

s is a consequence of their pressure bomb technique pressures are only high prevents the simultaneously grown. It is worth noting that these authors p) curve near the yield strength.

*Zirconium*

e with three atoms per unit cell<sup>15,16</sup>. similarity it is supposed that its formation e  $\beta$ -Zr (bcc) is diffusionless. It is not yet n the  $\alpha$  phase, too<sup>17</sup>. The transition from between 50 and 60 kbar at room temper- which increases with pressure in  $\alpha$ -Zr, at the transition by about 18%, but in such drop is observed at all<sup>17</sup>. Of the  $\omega$ -Zr only  $T_c$  in the metastable state red before<sup>18</sup>.

essure dependence of  $T_c$  of the  $\omega$  phase influence on the low pressure behaviour, n pressure is comparable to the maximum cell in the tongs, most of the attempts hnikue failed because the cells fractured. experiments, in which the pressure came . In none of them any drop in resist- both samples showed a strongly reduced as an enhanced  $T_c(p)$ , lying distinctly urve for the  $\alpha$  phase. After release of ling at room temperature  $T_c(0)$  of one other sample was damaged on removal

e the  $\alpha$  to  $\omega$  transition, the opposed sponding clamp apparatus did not fit d thus only be cooled in a He<sup>4</sup> dewar. ase transition could not be determined. ailable experimental equipment leaves ssure and temperature, just in the inter-

€/bar for unannealed and  $dT_c/dp=15 \times 10^{-6}$

963).

et. 8, 575 (1960).

Kennedy, G. C.: Phys. Rev. 131, 644 (1963).

man, A.: J. Appl. Phys. 35, 732 (1964).

esting transition region. The observed dependence of the electrical resistance on the pressure was as follows: In a first compression run  $R$  increased until the transition was reached, whereupon it decreased. This drop, however, was in none of the cases as great as could be expected. With further increase of pressure  $R$  decreased slightly. Any sample, once compressed above 55 kbar, showed a monotonic decrease of  $R$  from  $p=0$  up to the highest attainable pressures in each following experiment and a corresponding increase of  $R$  upon lowering of pressure. This behaviour corroborates the observation, that the transformation from  $\omega$ -Zr to  $\alpha$ -Zr is strongly retarded.

The experimental points for  $T_c(p)$  of the  $\omega$  phase can be approximated by a straight line, determined by a least squares fit, with the slope  $dT_c/dp=7.7 \times 10^{-6}$  K/bar. The broad superconducting transitions as well as a small residual resistance ratio of about 8 indicate a highly disturbed state of the samples, but annealing at room temperature is of no influence on  $T_c$ . If the straight line is extrapolated to zero pressure,  $T_c(0)=0.72$  K is found. Although the agreement with the value gained by the piston-cylinder technique\* is good, it should not be overestimated because of the uncertainties of such an extrapolation. It should be noted that our value disagrees with that of Tittmann *et al.*<sup>18</sup> for metastable  $\omega$ -Zr ( $T_c(0)=0.65$  K).

Measurements with zirconium from another stock have been performed. This sample showed an unusually high  $T_c(0)=0.8$  K, but a  $dT_c/dp$  comparable with that of the Koch-Light Zr in the pressure range below 50 kbar. On the other hand, for  $\omega$ -Zr  $dT_c/dp=11.3 \times 10^{-6}$  K/bar, which is distinctly greater than the corresponding value for Koch-Light material. We have no explanation for this at present.

Induced by the high  $T_c(0)$ -values, efforts were made to anneal cold rolled and trimmed samples in an ultrahigh vacuum of  $10^{-10}$  Torr at about 1070 K, a few degrees below the transition temperature into the cubic, high temperature  $\beta$  phase\*\*. If the high  $T_c(0)$  were caused by lattice defects, this procedure should result in a lowering of these values. This was the case ( $T_c(0)=0.5$  K for MRC-Zr after heat treatment), but at the same time the residual resistance ratio was as low as 4, so that a contamination of the samples had to be supposed. This can be understood by the well known gettering properties of zirconium. The slope  $dT_c/dp$  after heat treatment was about twice the previous value of  $3.5 \times 10^{-6}$  K/bar. The lowering of  $T_c$  and raise of  $dT_c/dp$  agrees with the behaviour observed by Brandt and Ginzburg<sup>5</sup> after heat treatment and might suggest that their annealed samples had also been contaminated. Unfortunately, these authors do not report data of their residual resistance ratio.

The correct value of  $T_c(0)$  for Zr is as yet an open question, even though the value 0.55 K is commonly accepted.  $T_c$  is influenced by such phenomena as im-

\* It cannot be stated unequivocally that the sample referred to had totally transformed into  $\omega$ .

\*\* We want to thank Dr. P. Flécher and Mr. R. Vincon, Institut für Experimentelle Kernphysik, Universität Karlsruhe, for the performance of this annealing treatment.