AUTOMATED INSTALLATION FOR DETERMINING THE PARAMETERS OF SEMICONDUCTORS BY THE VAN DER PAUW METHOD

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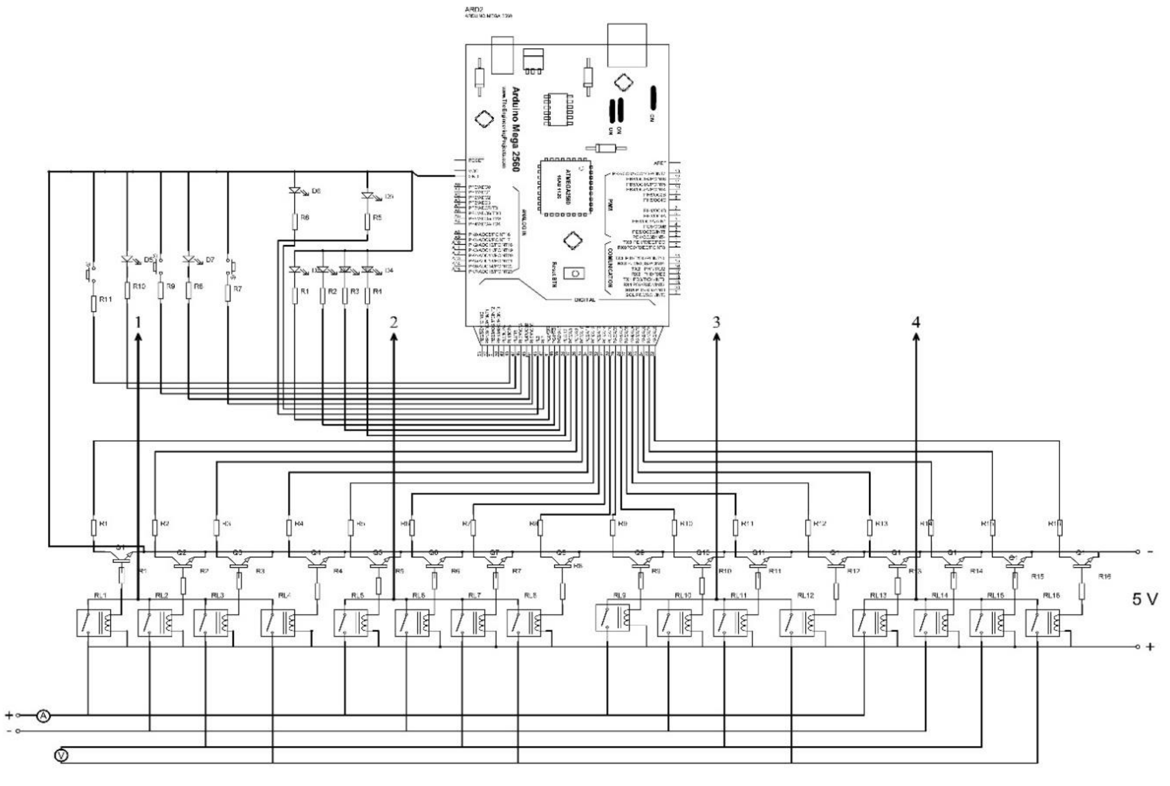
Perspective modern materials for nanoelectronics, photonics, spintronics and photo energetics are semiconductor materials with nanoclusters of impurity atoms, the production technology of which is currently being developed in the world.

The formation of nanoclusters of impurity atoms makes it possible to create and obtain a new class of bulk nanostructured semiconductor materials The possibility of ordering nanoclusters in the bulk of the crystal lattice in certain directions makes it possible to create local nanomagnetic domains, nanoscale structures, and nano superlattices, which significantly expands the functionality of nanoelectronics devices made on the basis of such materials [1] - [4



]. Fig.1 Electric circuit of the developed switching matrix

One of the perspective methods for solving these problems is the Van der Pauw method, which is used to determine the type of conductivity, resistivity, concentration, and Hall mobility of the main charge carriers of semiconductors of arbitrary shape, which is a very important factor in research on the creation of new volumetric nanostructured semiconductor materials and devices based on them. However, the application of the Van der Pauw method in practice is very difficult due to the large number of measurements that must be carried out on one sample, varying the points of connection of the measuring probes (12 combinations), changing the polarity of the voltages applied to the sample under

