# Time and cross-correlation histograms in conductance measurements of atomic nanowires

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The quantum effects occurring in nanowires with quantum point contact (QPC) can be useful in novel electronic circuits of nanometer dimensions. The QPC occurs when the width of the nanowire at its neck is comparable to the Fermi wavelength [1]. In the nanowire with a QPC the electrical conductance results from independent electron wave modes, referred to as conductance channels, contributing to the electron transport, and can be described by the Landauer formula. Its value strongly depends on particular atomic arrangement in a QPC. Typically fabricated by means of a scanning tunneling microscope and a mechanically controllable break junction, nanowires with QPC have also been produced in relays and between macroscopic wires. In each case, the QPC is achieved by pulling a previously formed nanowire. Obtained while the nanowire is being pulled, conductance versus time plots (conductance traces) reveals steps, which result from the closing of consecutive conductance channels as the nanowire narrows down. As the process of nanowire pulling is by its nature not fully reproducible, conductance histograms are constructed from a large number of conductance traces providing the conductance histogram maxima. The conductance values of maxima do not correspond to integer numbers of the quantum conductance since the conductance depends on the exact atomic and crystallographic structure as well as on the exact electronic structure of the whole nanocontact [2]. Usually, only some of the particular atomic arrangements appear consecutively one after the other during breaking of nanowires forming particular history of breaking. That rises following questions about possible correlation between different arrangements: whether the presence of one particular arrangement determines the appearance of a different one that is correlated with the first one, or on the contrary, whether some arrangements never follow some of the previous arrangements; whether the fluctuations of plateaus' positions of different atomic arrangement are correlated. In order to answer these questions we develop a new type of time- and cross-correlation analysis [3] of the preferred conductance values depicted in the form of the 2D density plots that provide new type of information on a few-atomic-nanocontact formation dynamics. Furthermore, the correlation analysis can resolve fine structures related to different atomic configurations, which are covered by uncorrelated noise in the usual conductance histogram. The study of time correlations is a useful tool for tracing some transient effects during tuning of external parameters such as concentrations of molecules dosed to the junction [4], temperature, voltage etc. It also demonstrates that in some materials successive traces are not independent showing some history of the QPC environment evolution. These novel types of analysis can provide new information on correlation between different atomic arrangements formed consecutively during the formation and breaking of contacts in the metallic nanowires, that allow for more detailed comparison with advanced theoretical simulation of the formation of atomic QPCs.

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