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AFFINAGE OF METALLURGICAL SILICON TO CLEANNESS OF SUN SORT

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There are presented characteristics of metallurgical grade silicon and measure on the improvement of it quality. There are considered technologies for affinage of metallurgical silicon with taking of it to the cleanness of sun grade, suitable for making photoelectric transfers of sun ehergy. Importance of cleaning of silicon from the boron with used of different methods is shown.

Keywords: silicon metallurgical and sun grades, cleaning, hydrometallurgical treatment, electrolytic affinage, vacuumizing, refining meltings, crystalphysical methods, boron

A presence in metallurgical silicon of bundle admixtures does not allow to use it for making of photo-electric transformers of sun energy (PET).

Most effective for cleaning of silicon from a calcium and aluminium is flux-oxygenic affinage of silicon fusion in a ladle by blowing out of air it is inculcated on the largest in Russian Federation plant of losed corporation «Silicon», productive silicon of metallurgical sorts.

It is worked out the great number of technologies of metallurgical silicon cleaning to the requirements of sun cleanness: hydrometallurgical treatment, electrolytic affinage, vacuum distillation and degassing, plasma and cathode-ray melting, cryatal-phisics affinage. There are known also complex industrial technologies of affinage for technical silicon, as, for example, technologies of «JFE Steel» (Japan) and «Elkem ASA» (Norway) [1-3].

In Institute of geochemistry SB RAS new technology is worked out, which allows due to building in the existent systems of industrial affinage of unique apparatuses and dedicated regimes of realization of barbotage of silicon fusion of to ob-tain moving away from fusion of admixtures of boron, phosphorus, arsenic, aluminium, calcium and row of other metals [4].

For the hydrometallurgical cleaning of silicon of metallurgical sort usually use hydrochloric treatment for a temperature 150-160 °C and pressure in an autoclave 1.5-1.6 MPa [5]. Diminishing of size of particles of silicon powder, height of temperature and concentration *HCl*, and also addition of oxidants ($FeCl_3$ and $(NH_4)_2S_2O_8$) are assisted passing to solution of admixtures [6]. The appearing intermetallide phases *Si-Fe* and *Si-Fe-Ti* hinder cleaning from iron and titan.

In work [7] there are carried out cleaning from titan treatment of silicon MG-Si by mixture of *HF* and *HCl*. At lixiviation of MG-Si by 3 % *HF* and 2 % *HCl* after 0.5 hours it was extracted 97 %, and after 5 hours - 99 % titan.

The scientists of China investigated the process of affinage of metallurgical sort silicon a cleanness 99.5 % in the electrolyte of composition, %: $CaCl_2$ (80-81)-*NaCl* (8-10)-*CaO* (5.0-8.5)-SiO_2 (2.5-5.0) at a temperature 850-950 °C. On a cathode silicon was besieged, substantially more clean, than initial. Structure and properties of sledges of silicon, got by method of electrolytic affinage in fusion of salts *KCl-KF-CsCl-*K_2SiF_6, described in work [8].

For the affinage of metallurgical sort silicon and moving away from it more than 90 % admixtures of iron, aluminium, titan and copper the method of the partial melting and moving away of liquid phase by centrifugation can be used [9]. In work [10] the affinage of MG-Si at vacuumizing of fusion in crucibles from *MgO* and mullite studied: at rarefaction to 5 KPa takes place cleaning of silicon from volatile admixtures. A vacuum treatment of fusion of silicon of metallurgical cleanness (99.46 % *Si*) with the use of arc plasma allows to clean it to the cleanness of sun silicon of SoG-Si (99.93 % *Si*).

By plasma treatment (during 5 minutes) substantially it is reduced content of admixtures in silicon, and phosphorus retires fully. Plasmachemical technology was used for the receipt of especially clean quartz and polycrystalline silicon from this quartz [11].

Structure of high-clean polycrystalline silicon of PG-Si, got by cathode-ray affinage silicon MG-Si in a vacuum, investigated in work [12]. It is shown that a height and sizes of particles of admixtures depend on the method of affinage (vacuum or oxidation) unlike the sizes of crystalline.

Zone melting of silicon of MG-Si (99.855 %) executed in a cathode-ray furnace with water-cooled copper crucible. The contents of carbon and oxygen here went down from 106 to 35 mil^{-1} and from 30 to 5 mil^{-1} accordingly.

In work [13] the process of forming of electrophysics characteristics of multicrystalline silicon given in sun energy at the affinage of metallurgical silicon by directed crystallization with the use of admixture of neodymium as the third component are investigated.

After cleaning of silicon an additional remelt is required it in bars, suitable for making of plastins of PET. For a remelt both single-crystal and polycrystalline silicon can be used. The last has less CE as compared to a single-crystal, but technology of smelting of polycrystalline silicon is much cheaper.

Experiments on cleaning of molten silicon (temperature 2150-2250 °C) from boron by means of gas reagents showed that a most effect was arrived at the use of argon-hydrogen mixture.

For cleaning from boron the lithiumcontaining slag of the systems *CaO-*SiO_2*-*Li_2O or *CaO-*SiO_2*-LiF* can be also used [14].

Conclusion. For the affinage of metallurgical silicon to the cleanness of sun sort (no less than 4N) such methods, as hydrometallurgical treatment, electrolytic affinage, vacuum distillation and degassing, plasma and cathode-ray melting, crystalphisical affinage, are used.

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