In-situ TEM Probing of Nanomaterials

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Abstract

Nanomaterials because of their small size, may have special properties unlikely to be seen in ordinary types of materials. Nanomaterials like nanotubes, nanowires and nanoparticles are best studied at the nanoscale, vital but also problematic. In this thesis we use a transmission electron microscope (TEM) combined with a scanning tunneling microscope probe. This system allows TEM images to be captured and recorded into a movie together with recorded electrical data for real time analysis.

Using this method we found that the electrical conductivity of molybdenum based nanowires $Mo_6S_3I_6$ can be improved by current induced transformation. This might be a general method of improving nanowires which is of high value if the wires are to be used in electrical circuits or field emission devices. The bending modulus for these nanowires were also determined, by an electromechanical resonance method, to 4.9 GPa.

The sintering phase of silver nanoparticles, used in electrical conductive ink for printing electrical circuits, were studied by the in-situ TEM probing method. We observed that percolation path ways are formed and that the dispersive agent of the particles can be pyrolysed into a net of carbon with characteristics similar to graphite.

We also developed a method for decorating nanowires and nanotubes with gold nanoparticles. Nanowire particle composites are often used in assembling more complex devices (electronic circuits) or for linking to organic molecules (biosensor applications) and existing particle decoration methods are either difficult or with low yield. By in situ TEM probing we found that carbon nanocages can be grown onto these gold nanoparticles. The size of the gold nanoparticles is controllable an thus the size of the nanocages. These nanocages may be used in medicine- or hydrogen storage-applications.

Keywords: nanotechnology, in situ, TEM, probing, nanowires, nanoparticles, ink