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INFLUENCE OF THE PURITY OF SUPERCONDUCTING NIOBIUM ON THE SHAPE OF THE MAGNETIZATION CURVE

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A stretching of the magnetization curve is a characteristic of niobium, the only representative of superconductors of the second type among individual substances. It is important to ascertain the degree to which this property is the consequence of unavoidable contamination with nitrogen and oxygen in the case of niobium, which is a chemically very active metal, and also a consequence of the accompanying tantalum.

The magnetic properties of pure niobium in the superconducting state were investigated in detail in [1], but the investigated samples contained up to 0.0175 wt.% tantalum.

To obtain even purer samples, we used a setup for simultaneous thorough purification of niobium pentachloride and its subsequent reduction to the metallic state [2,3].

The initial $NbCl_5$, containing 0.15% tantalum, was rectified twice in a column with 30 actual plates (the data of the analysis of the rectified $NbCl_5$ are listed in the table), and

Impurities relative to the metal in $NbCl_5$	Analysis method	Sensitivity of analysis method (mass %)	Analysis data (mass %)
Ta	Activation	1×10^{-6} - 1×10^{-7}	2.6×10^{-5}
Si	Spectral	2×10^{-3}	not observed
Al	"	5×10^{-4}	"
Fe	Chemical-spectral	5×10^{-4}	"
Ti	"	1×10^{-4}	"
Bi	"	1×10^{-5}	"
Cd	"	2×10^{-5}	"
Zn	"	5×10^{-5}	1×10^{-5}
Cu	"	2×10^{-6}	1×10^{-5}
Mn	"	5×10^{-6}	not observed
Pb	"	1×10^{-5}	"
Co	"	1×10^{-5}	"
Ni	"	1×10^{-5}	"
In	"	1×10^{-5}	"
W	Chemical	2×10^{-3}	"
Mo	"	5×10^{-4}	"

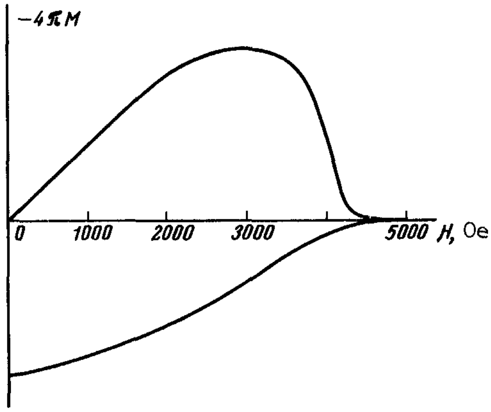

Fig. 1. Magnetization curve of initially not-outgassed wire.

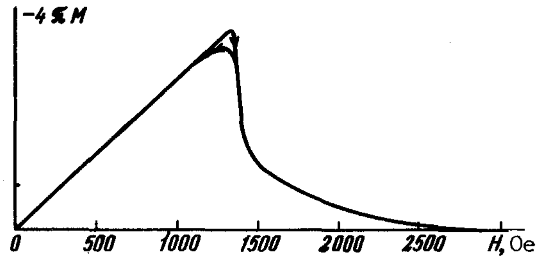

Fig. 2. Magnetization curve of the same wire, outgassed in a vacuum of 5×10^{-11} Torr.

then fed together with hydrogen (molar ratio $H_2/NbCl_5 \simeq 15$) from a thermostatically controlled evaporator into a vessel in which the metallic niobium was precipitated (by the de Boer method) on a U-shaped niobium wire (0.8 - 1.0 mm diameter) or ribbon (8 x 0.2 mm) 600 mm long. At a pentachloride delivery ~50 g/hr, the mass precipitation rate was 10 - 15 g/hr, corresponding to a yield up to 60%. We were able to obtain ~350 g of the metal in one experiment. The precipitate was in the form of well-shaped single crystals with dimensions up to 12 mm.

The niobium crystals were remelted in an electron-beam furnace into an ingot, from which a wire 1 - 0.4 mm diameter was drawn.

The magnetization curves were plotted by a ballistic method in a longitudinal magnetic field at 4.2°K. The sample length-to-diameter ratio was 75.

Figure 1 shows the magnetization curve of the initial not-outgassed wire. We see that the presence of gas impurities and case hardening greatly distort the shape of the curve.

Figure 2 shows the magnetization curve obtained for samples of the same wire as in Fig. 1, but outgassed in a vacuum of 5×10^{-11} Torr.

Thus, at the degree of purification and outgassing attained by us, the niobium retained fully its properties of a superconductor of the second kind.

In conclusion we note that in the purest of our samples the resistance ratio reached 14 000.

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