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Abstract

Full Text

PHYSICS

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EFFECT OF NEUTRON IRRADIATION ON THE MAGNETIZATION CURVE OF SINGLE CRYSTALS OF SILICON IRON

(Presented by Academician I. K. Kikoin, January 3, 1960)

In recent years considerable attention has been devoted to studies of changes in the properties of matter after its irradiation with neutrons. Among the numerous works devoted to investigations of the physical (mechanical, electrical, etc.) properties of matter, there are few works concerning ferromagnetism.

Fig. 1. Hysteresis loops of a silicon-iron single crystal. The curves on the left are in the [001] direction. The curves on the right are in the [111] direction. Solid lines—before irradiation. Dashed lines—after irradiation in a reactor.

The present work is devoted to a study of the effect of neutron irradiation on the magnetization curve of single crystals of silicon iron (3% Si). Investigations on single crystals may make it possible to clarify, at least qualitatively, the influence of neutron irradiation on the course of the processes of displacement of the boundaries of ferromagnetic regions and rotation of the magnetization within them.

The starting material for the study was single crystals of transformer steel, grown as a result of annealing after cold rolling of industrial steel sheets. According to X-ray analysis data for several single crystals, a single crystal was selected in which the axes [001], [011], and [111] coincided with the plane of the sheet to an accuracy of 2-3°. Specimens measuring $70 \times 2 \times 0.5$ mm^3 were obtained by cutting along the indicated crystallographic directions.

The magnetization curves of the specimens were recorded before and after irradiation at room temperature using an astatic magnetometer. During measurements and irradiation, each specimen was kept in an aluminum container. After irradiation, the container with the specimen was placed in a lead cylinder at the center of one of the magnetometer solenoids, in exactly the same position as it had occupied during measurements before irradiation. The lead cylinder served as shielding against the residual γ-radiation of the specimens under investigation. The integral irradiation dose in the reactor was $4.7 \cdot 10^{18}$ n/cm^2. The temperature in the reactor channel was maintained at about 50°.

The measurement results are presented in Fig. 1. As can be seen from the curves, the hysteresis loops of silicon-iron single crystals broaden as a result of neutron irradiation. The relative change in the hysteresis curve for a single crystal magnetized along the [001] direction is considerably greater than along the [111] direction. The coercive force of the single crystal in the [001] direction increased from 0.3 to 0.8 oersted (with an accuracy of ± 0.1 oersted), while in the [111] direction it increased from 1 to 1.2–1.3 oersted. Neutron irradiation apparently affects mainly the processes of displacement of the boundaries between ferromagnetic regions.

The data obtained, which are still preliminary in character, do not yet make it possible to fully clarify the mechanism that caused the change in the magnetization curve. It may be assumed that, at the comparatively high temperatures, the observed changes in the magnetic properties of the single crystals studied are associated chiefly with the appearance of so-called "displacement zones." Further, more detailed experiments will make it possible to refine the existing ideas about the mechanism of crystal-lattice disturbances caused by irradiation with heavy particles.

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Note: Figure translations are in progress. See original paper for figures.