MEASUREMENT OF THE HEAT CONDUCTIVITY OF SEMICONDUCTORS BY THE BRIDGE METHOD

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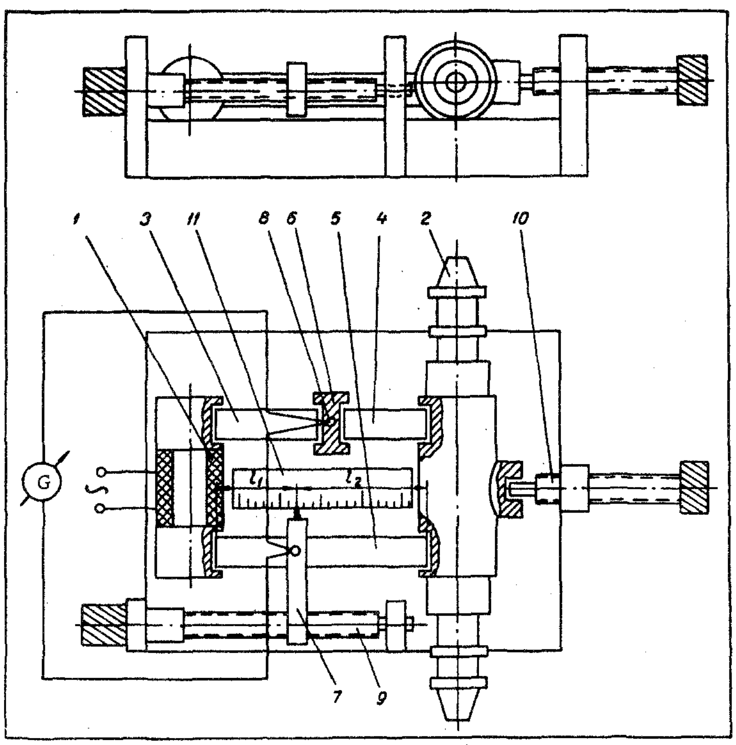
So far, the heat conductivity of semiconductors has clearly been insufficiently studied, although the role of the thermal characteristics in technical applications is well known [1]. This situation can be attributed, in the first instance, to the absence of reliable, simple methods, not requiring complex and expensive apparatus, for measuring the heat conductivity of semiconductors [2, 3]. In our work in the field of semiconductors we have been keenly aware of this. Therefore, to determine the heat conductivity of solid semiconductors we have utilized successfully the bridge method [4, 5].

At our request, F. S. Ageshinym designed a special apparatus, a thermal bridge, analogous to the electric Wheatstone bridge. In the arms of this bridge "flows" not electric current, but a heat flux due to the temperature difference between a heater T_2 and cooler T_1. The bridge for relative measurement of the heat conductivity of solid semiconductors is mounted on a thermally insulated board (figure).

The apparatus consists of three arms of known heat conductivity λ_S, λ_1, λ_2, and one arm of the test semiconductor, the heat conductivity of which λ_X is to be measured.

To one of the diagonals of the bridge is applied the temperature difference $T_2 - T_1$ of the heater and the cooler. The heater is fixed to the insulated board and takes the form of a brass cylinder, on which a high-resistance wire heater is wound. The cooler is a water-cooled brass tube.

The test sample, standard semiconductor and thermochord are cylindrical solids of the same diameter. The thermochord comprises two arms l_1 and l_2 of the bridge. Their length is measured by a micrometer scale. The lateral surface of all the cylinders must be smooth.



Layout of bridge for relative measurement of the heat conductivity of solid semiconductors: 1) heater; 2) cooler; 3) test semiconductor; 4) standard semiconductor; 5) thermochord; 6) coupling; 7) thermochord slide; 8) thermocouple with galvanometer; 9) screw for moving slide; 10) screw for making contact between test and standard semiconductors and thermochord and heater and cooler; 11) reading scale (special micrometer).

In the other diagonal of the bridge there is inserted a "null instrument," an indicator consisting of a thermocouple and a sensitive galvonometer.

For a more reliable thermal contact between these cylinders and the heater and cooler, a small depression was made in the heater cylinder and in the cooler tube at the point of contact, the diameter being such that the cylinders penetrated into them with a close fit. The test sample and standard, two cylinders of the same size, are kept in contact with the aid of a metal coupling with a small hole for connecting one junction of a thermocouple; the other junction is in contact with the slide on the thermochord, for which purpose the slide also has a hole. Mechanical contact between these cylinders and the thermochord and the heater and cooler is achieved by means of a set screw. The thermal bridge is handled in the same way as the electrical Wheatstone bridge.

The bridge is balanced by moving the slide along the thermochord. The slide is a sleeve with a pointer. This sleeve is moved along the thermochord by means of a screw. The heat conductivity is calculated from the formula

$$\lambda_x = \lambda_s \frac{l_1}{l_2},$$

where λ_x and λ_s are the heat conductivities of the test and standard semiconductors.

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