LOW VOLTAGE SEMICONDUCTOR STABILITRON

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A device has been manufactured having an active region consisting of a semiconductor alloy composed of silver selenide and silver telluride taken in an equimolar ratio with an n-type conductivity. It has been determined that the proposed device is capable of stabilizing and limiting low alternating voltage. A mechanism for the observed breakdown has been suggested.

Keywords: stabilitron, threshold voltage, breakdown, active region.
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INTRODUCTION

The accelerated development of semiconductor technology sets new challenges for researchers related both to the search for opportunities to create a variety of devices and to improve the electrophysical properties of the materials used in them. To date, MSM, MDM, MDS (M – metal, S – semiconductor, D – dielectric) and other more complex structures based on a range of dielectric and semiconductor materials have been investigated quite well at our Institute of Physics and the results obtained have been used in the manufacture of various devices. Similar work has also been carried out by us using binary or ternary silver chalcogenides as semiconductors and various oxides as dielectrics in the above structures, some of which [1-10] have reported the obtaining of simple experimental devices such as switching and valve elements, an air pressure sensing switch, negistors, varistors, etc.

The purpose of the presented work is to produce a stabilitron based on binary silver chalcogenides stabilizing low alternating voltages.

EXPERIMENTAL PART, RESULTS AND DISCUSSION

Known semiconductor stabilitrons, especially today's popular silicon ones, operate in the region of p-n junction breakdown at reverse voltage and can only stabilize constant or unipolar voltage due to the asymmetry of their current-voltage characteristics (CVC). However, in order to obtain a symmetrical stabilitron characteristic, it is necessary to connect two identical stabilitrons back to back, which makes their construction much more complicated. Additionally, such stabilitrons cannot be used to stabilize small (in the order of 1.0 – 1.5 V) voltages, since they have a threshold voltage of at least 5V. Another disadvantage is that overcurrent is unacceptable in them, as it leads to the destruction of the p-n junction. We can also point to another stabilitron with a threshold voltage of 5-20 V, with an active region consisting of polycrystalline and monocrystalline silicon layers. And in this case, the need to grow a single crystal of silicon also complicates the design of the device.

Based on the above-mentioned disadvantages of operating silicon stabilitrons, and in order to achieve the objective, we have manufactured a device in the form of an MSM structure (Fig.1), the active region (1) of which is made of a homogeneous polycrystalline quasi-binary alloy of silver selenide and silver telluride with n-type conductivity (Ag_2Se and Ag_2Te), synthesized both from initial compounds and from individual elements taken in stoichiometric ratio.

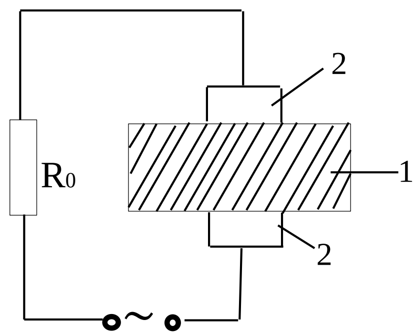

Fig. 1. Schematic representation of the sample structure: 1 - active area; 2 – electrodes.

Subsequently, from the alloy obtained with a concentration of 10^{18} -10^{19} cm^{-3} determined from Hall measurements, a disc of about 1.0 - 1.5 mm thickness was cut and placed between tungsten or molybdenum electrodes (2), which can be either pressed or sputtered. The resistance R_0 not only limits the current in the device circuit, but also plays an essential role in obtaining a stabilizing effect. So, if R_0 = 0, then the stabilization coefficient k = R_s/ R_d=1, i.e. there is no stabilization (R_s=U/I – static resistance, R_d=dU/dI – dynamic resistance).

