Air-stable monocrystalline nickel nanorods and Ni-CNT hybrids for aeronautical applications

Glenna L. Drisko,[1] Pier-Francesco Fazzini,[2] Anne-Françoise Mingotaud,[3] Brigitte Caussat,[4] Emmanuel Flahaut,[5] Pierre Fau,[1] Myrtil Kahn,[1]

1. Nanochemistry, Organisation and Sensors, Laboratoire de Chimie de Coordination, BP 44099, 205 route de Narbonne, 31077 cedex 4, Toulouse, France.
2. Laboratoire de Physique et Chimie des Nano-objets, Institut National des Sciences Appliquées, 135 ave de Rangueil, 31077 cedex 4, Toulouse, France.
3. Laboratoire des Interactions Moléculaires et de la Réactivité Chimique et Photochimique, Université Paul Sabatier, Bâtiment 2R1, 118 route de Narbonne, 31062 Toulouse, France.
4. Laboratoire de Génie Chimique de Toulouse, Campus INP-ENSIACET, 4 allée Emile Monso, CS 84234, 31432 cedex 4, Toulouse, France.
5. CIRIMAT-LCMIE, Université Paul Sabatier, Bâtiment CIRIMAT, 118 route de Narbonne, 31062 Toulouse, France.

glenna.drisko@lcc-toulouse.fr

Abstract

Nickel-carbon fiber-reinforced composites are of interest for aerospace vessels to increase the electrical conductivity of the light weight material, thus diminishing the risk of damage from electromagnetic radiation, electrostatic discharge and lightning strikes. Nickel nanowires and hybrid nickel-carbon nanotube materials are suitable nanostructures to ensure high conductivity at low mass loading.

Monocrystalline nickel structures have even better conduction properties than the polycrystalline equivalent due to possessing less particle-particle junctions [1]. We have developed a solution-based method that produces monocrystalline nickel nanowires *via* decomposition of metal-organic precursors in the presence of self-assembled surfactants. The resulting wires are approximately 20 nm wide by 1.5 µm in length. The nanowires have a morphology consisting of semi-flattened rods with pyramidal ends. Despite the changing dimensions between the nanorod body and its head, there was no disruption in the crystallographic orientation, as observed with HRTEM and diffraction patterns (see figure).

The nickel nanostructures were exposed to air for several weeks, but no oxidation was detectable by magnetic measurement, *i.e.* the saturation magnetization corresponds to Ni^0 and no bias is observed in the hysteresis loops. It seems that the long alkyl chain amine surfactant, in addition to being a structuration agent, remains at the surface of the Ni wires after washing and acts as a protective layer. The distribution in the magnetic field along the Ni nanowire was imaged using magnetic force microscopy. It shows that one Ni wire is a magnetic monodomain.

Routes to prepare hybrid nickel-CNT materials were explored using chemical vapor deposition in a fluidized bed, solution chemistry and dry preparation in a Fisher-Porter reactor. Different nickel compositions and material morphologies resulted, depending on the preparation technique.

The nickel nanorods and hybrid materials were incorporated into carbon fiber-reinforced polymer composites. The electrical conductivity as a function of wt% loading was measured, showing promise for these materials in discharging electrostatic charges.

References

[1] Perry, N. H.; Mason, T. O. *Solid State Ionics* **181** (2010) 276.

Figure. Anisotropic monocrystalline nickel nanorod