Letters to the Editor

NEW SHORT-LIVED ISOMERS OF RUTHENIUM AND TELLURIUM

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THE experiments were carried out with the extracted beam of a 1-meter cyclotron [1]. "Thick" targets of chemically pure elements were pulse-irradiated with 22 MeV α particles and 11 MeV deuterons. The gamma radiation of the target was detected with a scintillation counter with NaI(Tl) crystal and an FÉU-13 photomultiplier. The decay and the energy spectrum of the induced activity were measured in the intervals between the irradiation pulses with the aid of high-speed analyzers (ten-channel time and five-channel pulse-height). The irradiation and the measurements were programmed in time by means of a special circuit, which controlled the operation of the cyclotron and of the measuring apparatus.

Bombardment of molybdenum with alpha particles disclosed a new activity with $T_{1/2} = 1.84 \pm 0.06$ msec and $E_\gamma = 227 \pm 5$ keV, while bombardment of tin yielded an activity with $T_{1/2} = 104 \pm 5$ msec and $E_\gamma = 284 \pm 5$ keV. The gamma spectrum of the activity produced with a tin target also showed the presence of a weak line with 85 ± 5 keV energy. No other lines were observed in the gamma spectra of these activities in the interval from 50 to 1500 keV.

In order to identify the observed activities, Mo, Ru, and Sn targets were bombarded with deuterons. Bombardment of Ru yielded an activity with $T_{1/2} = 1.84$ msec. On the basis of these data it must be assumed that the activity with $T_{1/2} = 1.84$ msec is due to the decay of an Ru isomer, while that with the activity of $T_{1/2} = 104$ msec is due to a Te isomer.

Some assumptions concerning the mass numbers of the new Ru and Te isomers can be drawn from the following considerations. First, we exclude even-even nuclei from consideration. Second, no activity with $T_{1/2} = 1.84$ msec and $E = 227$ keV was observed following bombardment with 22 MeV gamma quanta [2] and 20 MeV protons [3]; this can be attributed to the relatively low content of the stable isotope from which this activity could be obtained via the (γ, n) or (p, pn) reaction. Consequently, the isomer is probably Ru^{97}. Third, the characteristics of the odd isomers of Te with $A = 119-127$ are well known [4,5]. It is natural to assume that the mass number of the new Te isomer is either 117 or 115. The yield of the activity with $T_{1/2} = 104$ msec was $\sim 1 \times 10^{-7}$, which agrees with the yield of Te^{117} in the $Sn^{114}(\alpha, n)$ and $Sn^{115}(\alpha, 2n)$ reactions from a natural mixture of Sn isotopes, calculated by the procedure proposed by Maksimov [6] and equal to $\sim 6 \times 10^{-7}$.

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LAYERED AND FILAMENTLIKE STRUCTURE OF SUPERCONDUCTING Nb-Zr *AND* Nb-Ti *ALLOYS*

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THE existing theoretical concepts [1] explain well the large critical magnetic fields of superconducting alloys of the equilibrium solid solution type. However, in the case of non-equilibrium alloys, which become stratified under certain conditions, there exists apparently also a different mechanism, connected with the formation of a developed system of continuous thin films or filaments. It is known that the critical magnetic field increases hyperbolically [2] with decreasing thickness of a superconducting film or filament, and can exceed the field of a bulk metal by one or two orders of magnitude [3], and if the number of such thin superconductors is large, the density of the critical current also becomes very large [4]. Such a mechanism was proposed for alloys previously, but without a direct experimental confirmation [5].

In the present communication we present data on electron-microscopic observations of thin films and filamentary systems of tracks in the alloys Nb—25 at .% Zr and Nb—66 at .% Ti. As is well known, these alloys have critical magnetic fields near 10^5 Oe [5] and large critical-current densities (10^4—10^5 A/cm^2) in appreciable magnetic field[5-7]. At high temperatures these alloys are solid solutions with a body-centered cubic lattice (the high-temperature structures of all three metals); they remain in this state also after cooling. However, the alloys are then in a non-equilibrium state, since Zr and Ti have stable modifications with hexagonal lattice below 865 and 882°C, respectively [8]. As is well known, plastic deformation stimulates relaxation of the non-equilibrium state; the equilibrium phases may separate out in regions where the deformation is localized. If the deformation occurs at low temperatures (room temperature or somewhat lower), as is the case when a wire is drawn or a ribbon is rolled from these alloys, then the precipitating phase is extremely finely dispersed (it cannot be resolved by x-ray diffraction). It is known that it is just the plastic deformation which increases very strongly (by one or two orders of magnitude) the critical current density of these alloys. In our case the current density at 16,500 Oe increased to much above the 10^2—10^3 A/cm^2 of the original alloys after passage between rollers at room temperature (reduction in thickness from 2—5 mm to 0.05—0.5 mm). At the same time, the previously noted [5] strong anisotropy is exhibited by the alloy ribbon in a transverse magnetic field of 16,500 Oe; when the field direction is parallel to the plane of rolling, the critical density of the superconducting current becomes equal to (2—4) $\times 10^4$ A/cm^2; when the field is perpendicular to the plane of rolling, the current density is of the order of the current density of the initial alloy. This pertains to both alloys. Annealing (Nb-Zr at 670°C [5]) also increases the critical current density appreciably.

