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ADMITTANCE SPECTROSCOPY FOR THE RESEARCH OF GERMANIUM-ON-SILICON QUANTUM DOT STRUCTURES PARAMETERS[1]

I In this work Si/Ge nanoheterostructures properties are investigated using the method of admittance spectroscopy. The results of experimental research are presented. The activation energies of the emission process from quantum dots are calculated.

Keywords: *admittance spectroscopy, quantum dots, germanium, silicon.*

Currently optoelectronics is experiencing rapid development, and the main objects of research are complex heterostructures with nanoscale inclusions. A breakthrough in this area became possible because of the development of manufacturing technologies of nanostructures. The main focus is on structures based on silicon constituting basic elements of most modern electronic devices. Germanium-silicon materials system with germanium QDs is promising for creating high-performance solar cells [1, 2].

To date a search for new methods of diagnostics of nanoelectronic devices and structures takes place. The methods of the current-voltage characteristics, capacitance-voltage characteristics, admittance spectroscopy, deep level transient spectroscopy (DLTS) have great potential for the characterization of semiconductor quantum structures [3].

In this work measurements of silicon *p–i–n*-strucrures parameters which bases contain germanium QDs were conducted using the automated admittance spectroscopy installation. The installation allows to conduct the quantitative measurements of electrical parameters of materials and structures of nanoelectronics over a wide range of temperatures (10–475 K), bias voltages (±40 V), and external test signal frequencies (20–2000 Hz). Two samples (1 and 2) fabricated by means of molecular beam epitaxy method at the Institute of semiconductor physics (Novosibirsk) were investigated. The *i*-region of each sample contained 30 layers with embedded Ge QDs 6 monolayers (ML) thick separated by thin Si layers.

By analogy with the deep levels in semiconductors, the principle of admittance spectroscopy of structures with quantum dots is based on measuring the complex conductivity of the system caused by QDs recharging due to the emission processes of charge carriers from the QDs, and their capture by the localized states in the QDs [4].

Figure 1 shows the capacitance-voltage characteristics of sample 1, Fig. 2 – sample 2. The measurements were conducted at room temperature.

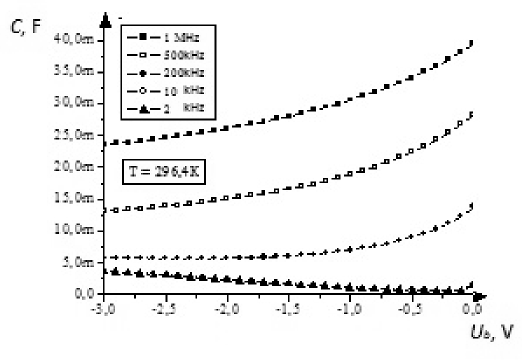

Fig. 1. Capacitance-voltage characteristics of sample 1 measured at room temperature.

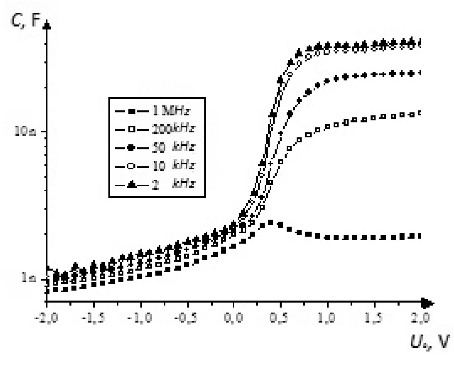

Fig. 2. Capacitance-voltage characteristics of sample 2 measured at room temperature.

Figure 3 shows the temperature dependence of the conductance of the sample 1, Fig. 4 – sample 2. The measurements were performed at different bias voltages V_b and different frequencies of test signal *f*.

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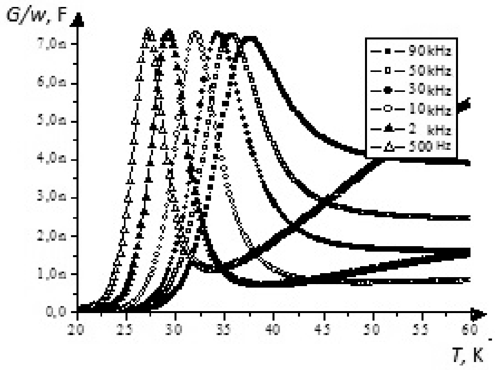

Fig. 3. Temperature dependence of conductance of sample 1, $V_b = -0{,}5$ V.

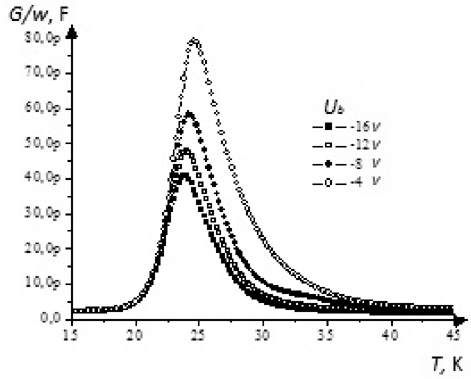

Fig. 4. Temperature dependence of conductance of sample 2, $f = 100$ kHz.

The processing of the temperature the spectra leads to a typical family of Arrhenius plots. The plots in coordinates $\omega = f(1 / T)$ for the position of the conductance temperature spectra maxima determine the activation energies, which characterize the position of quantization levels in QDs. The activation energies for the investigated structures are estimated (Figs. 5 and 6).

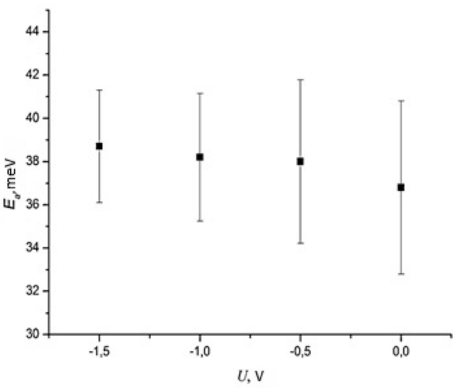

Fig. 5. Activation energies of sample 1 at different bias voltages.

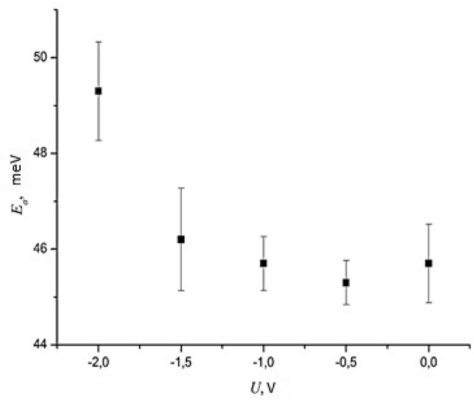

Fig. 6. Activation energies of sample 2 at different bias voltages.

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