Zeitschrift: Helvetica Physica Acta
Band: 62 (1989)
Heft: 6-7

Artikel: The Corbino disk
Autor: Jaggi, R.
DOI: https://doi.org/10.5169/seals-116079

Nutzungsbedingungen
Die ETH-Bibliothek ist die Anbieterin der digitalisierten Zeitschriften auf E-Periodica. Sie besitzt keine Urheberrechte an den Zeitschriften und ist nicht verantwortlich für deren Inhalte. Die Rechte liegen in der Regel bei den Herausgebern beziehungsweise den externen Rechteinhabern. Das Veröffentlichen von Bildern in Print- und Online-Publikationen sowie auf Social Media-Kanälen oder Webseiten ist nur mit vorheriger Genehmigung der Rechteinhaber erlaubt. Mehr erfahren

Conditions d'utilisation
L'ETH Library est le fournisseur des revues numérisées. Elle ne détient aucun droit d'auteur sur les revues et n'est pas responsable de leur contenu. En règle générale, les droits sont détenus par les éditeurs ou les détenteurs de droits externes. La reproduction d'images dans des publications imprimées ou en ligne ainsi que sur des canaux de médias sociaux ou des sites web n'est autorisée qu'avec l'accord préalable des détenteurs des droits. En savoir plus

Terms of use
The ETH Library is the provider of the digitised journals. It does not own any copyrights to the journals and is not responsible for their content. The rights usually lie with the publishers or the external rights holders. Publishing images in print and online publications, as well as on social media channels or websites, is only permitted with the prior consent of the rights holders. Find out more

Download PDF: 07.01.2026

ETH-Bibliothek Zürich, E-Periodica, https://www.e-periodica.ch

THE CORBINO DISK

R. Jaggi, IBM Research Division, Zurich Research Laboratory
CH-8803 RÜSCHLIKON, Switzerland

Abstract: The electrostatic field distributions in Corbino disk and film geometries have been investigated within the framework of a hydrodynamic model. Owing to the absence of space charge, the Corbino disk allows a simple treatment of this problem. The thickness dependence of the effective conductivity is derived and compared with recent experimental data for thin $CoSi_2$ films.

We analyze transport phenomena within the framework of an electron-fluid model in which the Navier-Stokes equation and Maxwell's equations lead to a generalized Ohm's law [1]. After linearization we obtain for stationary conditions and zero magnetic field the symmetric relation between current density **J** and electric field **E**

$$\mathbf{J} - \alpha^{-2}\Delta\mathbf{J} = \sigma_0 (\mathbf{E} - \delta^{-2}\Delta\mathbf{E}) \quad , \tag{1}$$

where $\sigma_0 = N_0 \dfrac{e^2\tau}{m}$ = bulk conductivity

with N_0 = electron concentration
e = electron charge
m = effective mass
τ = relaxation time

$\alpha^{-1} = \left(\dfrac{\eta\tau}{N_0 m}\right)^{1/2}$ = adherence length

with η = viscosity coefficient

$\delta^{-1} = \left(\dfrac{\varepsilon_0 \varepsilon \zeta}{N_0 e}\right)^{1/2}$ = Debye length

with $\varepsilon_0 \varepsilon$ = permittivity
ζ = electrochemical potential.

Exact solutions of equation (1) can be easily derived for simple geometries. The Corbino disk (inner and outer radius a and b, thickness $d = 2z_0$) allows an especially simple formulation since no space charge occurs. In short, we obtain for the conductance in the entire range of $z_0 = d/2$

$$G(z_0) = 4\pi\sigma_0 \frac{z_0}{\ln \frac{b}{a}} \left[1 - \frac{\tanh \alpha z_0}{\alpha z_0} \right] .$$

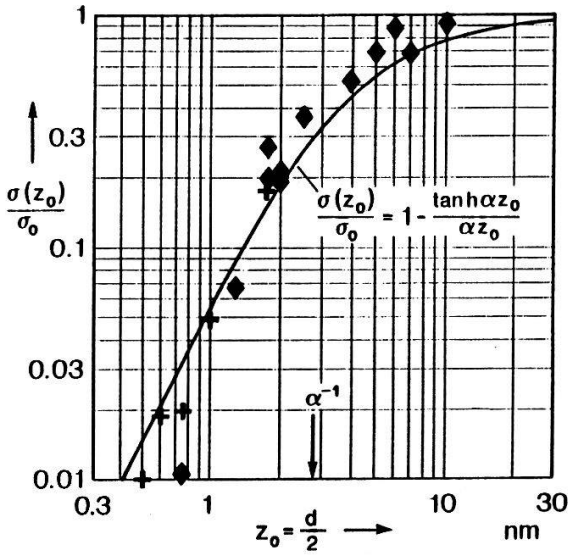
If we define an effective conductivity

$$\frac{\sigma(z_0)}{\sigma_0} = \frac{G(z_0)}{G(z_0 \to \infty)} = 1 - \frac{\tanh \alpha z_0}{\alpha z_0} ,$$

we obtain within the limits of thin and thick samples, respectively,

$$\alpha z_0 \ll 1: \quad \frac{\sigma(z_0)}{\sigma_0} = \frac{\alpha^2 z_0^2}{3} ,$$

$$\alpha z_0 \gg 1: \quad \frac{\sigma(z_0)}{\sigma_0} = 1 - \frac{1}{\alpha z_0} \quad \text{(Nordheim rule).}$$



The effective conductivity above is also a first approximation for the case of a rectangular plate of thickness $d = 2z_0$. As shown in the figure, this conductivity represented by the solid line is found to fit experimental data (total conductivity $\sigma(z_0)$ at $T = 4.2$ K normalized by the bulk residual conductivity $\sigma_0 = 4.255 \times 10^7\ \Omega^{-1}\mathrm{m}^{-1}$) of thin $CoSi_2$ films [2] for a value of the adherence length $\alpha^{-1} = 2.4$ nm.

We are now investigating the significance of our phenomenological approach (1) as compared to microscopic quantum-mechanical approaches [3].

References

[1] R. Jaggi, Helv. Phys. Acta 53, 257 (1980).

[2] J.Y. Duboz, P.A. Badoz, E. Rosencher, J. Henz, M. Ospelt, H. von Känel and A. Briggs, Appl. Phys. Lett. 53, 788, (1988).

[3] G. Fishman and D. Calecki, Phys. Rev. Lett. 62, 1302 (1989).