film, which reduces yield of devices due to electrical breakdown of the insulating layer[2].

The oxidation stacking faults originate on micro defects are clusters of interstitial silicon atoms formed in the silicon single crystal during its cultivation. This is due to the fact that as the pulling of the single crystal from a melt of its upper portion gradually cools. The equilibrium concentration of point defects (vacancies and interstitial silicon atoms) decreases, so they begin to form selection. Microdefects vacancy nature are formed mainly during the cooling of the temperature 1420 K to 1350 K [3], and interstitial nature - in a wider temperature range – 1670…1220 K [4]. It is shown that aggregation of interstitial silicon atoms occurs at impurity carbon atoms [5]. The oxygen atoms are actively involved in education as vacancy micro-defects of nature, and a variety of complexes.

The current level of growing silicon single crystals by the Czochralski technology ensures the required purity of Ukraine, as well as places without linear (dislocations) and two-dimensional defects (twin boundary blocks growth of stacking faults).

To achieve the full otsustvija micro-defects in the silicon single crystal growing by the Czochralski method is impossible. You can only control the concentration and type of micro-defects by adjusting the thermal history of a single crystal, which depends not only on the growth process parameters, but also on the characteristics of specific plants for cultivation. Therefore, in practice, it requires an experimental study of density and distribution of the OISF in silicon single crystals grown in an industrial environment.

Following an analysis of the impact of oxygen and carbon atoms to the nucleation process of OISF in silicon single crystals can be seen the following:

In all six test me single crystals in the upper section of the cylindrical part of the ring detected pucks circumferentially OISF and OISF, uniformly distributed over the area outside of the washer rings. The density of the OISF in the rings at the 2 ... 3 orders of magnitude higher than the outside.

As the distance from the upper section of the cylindrical part of the radius of a single crystal rings increased OISF, that is shifted to the periphery of the ring washer. At some distance from the upper rings OISF already otsustvovali. In single crystals of number 1, number 3, number 5, grown from the initial download, ring OISF places without at a distance from the upper section 30 ... 40 mm, and in single crystals of number 2, number 4, number 6, grown after reloading - the distance from the top sections 75 ... 95 mm.

The area with a high density of OISF ~ $10^5 \ldots 10^3$ $см^{-2}$ cervix begins immediately after the single crystal has a conical shape and extends deep into the growing crystal. In cross sections, this area is in the form of rings. The rest of the volume of a single crystal of the OISF allocated randomly, and their lower density 10^3 $см^{-2}$.

The results of measuring the density of the OISF compared with the concentration of oxygen and carbon impurities out of their rings. The silicon single crystal growing in the installation by the Czochralski method, the concentration of background impurities varies along its length from the top to the bottom: oxygen - is reduced and carbon - increased [11]. In [12] it was shown that complex formation processes in silicon single crystal are determined not so much the absolute values of these concentrations as their ratio. Generalized six investigated single crystals of silicon brand me KDB 12/24 of measuring the density of the OISF are shown in Picture - 1.

Picture 1 - The dependence of the density of the TAC, located outside the rings, the ratio of the background concentrations of impurities in silicon single crystals

From the data in Picture 1 shows that the OISF density is higher, the greater the ratio of the concentration of oxygen to the carbon concentration. conclusions It was established experimentally that the density of micro-defects which serve as nuclei for the formation of oxidation stacking faults (OISF) in silicon single crystals doped with boron, the higher, the greater the ratio of the concentration of oxygen to the carbon concentration in a single crystal. The results make it possible to adjust the parameters of silicon single crystal growth process in an industrial environment with a view to increasing the yield of usable product on the density parameter oxidation stacking faults.

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