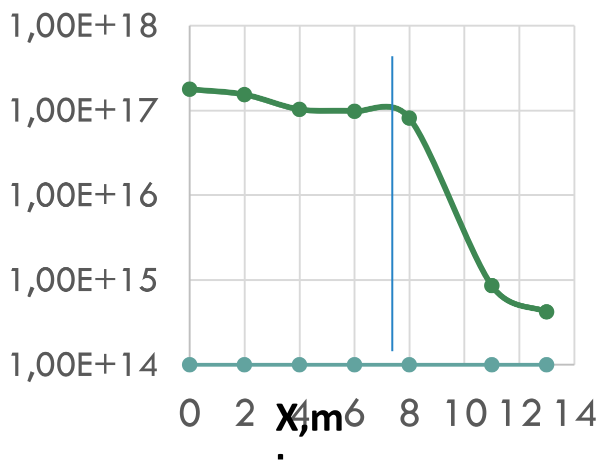


Fig.2 Concentration depth distribution after diffusion T=1250° C t= 20 h ρ=100 ohm*cm

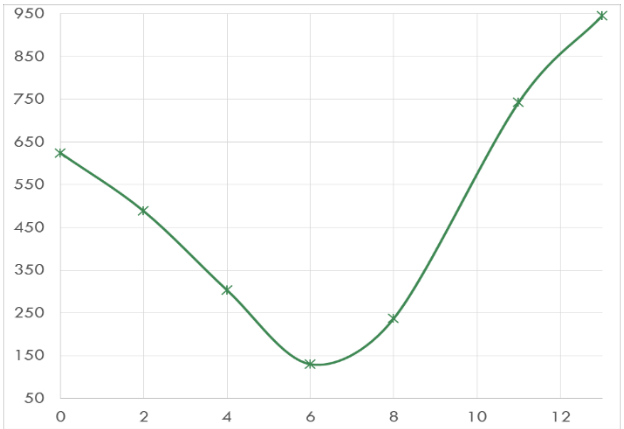


Fig.2 .Mobility of charge carriers in depth after diffusion T=1250° C t= 20 h ρ=100 ohm*cm

study when changing the direction of the magnetic field (Fig.1).

The basis of the developed setup for automatically determining the type of conductivity, resistivity, dopant concentration and Hall mobility of the main charge carriers of semiconductor materials is a transistor-reed switching matrix, which eliminates the need for manual connection and disconnection of the contacts of the used measuring probes. To determine the resistivity and Hall voltage, it is necessary to carry out measurements with 12 combinations of probes. The electrical circuit of the developed transistor-reed switching matrix for controlling the contacts for connecting probes is shown in fig. 1. The transistors are controlled by the ATmega2560 programmable microcontroller module, which has 54 digital inputs and outputs. Each of the 54 digital pins on the ATmega2560 microcontroller module can be configured as input or output using the pin Mode, digital Write, and digital Read functions

Since the launch of the device, many experiments have been carried out. For example, the resistivity, mobility, and concentration of SiGe samples were measured several times. On fig. 2 shows the concentration distribution of germanium atoms in silicon after diffusion T=1250 °C, t=20 hours. As can be seen from the experimental results, the concentration of germanium in the surface is $N_{Ge}=2\cdot10^{17}$ cm^{-3}, while at a depth of x=8 μm, its concentration is reduced to ~10^{14} cm^{-3}, while the samples remain n-type all the time. This is fully consistent with the literature data. On fig. 2 shows the results of mobility, which is one of the main parameters of semiconductor materials. These measurement processes were measured several times.

The results of measuring the parameters of semiconductor materials obtained on the basis of the Hall effect method and the Van der Pauw method on the developed installation show that the values of the parameters of semiconductor materials measured by various methods correspond to each other. The use of the developed setup for studying the electrical properties of bulk nanostructured semiconductor materials of arbitrary shape with nanoclusters of impurity atoms of various nature makes it possible to reveal the yet unexplored facets of the physics of magnetic and multiply charged ordered quantum dots and to discover new physical phenomena associated with them. In addition, as a result of numerous studies using the device, the main parameters of semiconductor materials (SiGe, BP, GaP, GaSb, ZnSe) were studied. These studies can help us develop various sensors, solar cells, which will play an important role in the electronics industry in the future.

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