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Templated electrodeposition of indium nanowires and measuring their electrical resistance

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Nanowires are of great scientific interest, both from the point of view of fundamental science and application. For instance, superconducting nanowires serve as elements of a Josephson junction, which is an important component of superconducting and quantum microelectronics, which has been actively developing in recent years. The key areas of development of superconducting microelectronics are increasing the breakdown current and stability in air, as well as increasing the operating temperature and sensitivity to a magnetic field. Indium is a promising material for solving these problems. Due to geometric parameters of nanowires, they exhibit physical properties that are not typical for bulk materials. However, the electrical resistance of indium nanowires has not been measured yet.

Obtaining arrays of indium nanowires by template electrodeposition into a template of anodic aluminum oxide is one of the most effective synthesis techniques since it allows the formation of ordered arrays of cylindrical nanowires with tailored geometric parameters (diameter and length).

In this work arrays of indium nanowires with diameters of 40 nm, 50 nm and 200 nm were fabricated. The technique was proposed for measuring the resistance of single nanowires without removal from the template based on I-U curve analysis. By sweeping the potential up to 1 V, it is possible to register discrete current jumps corresponding to the sequential burnout of nanowires inside the template. This phenomenon allows one to calculate the resistance of a single nanowire (figure 1).

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The experimental data were described by the theoretical Fuchs-Sondheimer model:
$\frac{\rho}{\rho_0} = 1 + \frac{3}{4}(1-p)\frac{l_e}{d}$
where ρ_0 is the resistance of a normal material, ρ is the fraction of electrons that are secularly reflected from the surface, d is the width of the wire, l_e is the mean free path in the bulk material. Based on the approximation the electron free path in a bulk indium was estimated to 57 ± 5 nm.

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