IMAGINENANO 2020 ONLINE

SEPT 29 – OCT 01, 2020

Bringing together Nanoscience & Nanotechnology

Synthesis of Carbon Nanotubes at Atmospheric Pressure for Supercapacitor Applications

Islam Alshaikh[1,2] , Ruairi McGlynn[3], Paul Brunet[3], Roger Amade Rovira[1,2], Enric Bertran-Serra[1,2], Davide Mariotti[3].

[1]Dep. Applied Physics, Universitat de Barcelona, C/ Martí i Franqués 1, 08028 Barcelona, Spain.

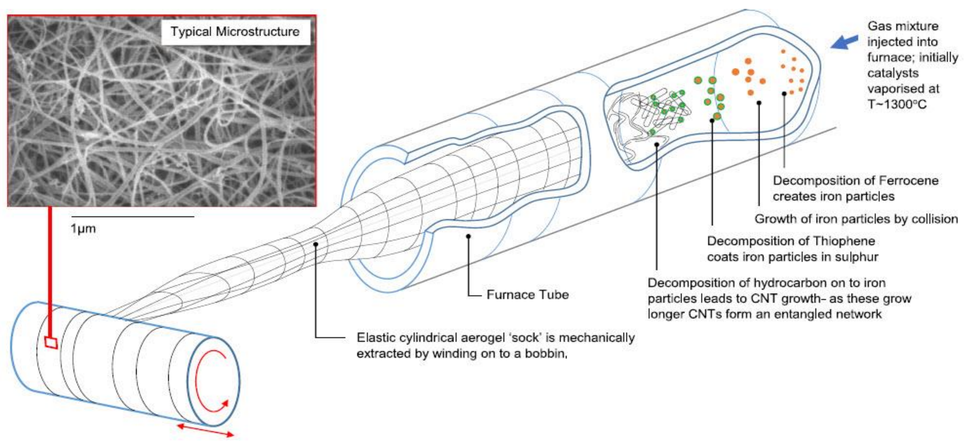
[2]ENPHOCAMAT-FEMAN Group, Institute of Nanoscience and Nanotechnology (IN2UB), Universitat de Barcelona

[3]Mariotti Research Group, NIBEC, Ulster University, Jordanstown, BT37 OQB, Nothern Ireland, United Kingdom.

Abstract

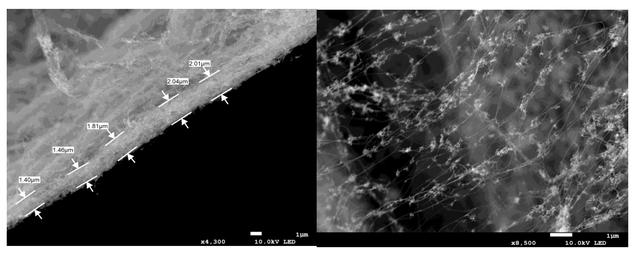
Scalable and qualitative synthesis of carbon nanotubes (CNTs) is a challenge for industrial use. In this work, the floating catalyst chemical vapor deposition (FC-CVD) process was used which allows the continuous growth of CNTs in a free-oxygen atmospheric pressure ambient from a floating-catalyst at high temperature above 1200^{0}C. Ferrocene ($C_{10}H_{10}Fe$) was used as a catalyst source and methane (CH_4) as a carbon source while thiophene (C_4H_4S) was used as a sulphur source to affect the carbon diffusivity at the surface of catalyst. Scanning electron microscopy (SEM), transmission electron microscopy (TEM) and Raman spectroscopy were used to characterize the CNTs. NiO_x nanoparticles where synthesized using plasma-liquid interaction process using helium (He) plasma and ethanol as an electrolyte. The CNTs were dispersed in the electrolyte with suspended nanoparticles and then it was sprayed over a graphite substrate to be used as electrochemical electrode.

