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**Recommended Citation**
B., Utamuradova Sh.; Sh., Daliyev ..; and M., Bekmuratov .. (2021) "INFLUENCE OF YTTERBIUM IMPURITY ON THE GENERATION CHARACTERISTICS OF MDP STRUCTURES," *Euroasian Journal of Semiconductors Science and Engineering*: Vol. 3 : Iss. 1 , Article 2.
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INFLUENCE OF YTTERBIUM IMPURITY ON THE GENERATION CHARACTERISTICS OF MDP STRUCTURES

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Abstract. The influence of ytterbium atoms on the electrophysical properties of silicon MIS-structures is investigated by means of CC-DLTS and high-frequency volt-faradic characteristics. It is shown that the presence of ytterbium atoms in the volume of the silicon substrate leads to a decrease in the density of surface states of MIS - structures. It is found that the presence of Yb atoms in the substrate does not lead to noticeable changes in the density distribution of surface states of Nss over the width of the band gap Eg.

Keywords: CC-DLTS, MIS structure, ytterbium, V-F characteristics.

1. Introduction

It is known that the main parameters of MIS structures largely depend on the presence and properties of various defects in the dielectric, the presence of defects in the Si-SiO₂ transition layer and in the semiconductor volume [1-2]. The presence of defect states at the Si-SiO₂ interface of semiconductor devices based on MIS structures affects such generation characteristics as threshold voltage, steepness of transfer characteristics, leakage currents, charge transfer efficiency, noise, dark currents and information charge storage time in memory cells. The cause of the instability of generation characteristics is various defects in dielectrics, arising under the influence of such external
influences as the special introduction of dopant impurities, ionizing radiation, temperature, electric field and other factors [3-4]. In this regard, the study of defect formation and the change in the electrical properties of the Si-SiO$_2$ system under external influences is of interest to a wide range of researchers working in the field of semiconductor electronics [5-6].

It is known that impurities of rare-earth elements (REE) introduced into silicon from melt during growth, possessing high chemical activity and propensity to complexation, are present in silicon in electrically inactive state, but at the same time they render essential influence on working characteristics of semiconductor devices [7-8].

The purpose of this work is to investigate the influence of ytterbium impurity on the electrophysical properties of silicon-silicon dioxide system with thermal oxidation.

2. Experimental technique

The results of the complex study of CC-DLTS and volt-farad characteristics in silicon MIS-structures doped with an impurity of a rare-earth element - ytterbium are presented below. MIS structures on n-Si wafers doped with ytterbium in the process of growth from melt were used for measurements. After doping on Si wafers with <100> orientation and 15 Ohm-cm resistivity, a 650 - 700A thick SiO$_2$ layer was grown at 900°C in a humid oxygen atmosphere with the addition of trichloroethylene. Metal electrodes on SiO$_2$ with the area A=0.03 cm$^2$ and thickness 7000A were created by thermal spraying of Al.

3. Results and discussion

The $V$-$F$ characteristics measurements of Si< Yb> based MIS structures showed that they are shifted towards positive bias voltages compared to the control samples (Fig. 1). This indicates that, the introduction of impurity of ytterbium in silicon leads to a decrease in the density of surface states of MIS structures and a decrease in the value of the positive charge at the Si-SiO$_2$ interface (relative to control samples).

![Fig.1. High-frequency C-V characteristics of MIS structures based on Si with Yb (1) and control MIS structures (2)](image-url)
Measurements of CC-DLTS spectra in Si Yb-based MIS structures and control MIS structures (Fig. 2, curves 1 and 2) showed that their spectra are somewhat different, since the $N_{ss}$ value decreases when ytterbium is introduced into the silicon substrate of the MIS structures, no peaks in appreciable concentration were found in the DLTS spectra.

The measurement of the distribution of the surface state density $N_{ss}$ over the bandgap width $E_g$ of silicon MIS semiconductor structures with and without ytterbium admixture showed that the distribution spectrum $N_{ss}(E_g)$ has a typical U-shaped character. Analysis of the obtained dependences showed that the presence of Yb atoms in the substrate does not lead to marked changes in the $N_{ss}$ distribution of $E_g$ and the formation of any distinct peaks.

**Fig. 2. CC-DLTS spectra in Si Yb-based MIS structures (curve 1) and control structures without Yb (curve 2)**

4. Conclusion

Thus, the presence of electroneutral Yb impurity in the silicon substrate of MIS structures leads to a decrease in the density of surface states of MIS structures, but no noticeable change in the distribution of $N_{ss}$ by $E_g$ is observed. It is assumed that the presence of Yb in silicon after thermal oxidation of silicon at 900° C activates ytterbium atoms and partially compensates the amount of broken bonds on the silicon surface.

References


