Current-driven structural transitions in suspended Pt/C nanowires grown by EBID

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Electron beam-induced deposition (EBID) [1] performed by lateral shift of the beam from an elevated edge is a powerful method to obtain suspended nanowires (SNWs), [2] because of the lack of secondary emissions from the substrate. Here we will show an in-situ electrical characterization of Pt/C SNWs by means of a two-probe system and live SEM video recorded during the I-V measurement. TEM analysis of the transformed SNWs will be also presented.

SNWs about 20nm in diameter, are connecting the tips of Pt/C pillars grown on opposite Au electrodes, patterned by FIB-lithography on a thin membrane. The gap between the electrodes (200-600nm wide), below the SNW bridge, is realized by opening a slit into the membrane in order to enable TEM observation of the wires and to avoid on-substrate deposition (Fig. 1a).

I-V measurements within a range of few hundreds of mV show an ohmic behavior, with typical resistivity of about 8-10 x 10^{-5} Ω m. As the voltage range exceeds 1 V, current departs from the linear trend, Fig. 1b, and structural evolution becomes dramatically evident. Transition consists of a sudden coalescence of the Pt nanocrystals (from 2-3nm to 20nm), separated by even wider gaps, embedded within the carbonaceous matrix.[3] When voltage is further increased, migration of the grains from the centre of the SNW to the ends is observed, transforming the SNWs in carbonaceous structures (Fig. 2). After this evolution SNWs can carry currents up ~ 50 – 80 μA, corresponding to current densities of the order of 10^7 A/cm^2, and when they eventually brake they remain stiff. Similar electrical characteristics have been reported in literature for amorphous carbon wires [4] undergoing transition to graphitic phase by the injection and alternated motion of metal nanoparticles. TEM observation of the transformed SNWs shows sheet-and ring-like structures consistent with a graphitization-like process (Fig.3).

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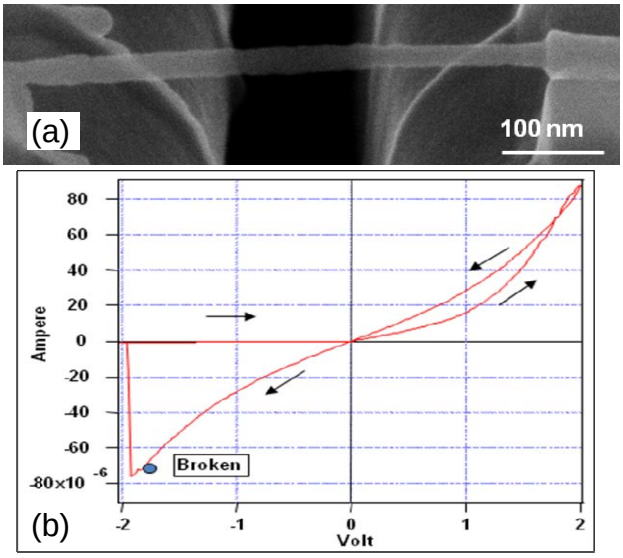

Figure 1. (a) SEM images of an as deposited SNW. (b) I-V cycle measured in situ.

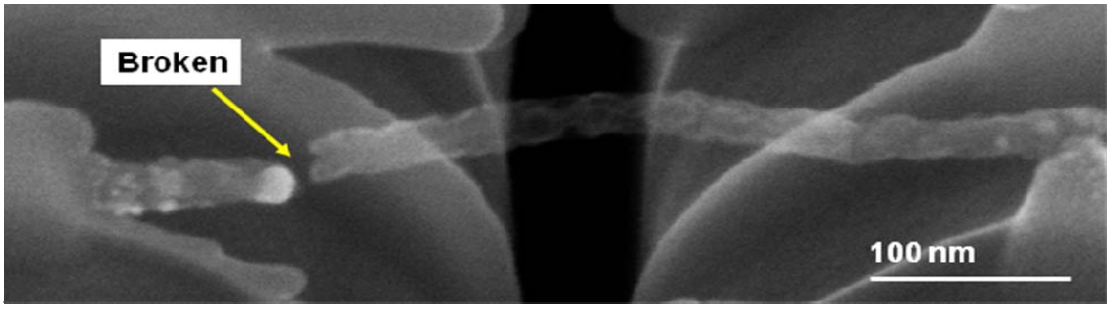

Figure 2. SEM image of a SNW after migration of the grains from the centre to the ends, transforming the SNW in carbonaceous structures.

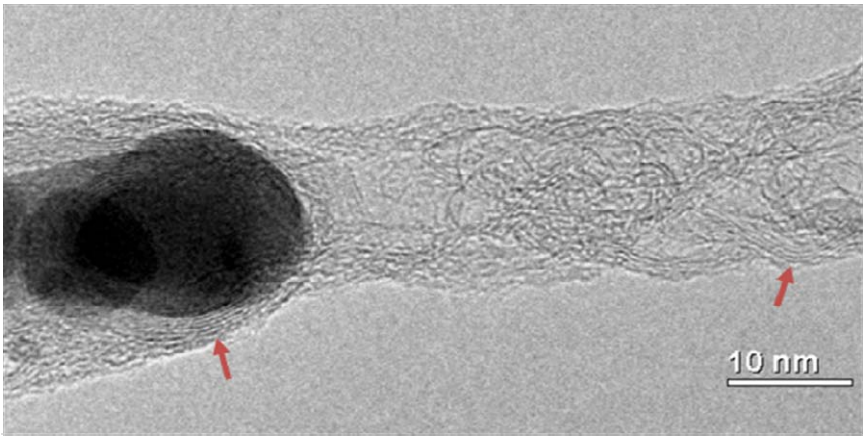

Figure 3. TEM image of the transformed SNWs showing sheet-and ring-like structures consistent with a graphitization-like process.

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