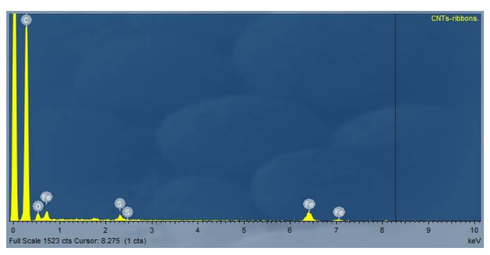
Synthesis of CNTs using FC-CVD



The setup used to obtain continuous CNTs mats which explains the steps starting from the injection of ferrocene, methane, and thiophene at a temperature above 1200C. [3]

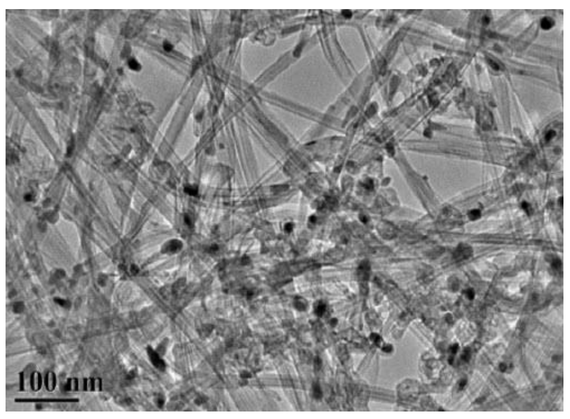
CNTs morphology

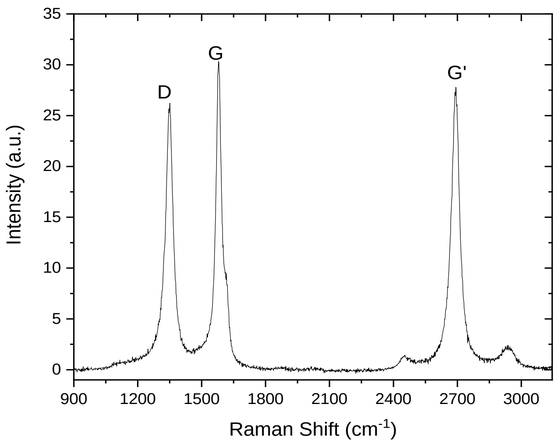




Characterization of the morphology of the CNTs using: (a,b) SEM which shows the thickness of the CNTs mat which ranges between 1.40 um and 2 um. (c) EDS for microstructural analysis which shows short peaks of iron (Fe) which comes from the ferrocene and sulfur which produced from the decomposition of thiophene.

CNTs characterization using TEM and Raman Spectroscopy



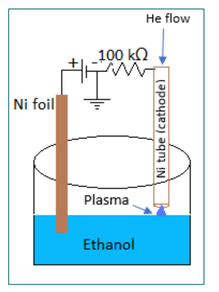


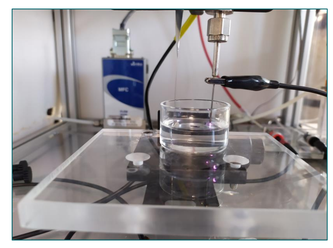
Characterization of the structure of CNTs using TEM and Raman Spectroscopy. TEM image shows the diameter of CNTs which has an average of 20 nm. Raman spectrum shows the D, G, and G' bands, which indicate the high graphitization of CNTs with a ratio IG/ID = 1.174.

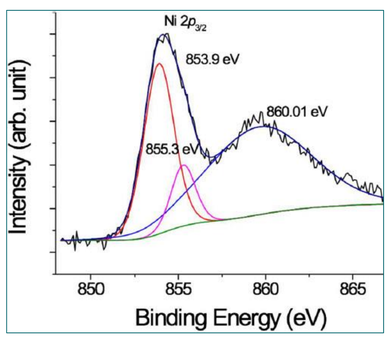
Synthesis and characterization of NiOx nanoparticles

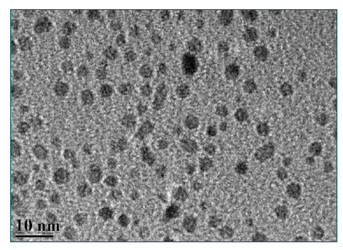
The process setup to synthesize the NiO nanoparticles is clear in images (a) and (b) where the Ni foil was emerged in the ethanol. Using 3kV applied voltage between the Ni foil and the Ni tube where the He flows, the He will be ionized to obtain the plasma.

