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# Ni, Cu Nanoparticles Decorating CNT as Precursors for Metal-Matrix Nanocomposites

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The increasing interest in nanostructure materials in recent years has provided incentive to develop new kind of composites containing carbon nanotubes (CNT). Such motivation relies on the well-established superior mechanical and transport properties of CNTs and their stability when submitted to thermo-mechanical processing together with the metal powder [1,2,3,4,5].

This work reports nano-scale structural characterization of Ni and Cu decorating CNT synthesized by chemical method. The former was produced by dissociation of a homogeneous suspension containing $Ni(NO_3)_2$. $3H_2O$ – MWCNT and the older was produced by dissociation of a homogeneous suspension containing $Cu(NO_3)_2$. $3H_2O$ – 2wt% SWCNT with an anionic tensoactive and $Cu(NO_3)_2$. $3H_2O$ – 2wt%MWCNT; followed by hydrogen reduction of the obtained NiO-MWCNT and CuO-SWCNT product.

Transmission Electron Microscopy and STEM EDS has been used as main characterization tools. The former have shown a good attachment, with measurable dihedral lower angle, of the Ni and Cu nanoparticles on to CNT, brought about by the *insitu* dissociation and reduction procedure of the metal nanoparticles together with the CNTs, as shown in figure 1. The later has confirmed, trough elemental mapping, the presence of Ni, C and some residual O, as shown in figure 2. The Ni powder particles were observed to be in the 4-40nm range, while the Cu powder particles were observed to range between 50-300nm in diameter. HREM images, such as Fig. 1a, reveal that oxygen is actually coating the Nickel particle, thereby suggesting it arises from an post -oxidation stage, rather than due to an incomplete NiO particle reduction.

Bulk Cu-SWCNT nano-composite pellets have been obtained by cold pressing under uniaxial pressure at 60 MPa, followed by isostatic pressure under 150MPa. Sintering of the compacted material was carry out at 650°C under Argon atmosphere for 15 min. Ours observations have also shown a heterogeneous grain growth of Cu-CNT pellets with sizes between 150nm -3μm. Low temperature electric resistivity measurements, show that the nanocomposite material exhibit a lower value ($2x10^{-6}$ Ω.cm) at 83 K as compared with copper pellets produced to the same route, however without CNT ($6x10^{-6}$ Ω.cm). Hardness and elastic modulus were determined trough nanoindentation measurements. The composite displayed higher hardness (1,7GPa) compared with copper (1,2GPa) (see figure 3). Similar values were reported by J.P. Tu et al [5]. Hot compactation, variation of volume fraction and properties measurements are currently in progress.

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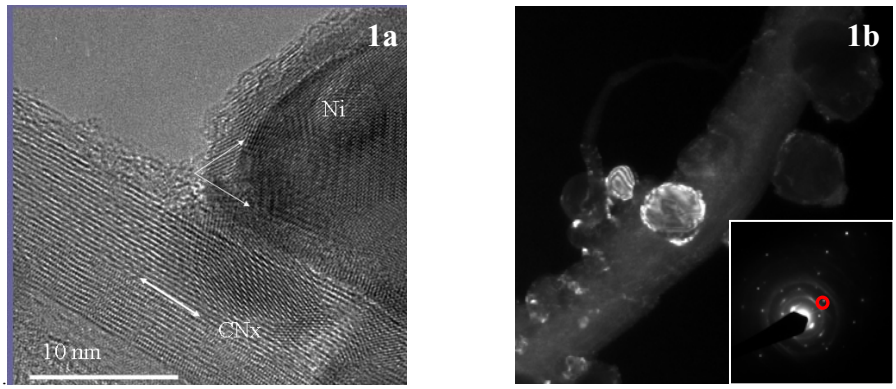


**Figure 1: a)** High Ressolution TEM image of Ni nanoparticle attached onto CNT **b)** Center dark field and diffraction pattern of Cu-MWCNT.

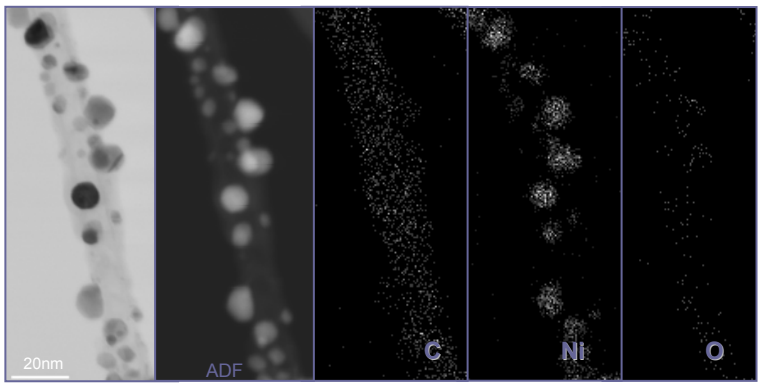


**Figure 2:** Bright field / Annular dark field STEM images and elemental mapping of Ni nanoparticles decorating MWCNT.

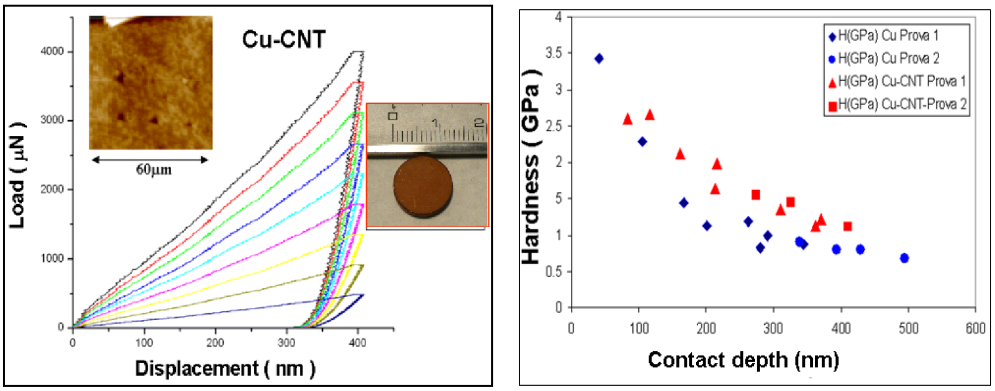


**Figure 3**. Hardness evaluated by Nanoindentation of a Cu-SWCNT nanocomposite

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