LETTERS TO THE EDITORS

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Determination of the Structure Factor of Thin Tin Films from Superconductivity Measurements

In a recent communication¹ on superconductivity of thin tin films, we mentioned the difference we found between the values for the magnetic threshold, the external field being parallel ($H_{c\parallel}$) or perpendicular ($H_{c\perp}$) to the support of the film (in both cases perpendicular to the direction of the current). We mostly use flattened strips of 'Pyrex' to support the films. Zavaritskii² has also found a difference between $H_{c\parallel}$ and $H_{c\perp}$.

Our films are prepared by condensation in vacuum or by sputtering in argon gas. As we remarked earlier¹, a very pronounced change is obtained for the form of the transition curve (R/R_0 as a function of an external field H) when the current increases. The transition curve becomes very sharp. We have now determined for different films, condensed or sputtered, the magnetic threshold values for $H_{\parallel}$ and $H_{\perp}$ for different values of the current and also as a function of temperature.

Table 1

Date	$R(\Omega)$ at 290° K.	$R(\Omega)$ at 4.2° K.	T (° K.)	Current	$H_{c\parallel}^c$ (Oersted)	$H_{c\perp}^c$ (Oersted)	$H_{c\parallel}/H_{c\perp}$
March 6, 1953	160	53.2	3.64	50 μ A.	320	240	1.33
				50 μ A.	1,650	880	1.87
			2.28	5 mA.	980	520	1.88
				50 μ A.	2,580	1,490	1.73
			1.86	5 mA.	1,900	1,050	1.81
				50 μ A.	2,920	1,860	1.57
				2 mA.	2,560	1,620	1.58
				5 mA.	2,340	1,480	1.58
				10 mA.	2,140	1,380	1.55
March 13, 1953	—	53.2	2.94	10 μ A.	1,390	1,020	1.36
				2 mA.	1,240	860	1.44
			2.26	5 mA.	920	590	1.56
				10 mA.	530	360	1.47
				10 μ A.	2,500	1,610	1.55
				2 mA.	2,090	1,400	1.49
				5 mA.	1,690	1,140	1.48
				10 mA.	1,220	830	1.47
March 20, 1953	—	67.0	2.41	50 μ A.	3,000	1,815	1.65
				2 mA.	2,550	1,440	1.78
				5 mA.	2,130	1,210	1.76
				10 mA.	1,395	850	1.64

In Table 1 are some results obtained with one of our condensed films in vacuum. This film has been measured three times on different dates, with the view of examining its behaviour; for certainly a change in the crystallization has occurred. After the second series of measurements the film was brought into contact with the air, so that an oxidation took place.

From the table we drew the following conclusions: (1) The ratio $H_{c\parallel}/H_{c\perp}$ is approximately constant as a function of current and temperature. Its value is between 1.5 and 1.8. Deviations occur near the transition temperature; but this seems to be due to errors in determining H_c . A small increase only is observed for the second series of measurements. (2) There is only a small variation of the ratio $H_{c\parallel}/H_{c\perp}$ in the different series of measurements in spite of the fact that the specimens have undergone several manipulations.

Fig. 1

For our sputtered films, we obtained for $H_{c\parallel}/H_{c\perp}$, as for our condensed films, constant values as a function of current, but which are larger. Thus we found $H_{c\parallel}/H_{c\perp} = 2$ in most cases, but in other cases a value of 5 was obtained.

The different results obtained can be explained by means of the demagnetizing factor. If we suppose that the layers are composed of flat ideal superconducting ellipsoids, we have $H_{c\parallel}/H_{c\perp} = 1/(1-D)$ with $D = N/4\pi$. Thus we found for our condensed films $D = 0.66$ and for our sputtered films $D = 0.5$ and $D = 0.8$ respectively, which correspond to a ratio m of the axes of 0.3, 0.5 and 0.15 (ref. 3).

On the other hand, pictures were taken of sputtered films (see Fig. 1) in our laboratory, for an earlier publication⁴, by means of the electron microscope. From this picture the equatorial axes of the ellipsoidal grains can be determined; knowing, however, the ratio m from the magnetic measurements the thickness of the grains can be estimated. Thus we have been able to estimate the thickness of the grains shown in Fig. 1. For the largest grains (diameter 120 m μ), we obtained a thickness of 36 m μ , and for the thinnest one 7.5 m μ (diameter 25 m μ). This seems to be a reasonable thickness, taking into account the value of the resistance.

But we may remark that the thickness seems to vary between wide limits.

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¹ Van Itterbeek, A., De Greve, L., Van Gerven, L., and Schepers, J., *Nature*, **171**, 834 (1953).

² Zavaritskii, N. V., *Dokl. Akad. Nauk., S.S.S.R.*, **82**, 229 (1952).

³ Hoselitz, K., "Ferromagnetic Properties of Metals and Alloys", Appendix B (Oxf. Univ. Press, 1952).

⁴ Van Itterbeek, A., De Greve, L., and Van Gerven, L., *Med. Kon. Vl. Acad., Brussels*, **14**, 9 (1952).