From the TEM image (d) we can observe the NiO nanoparticles which has a size ranges between 2-5 nm. From the XPS spectrum (c) we obtain form the obtained particles we can see Ni $2p_{3/2}$ where three peaks extracted. 853.5 eV peak indicates the presence of Ni+2 in the Ni-O octahedral bonding of cubic rock salt NiO. The peak 855.1 to the vacancy-induced Ni+3 or Ni hydroxydes or oxyhydroxides.

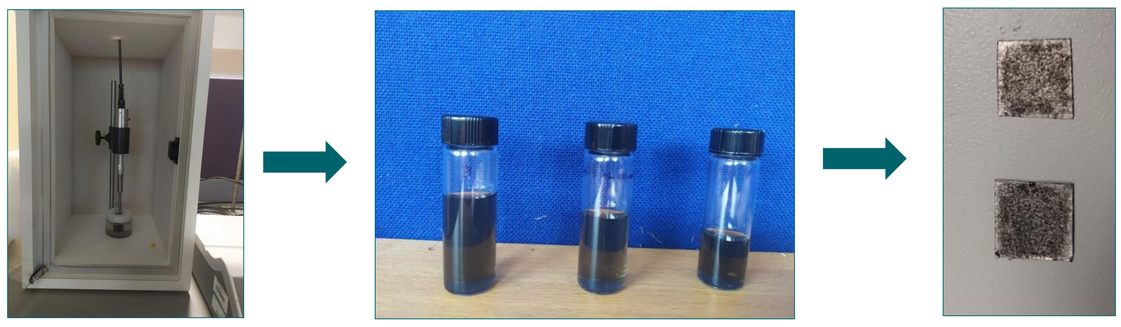






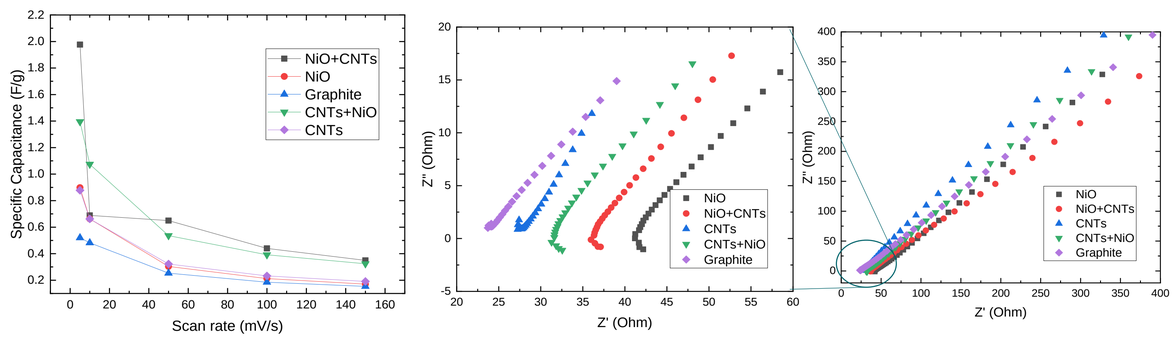


Samples Preparation



The obtained CNTs where dispersed inside the ethanol electrolyte that contains the NiO nanoparticles to be sprayed later on top of graphite substrate to use it as electrode for supercapacitors.

Electrochemical Characterization



For electrochemical measurements, 0.1 M of Na_2SO_4 was used as an electrolyte. The capacitance increased from 1.4 F/g for CNTs alone to 2 F/g for CNTs and NiO nanoparticles.

CONTACT PERSON

Islam Alshaikh
iralshaikh@ub.edu

PhD Student
ENPHOCAMAT Group (FEMAN)
UNIVERSITAT DE BARCELONA

REFERENCES

[1] Ya-Li Li, Science 304(2004) 276-278.

[2] Lee Weller et al., Carbon 146 (2019) 789-812.

[3] J.C. Stallard et al., Extreme Mechanics Letters 21 (2018) 65-75.

[4] Supria Chakrabarti et al., Nanoscale Adv. 1 (2019) 4915-4925.

[5] Christian Hoecker et al., Carbon 96 (2016) 116-124.

ACKNOWLEGEMENT

Ministry of Education for funding both the PhD and the stay at Ulster University in Northern Ireland through the FPU15 Project.

GOBIERNO DE ESPAÑA MINISTERIO DE EDUCACIÓN Y FORMACIÓN PROFESIONAL

IMAGINENANO 2020 ONLINE