MEASURING THE RELATIVE FAST-NEUTRON FLUX DISTRIBUTION IN THE VVR-M REACTOR WITH SEMICONDUCTOR DETECTING ELEMENTS

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Translated from Atomnaya Energiya, Vol. 11, No. 6, pp. 546-547, December, 1961
Original article submitted February 13, 1961

When using reactors to study the effect of nuclear radiation on the properties of a solid it is essential to know the fast-neutron distribution in the experimental channels.

For the relative measurement of the fast-neutron flux the "threshold indicator" method is usually used, using foils of sulfur, phosphorus and aluminum [1], the energy thresholds for which are between 1.5 and 6 Mev.

As well as this fairly simple method there is a method based on the use of the electrical conductivity of semiconductors during bombardment by fast neutrons [2].

When semiconductors are irradiated with fast neutrons crystal lattice defects are formed, the concentration of which is proportional to the integral neutron flux. The appearance of defects leads to a change in the concentration of current carriers, i.e., to a change in electrical conductivity.*

![Graph 1](image1.png)

**Fig. 1.** Dependence of electrical conductivity of n-type germanium on the integral fast-neutron flux.

![Graph 2](image2.png)

**Fig. 2.** Relative fast-neutron flux distribution in the vertical channel of the reflector.

* Crystal lattice defects form during irradiation of semiconductors by fast neutrons with energies exceeding a certain critical value. The critical energy depends on the actual crystal structure of the semiconductor. For example, for germanium $E_{cr} \approx 300$ ev. The defects can also be caused by $\gamma$-quanta, however the number of defects formed by one $\gamma$-quantum ($N_{\gamma} = 1.8 \times 10^{-4}$) [3] is much less than the number of defects formed by a fast neutron ($N_{n} = 1.6$) [4]. Since in the described experiment the $\gamma$-quanta flux (reduced to 1 Mev) was of the same order as the fast-neutron flux, the fractions of defects caused by the $\gamma$-quanta can be neglected.
The dependence of the electrical conductivity of n-type germanium on the integral fast-neutron flux is shown in Fig. 1 [5]. As can be seen from the figure, the electrical conductivity at first changes linearly with the flux.* The rate of change in the electrical conductivity is proportional to the fast-neutron flux intensity, and we used this fact to measure the relative fast-neutron flux distribution in the channels of the reactor in the A. F. Ioffe Physicotechnical Institute, Academy of Sciences, USSR.

The neutron-flux detecting elements were specimens of n-type germanium with a specific resistance of 1 ohm·cm, measuring 10 x 1 x 1 mm. The specimens, in 0.5 mm thick cadmium containers, ** were placed in the vertical channel of the reflector along the height of the active zone at an equal distance from one another.

![Graph showing relative fast-neutron flux distribution](image)

**Fig. 3. Relative fast-neutron flux distribution in the experimental channels of a reactor at the level of the center of the active zone: \( \bullet \) measurements using the activation of gold foils; \( \circ \) measurements using the change in electrical conductivity of germanium.**

![Diagram of reactor channels](image)

**Fig. 4. Arrangement of channels: 1) vertical channels; 2) active zone; 3) water cavity; 4) beryllium reflector.**

The electrical conductivity of the specimens was measured during irradiation by the change in the current intensity with a constant voltage applied to the specimen.

Figure 2 gives the relative fast-neutron flux distribution in one of the vertical channels of the reflector. Figure 3 gives the relative fast-neutron flux distribution in all experimental channels at the level of the center of the active zone. The given distribution was obtained for the arrangement of the active zone of the reactor shown in Fig. 4. For comparison, Fig. 3 gives the curve of the relative resonance neutron flux distribution plotted for the activation of gold foils.

This method can therefore be used for the fairly simple measurement of relative fast-neutron flux distributions for energies above 300 ev.

**LITERATURE CITED**


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* The value of the integral flux up to which the change in \( \sigma \) will remain linear is determined by the initial resistance of the specimen and can reach \( 10^{18} \) neutrons/cm\(^2\).

** The activation of germanium under the action of thermal neutrons causes chemical impurities which also affect the change in electrical conductivity of the specimens.

In our work the measurements were made in channels where the ratio of the thermal-neutron flux to the fast-neutron flux did not exceed 10 and a 0.5 mm thick cadmium screen was sufficient to reduce the contribution of thermal neutrons to the change in electrical conductivity to a value of about 10%.