Atom-Size Contacts and Gaps Between Electrodes Fabricated by Electrodeposition

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Abstract:

Continued advances in nanoscience and nanotechnology demand new methods to fabricate various nanostructured materials and devices. We describe a self-terminated electrochemical method to fabricate atomic-scale contacts and gaps between two metal electrodes. The conductance of the contacts varies in a stepwise fashion with a tendency to quantize near the integer multiples of $2e^2/h$ (G_0), a phenomenon that has been observed in metallic nanowires fabricated by both mechanical [1] and electrochemical methods [2]. Proposed applications of the contacts or nanowires include digital switches and chemical sensors. The conductance of the gaps is determined by electron tunneling. Electrodes separated with such a gap may be used to connect a small molecule to the external world, but fabricating such electrodes is beyond the reach of conventional methods. Several unconventional methods, including mechanical controllable break junction [3], electromigration [4] and electrochemical methods [5], have been reported. While each approach has its advantages, a simple and reliable method to fabricate a stable nanogap is still highly desired. Our method uses a directional electro deposition process. The final contact size and gap width are preset by an external resistor (R) that is connected in series to one of the electrodes. If 1/R is comparable or greater than the conductance quantum ($2e^2/h$), a contact with conductance near a multiple of $2e^2/h$ is fabricated. If 1/R is much smaller than $2e^2/h$, a small gap with conductance determined by electron tunneling is formed.

References:

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