Controllable Synthesis of Single Conducting Polymer Nanowire on electrodes Fabricated by Focused Ion Beam Milling

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Conducting polymers have received considerable attention because of their unique physical and chemical properties and potential applications such as solar cells, supercapacitors, chemical and biosensors. Among all kinds of conducting polymers, polypyrrole (PPy) is one of the best candidates for biosensors at its benign polymerization conditions and biocompatibility. Electropolymerization is one of the most widely used methods to fabricate PPy nanowires, especially in the case of device fabrication [1]. The morphology of PPy nanowires synthesized by electropolymerization, however, is usually disordered nanowire network. To fabricate sensors based on PPy single nanowire, the ability to fabricate well aligned and addressable PPy nanowires is of essential importance, which will consequently promote the sensing property of nanowire-based sensors.
In this work, we aim to control the position, alignment and quality of single PPy nanowire on nanoelectrodes by a combination of top-down and bottom-up methods. The electrode-pairs were fabricated by conventional photolithography and followed with a focused ion beam (FIB) milling. Nanoelectrode-pairs with tips and gap both in nanoscale were fabricated by FIB milling. Subsequently, a drop of pyrrole containing electrolyte was placed onto the electrode-pair region. The electropolymerization of PPy nanowire was carried out using a VMP3 potentiostat/galvanostat workstation. Three-electrode setup, one tip as working electrode while another tip as counter electrode and reference being a Ag/AgCl electrode, was used to fabricate single PPy nanowire between two electrode tips. Chronoamperometry techniques with 20 nA current between the working and counter electrodes were used to synthesize single PPy nanowire. As shown in Figure 1a, single PPy nanowire was precisely deposited bridging the electrode-pair. Typical current-voltage measurement of as-synthesized single PPy nanowire was carried out at room temperature (Figure 1b) and the sensing property of PPy to hydrogen chloride gas was investigated.

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[1] S. Sadki, P. Schottland, N. Brodie, and G. Sabouraud, Chem. Soc. Rev. **29**, 283 (2000).

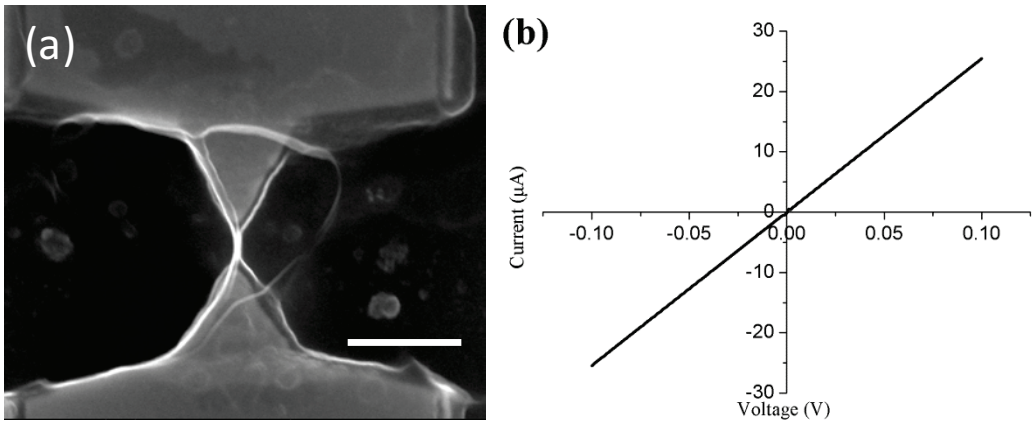

Figure 1: (a) SEM image of single PPy nanowire between the tips of electrode-pair. Scale bar is 500 nm. (b) Typical current-voltage measurement of as-synthesized single PPy nanowire in a two-terminal device in air at room temperature.