Electrochemical Growth and Characterization of Conducting Polymer Nanowires Array

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Individually addressable conducting polymer nanowires of polypyrrole, polymethylpyrrole and polyaniline were grown under galvanostatic conditions. The facile electro-oxidation reaction of the monomers on microfabricated gold electrodes resulted in the formation of a conducting polymer nanowire. The growth was monitored using chronopotentiometry and resistance changes. The successful formation of the conducting polymer nanowire was demonstrated by electrical and optical characterizations. Specifically, the current-voltage measurements, demonstrate the ohmic contact established between the polymer nanowire and the gold electrode. Optical imaging and scanning electron microscopy was used to observe the nanowires. Dimensional control was achieved for 1μm, 500 nm, 200 nm and 100 nm wide and 2-15 μm length of the polymeric nanowires. The electrochemically grown nanowires are stable under ambient conditions and individually addressable in multi-electrode "arrays". Nanowires of the same or different polymers could be grown on adjacent electrodes. The nanowires afford entrapment of biologically functional material within their structure, for biosensor applications.

Figure 1 shows the chronopotentiometric profile obtained during the growth of a polyaniline nanowire between microfabricated gold electrodes. Upon impressing a 100 nA current step the potential achieves a stable value of around 2.5 V and stabilizes at this value for about 150 s and shows a sudden drop to –0.5 V and tends towards 0.0 V with continued deposition. The observation of the drop is indicative of a nanowire formation and this has been verified by SEM (figure 2) and by recording the I-V characteristics (figure 3) of the nanowires following growth. The deposition process is carried out using a probe station, by placing a 2 μL drop of the monomer solution on the surface of the microfabricated gold electrodes on silicon wafers, prior to deposition. Electrical contact with the electrodes was established by using metal pins attached to micromanipulators and live imaging using a CCD camera.

Following growth the electrical stability under ambient conditions of the polymer nanowires of polypyrrole, polyaniline and poly(methylpyrrole) are found to be excellent for at least 10 hours. In addition, the polymer nanowires are confined within the channel between the gold electrodes and show minimal dendrite formation. Several other parameters pertaining to growth and conductivity of such conducting polymer nanowires have been investigated. Their response to varying pH was also investigated.

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References:

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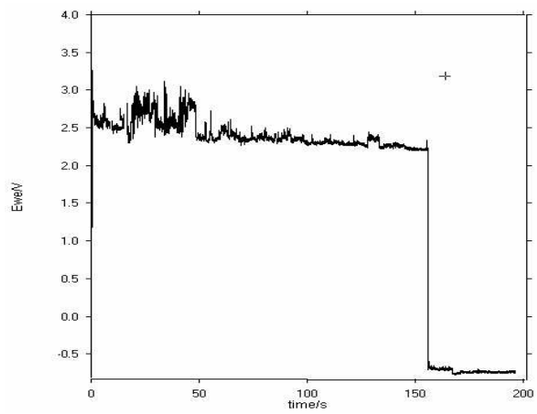

Fig.1: Chronopotentiometric recording during growth of a 100 nm wide and 2 μm long poly -aniline nanowire between gold electrodes.using a 100 nA current step upto 200 s.

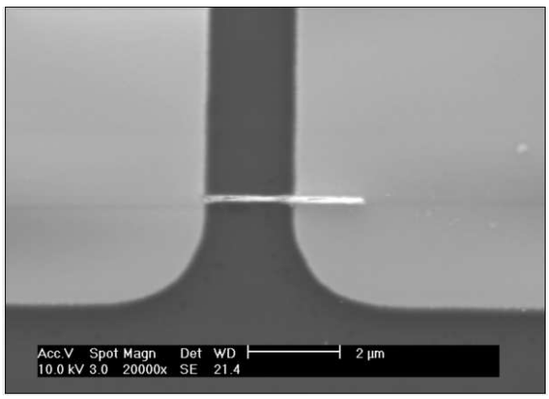

Fig.2: SEM image of a polyaniline nanowire at 20000X magnification.

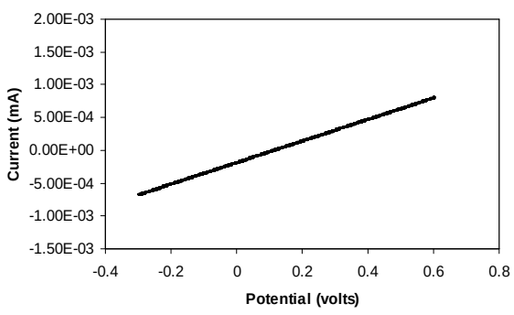

Fig.3: Current-Voltage profile of a 100 nm wide polyaniline nanowire at 50 mV/s from -0.3 to 0.6 V.