The question of "pressure hardening" and an anomaly in the magnetic properties of CdS

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(Submitted 3 February 1981)

Pis'ma Zh. Eksp. Teor. Fiz. **33**, No. 5, 282–285 (5 March 1981)

A method has been developed for rapid pressure release at rates up to 10^9 bar·sec^{-1}. Experiments on pressure-treated CdS did not reveal the anomalous magnetic properties that have been described in the literature.[1-3] By means of pressure hardening we were able to obtain a superconducting phase in Bi at a normal pressure.

PACS numbers: 74.70.Gj, 85.25. + k

The results of a study of the magnetic properties of CdS samples, which had been pre-treated by "pressure hardening" at room temperature, have been published recently.[1-3] By "pressure hardening" the authors[1-3] mean compression of the sample to 40 kbar and a rapid pressure release at rates in excess of 10^6 bar·sec^{-1}. Some of the CdS samples that had been treated in this manner exhibited, in the opinion of the authors of Ref. 2, an anomalous diamagnetism $\chi_v \sim -0.25/4\pi$ at 77 K, which they were inclined to attribute to a transition of the sample to a superconducting state.

Because a possible existence of superconductivity at 77 K is of great interest, we performed experiments similar to those described in Refs. 1–3. We used the system in Fig. 1 for the pressure hardening. It consisted of a Bridgman anvil (1), to which the force was transmitted via the hardened-steel ring (2). The brittle fracture of the ring at a sufficiently large deformation resulted in the rapid release of pressure at a rate of up to 10^9 bar·sec^{-1} (see Fig. 2). In addition to this method, we employed a manual pressure release of the press. A torsion balance, whose sensitivity was about 10^{-9} emu, was used to measure the magnetic susceptibility. CdS single crystals with $n = 4\times 10^{12}$ cm^{-3} were investigated.

Similarly to what was noticed in Refs. 1–3, the resistance of the samples under pressure decreased sharply, and after the pressure treatment the CdS samples acquired a black color and a metallic luster. The results of x-ray studies showed that a small amount of an unknown phase, which apparently has cubic symmetry, was observed in the pressure-hardened samples, together with the original hexagonal phase. Measurements of the susceptibility χ of several pressure-treated samples did not reveal the anomalous diagmatism that had been observed,[1,2] even though the pressure reached 10^5 bar before its release. The value of $|\chi_v|$ was about 10^{-6} for all samples. We must add that we also did not detect in the CdS samples the anomalously large paramagnetism ($\chi_v > 3\times 10^{-4}$) in fields greater than 300 Oe, as reported by the authors of Ref. 3. The reason for the difference between our results and the data in Refs. 1–3 may be attributed to the fact that the positive effect was observed in Refs. 1–3 only in samples obtained from Alpha Inorganic.

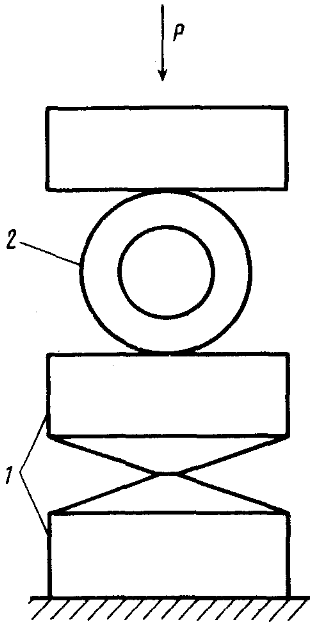

FIG. 1. A device for pressure hardening.

It should be noted, however, that the use of a vibration galvanometer in Ref. 2 does not preclude observations of the diamagnetic effect in a sample vibrating in a magnetic field if, for example, thin metallic loops were formed in it. Such loops can occur with the partial decomposition of the sample into its components.[1)]

We performed experiments on Bi in order to verify the existence of the pressure-hardening effect. To do this, we used a low-temperature press with Bridgman anvils, which make it possible to obtain pressures of the order of 10^5 bar at 4.2 K. The sample resistance was measured by a four-contact method. The Bi sample, which was transferred to the superconducting state and pressure-hardened by the broken-ring method, remained superconducting at a pressure of 1 bar. However, the sample returned to the normal state when the pressure was released slowly. It should be noted that by means of repeated deformation of the Bi sample at 4.2 K we were able to retain superconductivity in the entire sample even when the pressure was released slowly, similarly to

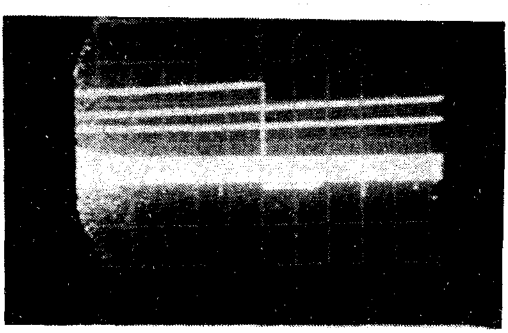

FIG. 2. Resistance of the pressure sensor as a function of time. The scale is 2 msec-/div. The lines of slow increase and rapid release of the pressure are visible.

what was mentioned in Ref. 5.

The results we have presented show that use of the rapid-pressure-release method actually makes it possible to harden the unstable phases, similarly to what occurs during temperature hardening. However, we were unable to observe anomalous magnetic properties in the case of CdS that has been pressure-hardened by the method described above.

The authors thank V. I. Novokshonov and E. P. Khlybov for making the x-ray measurements.

[1)]The precipitation of Cd was observed in Ref. 4 during the fabrication of CdS films.

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Translated by Eugene R. Heath
Edited by S. J. Amoretty