For the electron-microscopic investigation, we prepared ground sections of the samples, both original and rolled. Transverse and longitudinal cuts, and also cut at a very small angle ($\leq 3°$ for Nb—Zr), were made in the rolled samples. The ground sections were subjected to cathode etching, which disclosed quite clearly the microstructure of these alloys. The replicas were of the carbon type with chrome shading. A thin filament-like precipitate structure was observed on the original alloys only in a very small number of pictures. On the other hand, in the case of deformed alloys, even optical metallography of the ground sections (with magnification up to 450) has shown the presence of a developed system of layers.

With increasing magnification, electron optics discloses more and more fine elements in this system. The finest of these can hardly be resolved at the indicated cut angle even with a magnification of 20,000. The alloy contains a whole set of layer thicknesses, the smallest of which amounts to several times ten of angstroms. The layers are only approximately parallel to the plane of rolling and cross each other. Even in the most deformed samples, annealed under optimum conditions [5] and with the largest critical current density, the regions with a developed layer system come in packets, with the greater part of the transverse cross section of the samples not affected by this fine structure. Annealing the Nb-Zr samples at 100°C returns them to practically the initial state alloy with respect to the superconducting parameters (this agrees also with the literature data [5]). The fine structure of the closed paths then breaks up, and they coagulate into crystals measuring up to $\sim 0.1\mu$. These formations also become amenable to x-ray-diffraction investigation—the powder patterns show lines belonging, as in the main bulk of the alloy, to a cubic lattice but with a different parameter. The dependence of the niobium lattice parameter on the zirconium concentration is known [9], so that it is possible to estimate the composition of the precipitated phase—9—10% of zirconium in niobium, that is, practically the solid solution limit [8]. It must be noted that even pure niobium in the form of sufficiently thin films has a critical magnetic field of approximately 10^5 Oe [10].

Thus, it is experimentally demonstrated that the high superconducting parameters of deformed non-equilibrium alloys Nb-Zr and Nb-Ti are due to a well-developed system of thin layers and filaments, formed by precipitation of the indicated phase.

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BAND-STRUCTURE EFFECT ON THE ANGULAR CORRELATION OF ANNIHILATION RADIATION IN YTTRIUM

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A study of the angular correlation of the γ-quanta pairs which appear on annihilation of positrons in a solid gives information on the distribution function of the valence-group electrons in momentum space. However, because of the considerable experimental difficulties only the most general features of this effect have been studied so far. In the present work measurements carried out on yttrium showed certain details in the angular distribution of the annihilation quanta which have not been detected earlier in similar experimental studies.

The measurements were carried out on a sample of polycrystalline yttrium at room temperature. The measurement technique was essentially the same as that described by Green and Stewart.[1,2] The angular half-width of the resolution curve was 0.5×10^{-3} rad.

The direct results of measurements are given in Fig. 1. The ordinate gives the number of γ-quanta pairs recorded per unit time (in arbitrary units), and the abscissa represents the angle θ (which gives the projection of the momentum of a pair of quanta on a given axis z: $p_z = mc\theta$). The dashed curve in Fig. 1 was calculated for the photon angular distribution in the case when the valence electrons in the sample form an ideal degenerate Fermi gas. This curve corresponds to two electrons per yttrium atom and is plotted with allowance for the finite width of the resolution function. Both curves in Fig. 1 are normalized to the same area. The considerable difference between these curves is explained by the annihilation of positrons and electrons in the 4d band. This effect was observed earlier in transition metals of the iron, platinum and palladium groups and in the noble metals.[2-5]

Figure 2 gives on an enlarged scale parts of the experimental curve in Fig. 1. The circles and crosses denote the left-hand and right-hand parts of this curve respectively. Figure 2 shows the local changes in the slope of the $N(\theta)$ curve. Berko[6] detected anisotropy of the annihilation radiation in a single crystal of beryllium at values of the angle θ corresponding to $p_z = \pi/c$ (c is the parameter of the hexagonal close-packed lattice along the sixfold axis). It is evident from Fig. 2 that, in the present case, there is a clear local singularity of the $N(\theta)$ curve at a similar value of θ. It is also possible that the other similar singularities of the $N(\theta)$ curve are related to the influence of the periodic potential of the lattice on the electron spectrum.[5] Clarification of this problem could be obtained from measurements at a smaller angular resolution.

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