The proposed device works as follows: when a voltage of any polarity is applied to it, first it is in a high-resistance state, then when the voltage reaches about 1.0-1.2 V, there is a sharp, almost abrupt transition to a low-resistance state and the CVC becomes vertical, parallel to the current axis, as can be seen from Fig. 2, which depicts the observed characteristic taken from the screen of a transistor characteristics monitoring device (TCMD) type curve

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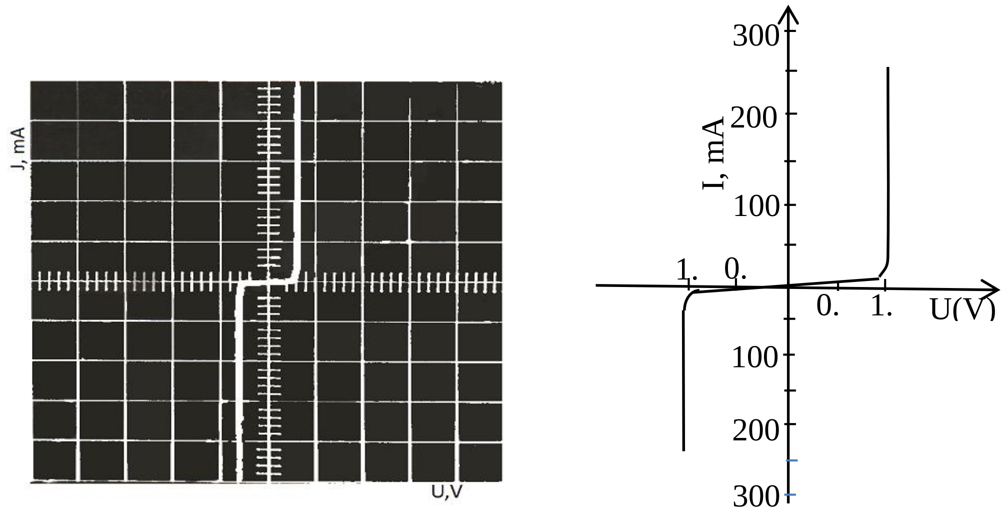
tracer (a) and in static mode (b). The threshold voltage (1.0 -1.2 V) remains constant when the stabilization current is varying from 5-10 mA to 250-300 mA.



(a). (b).

Fig. 2. CVC of the device, taken at 300K: a) from the curve tracer screen; b) in static mode; horizontal scale 2 V/div., vertical - 50 mA/div.

The CVC of the device depends neither on the method of creating the electrodes nor on their arrangement, which does not limit the structural design of the device. In addition, it is easy to fabricate as the active region is single-layer and no p-n junction or single crystal growth is needed.

In dependence on the nature of the physical processes that cause a sharp increase in current, thermal, avalanche and tunneling breakdowns are distinguished.

The breakdown observed by us is not thermal, since it is characterized by the presence of a negative resistance region in the working section of the CVC (Fig. 3, curve 1) [11]. Avalanche breakdown, usually caused by impact ionization of the semiconductor, is also excluded, since it occurs at sufficiently high electric field strength (10^5 - 10^6 V/cm and more) (section 2 of the characteristic).

We believe that at a given small threshold voltage (1.0 -1.2V), an electric field may arise that is sufficient to directly transfer electrons from the electrodes to the semiconductor or to cause intense leakage of electrons from one electrode to another through the active region, leading to tunnel breakdown (section 3 of the CVC).

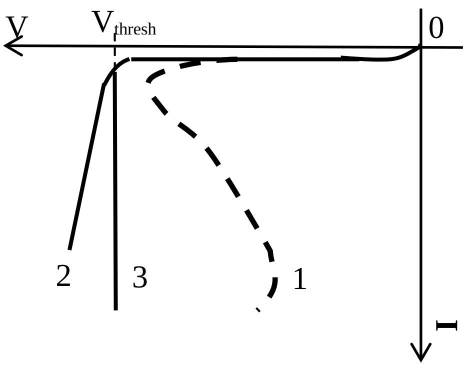


Fig. 3. The character of current growth at different types of breakdown: 1- thermal, 2- avalanche, 3-tunnel.

CONCLUSION

Compared to known stabilitrons, proposed by us device provides the ability to stabilize and limit small alternating voltages, as well as can be used as a two-way limiter, two-way rectangular pulse shaper, electric key, etc.

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