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Growth of vertically aligned carbon nanotubes on metallic surfaces

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Forests of vertically aligned carbon nanotubes (VACNTs) are attractive nanomaterials because of their unique structural, electrical and thermal properties. However, many applications require their growth on metallic substrates. Catalytic chemical vapor deposition (CCVD) is the best method to grow them but the catalytic particles can diffuse rapidly into the metal subsurface and thus become inactive. In this communication, I will address this issue through the recent results obtained in our laboratory. I will show how it is possible to grow VACNT on carbon fibers, stainless steel and aluminum surfaces by a single-step process, namely the aerosol assisted CCVD method, where the catalyst and carbon precursors are injected simultaneously. In the case of aluminum, due to its low melting temperature, the synthesis of VACNT requires a significant reduction in the growth temperature as compared to conventional substrates. Our results show that, with our single-step process, it is possible to obtain clean, long and dense VACNTs, with a growth rate at the best level compared to the state of the art at such low temperature. A particular attention has been paid to the study of the CNT/Al interface with various analysis technics: SEM, TEM, EDX, XPS, GDOES. The results suggest the crucial role of the interface for an efficient and reproducible VACNT growth. Finally, I will show that the aerosol-assisted CCVD process can be scaled-up to enable the fabrication of innovative ultracapacitors based on VACNTs grown on aluminum foils.

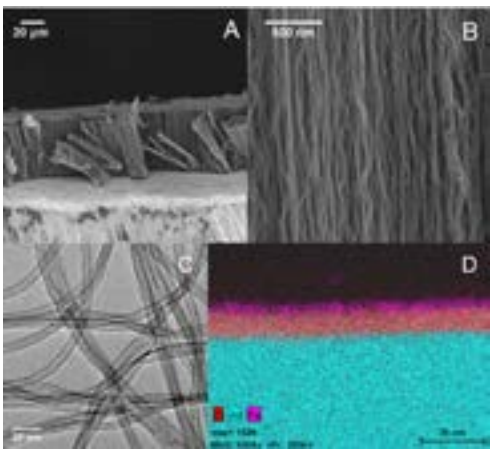

Figure: SEM (A, B) and TEM (C) images of VACNT on aluminum substrate. STEM/EDX (D) image of CNT/Al interface (blue: aluminum, red: oxygen, purple: iron).

Recent Publications

- M Delmas, M Pinault, S Patel, D Porterat, C Reynaud, M Mayne L'Hermite (2012) Growth of long and aligned multi-walled carbon nanotubes on carbon and metal substrates. Nanotechnology. 23(10):105604.
- P Landois, M Pinault, S Rouzière, D Porterat, C Mocuta, E Elkaim, M Mayne L'Hermite, P Launois, In situ time resolved wide angle X-Ray diffraction study of nanotube carpet growth: nature of catalyst particles and progressive nanotube alignment. Carbon. 7:0-10.
- C Castro, M Pinault, D Porterat, C Reynaud, M Mayne L Hermite. The role of hydrogen in the aerosol-assisted chemical vapor deposition process in producing thin and densely packed vertically aligned carbon nanotubes. Carbon. 61:585-594.
- P Boulanger, L Belkadi, J Descarpentries, D Porterat, E Hibert et. al. (2013) Towards large scale aligned carbon nanotube composites: an industrial safe-by-design and sustainable approach. J. Phys. Conf. Ser. 429:(1):1-12.
- S Lagoutte, P H Aubert, M Pinault, F O Tran Van, M Mayne-L 'Hermite, C Chevrot (2014) Poly(3-methylthiophene)/vertically aligned multi-walled carbon nanotubes: electrochemical synthesis, characterizations and electrochemical storage properties in ionic liquids. Electrochim. Acta. 130:754-765.

Biography

Cecile Reynaud has her expertise in the synthesis and chemical physics of nanomaterials. Her work has mainly dealt with silicon nanocrystals and aligned carbon nanotubes. She was the head of the Laboratory of Nanometric Assemblies (LEDNA) in the fundamental research division of the Saclay CEA center for 15 years. The LEDNA group follows the "bottom-up" approach of nanosciences. It develops its own synthesis methods for the elaboration of nano-objects and nanostructured materials with well-controlled characteristics. The processes of their formation and the characterization of their properties, especially those induced by size effects, are studied. The applications derived from these activities are relevant for energy, health, environmental issues and the development of composite materials. Another strong feature of the group is the up-scaling of synthesis processes in order to favor industrial transfer.

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