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Vertically Aligned Carbon Nanotube Growth on Aluminium Substrate at Low Temperature

F. Nassoy^{1,2}, M. Pinault¹, J. Descarpentries², C. Reynaud¹, P-E. Coulon³, M. Mayne-L'Hermite¹

1. NIMBE, CEA, CNRS, Université Paris-Saclay, CEA Saclay 91191 Gif-sur-Yvette France;

2. NawaTechnologies, Chez STMicroelectronics, 190 avenue Célestin Coq-ZI, 13106 Rousset Cedex, France;

3. Laboratoire des Solides Irradiés, CNRS, CEA-DSM-IRAMIS, Ecole polytechnique, Université Paris-Saclay, 91128

Palaiseau Cedex, France;

e-mail address: fabien.nassoy@cea.fr

This communication addresses the growth of VACNT on aluminium by a single-step process (simultaneously injecting catalyser and carbon source precursors), namely the thermal aerosol assisted CCVD. The aim is to get a scalable process to fabricate ultracapacitor electrodes exhibiting a great potential thanks to VACNT specific surface area, anisotropy and good electrical conductivity. Considering the aluminium melting temperature (c.a. 660°C), the synthesis of VACNT on such substrates requires a significant reduction in the growth temperature as compared to conventional substrates [1-3]. According to our previous work, when hydrogen is added in the gas phase, the decomposition of the catalyst precursor will be more efficient at low temperature [2]. Moreover, the use of acetylene as carbon source is more favourable for a decomposition at low temperature [4].

Our approach is first to identify the most relevant synthesis parameters to reach VACNT growth at such a low temperature by analysing the VACNT properties such as CNT length, density, diameter, ... This optimization study, involving no surface pre-treatment of aluminium substrate, shows clean, long and dense VACNTs (*Fig.1 A,B,C*), with a growth rate (ca. 5µm/min) on par with the state of art the state of the art. Secondly, the objective is to understand VACNT growth mechanisms on Al substrate occurring at low temperature in order to optimise the VACNT synthesis process. Indeed, attention is paid on the Al surface prior and past the initial step of VACNT growth, and on the CNT/Al interface, with various analysis technics: SEM, TEM, EDX, XPS, GDOES ... The results of the chemical analysis of the interface by STEM/EDX (*Fig.2 D*) exhibit clearly identifiable catalytic particles located at the CNT base within a well-defined oxide interface layer suggesting the crucial role of the interface for an efficient and reproducible VACNT growth.

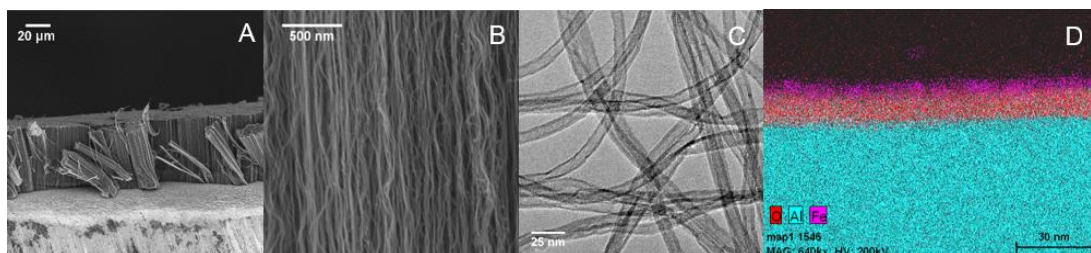


Figure.1 SEM (A,B) and TEM (C) images of VACNT obtained after 20min precursor injection with optimized synthesis parameters showing alignment and cleanness of the CNTs. STEM/EDX (D) image of CNT/Al interface after 1min of synthesis (Blue: Aluminium, Red: Oxygen, purple: Iron)

[1]. M. Pinault et al, 2005, *Nano Lett.*, **5**, 2394–2398

[2]. C. Castro et al, 2013, *Carbon*, **61**, 585-594

[3]. M. Delmas et al, 2012, *Nanotechnology*, **23**, 105604

[4]. M. R. Arcila-Velez et al, 2014, *Nano Energy*, **8**, 9–16