Electrochemical potential controlled electron transport in conducting polymer nanowires

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Conducting polymers are attractive for electronics applications because of their high electrical conductivity and mechanical flexibility. Fabrication of conducting polymer nanowires and measurement of the conductance of the nanowires are, therefore, long-sought goals. Conducting polymer nanowires have been fabricated using etched ion tracks in membranes or pores in zeolites as templates, but determining the conductance of each of the nanowires has been a challenge. Here we report an approach to fabricate conducting polymer (polyaniline) nanowires and measure the conductance of each nanowire. We start from an array of Au nanoelectrode pairs with gap from 20 to 80 nm in between on an oxidized Si substrate by electron beam lithography and optical lithograph. We then further reduce the gap by electrochemical deposition of gold based on the phenomena of electron tunneling [1]. After forming a gap of a few nm or less, we deposit polyaniline onto the nanoelectrodes by sweeping the electrochemical potential of the nanoelectrodes in aniline solution. When a polymer strand growing on one nanoelectrode reaches the second one, the current begins to flow across the gap and we stop immediately the deposition process. We have studied the electron transport through the polymer strand as a function of the electrochemical potential after removing aniline from the solution. For thick polymer strands, the conductance vs. the electrochemical potential plot has a bell shape with a maximum located at a potential of partial oxidation, which agrees with previous studies on macrowires. However, decreasing the polymer strands to the molecular scale, the smooth bell curve is replaced by an abrupt step change which shows that the conductance can be switched on and off abruptly by the electrochemical potential.

Ref. [1] C. Z. Li, H. X. He. N. J. Tao, *Appl. Phys. Lett.* 2000, 77, 3995