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VERTICALLY ALIGNED CARBON NANOTUBES GROWTH ON ALUMINIUM SUBSTRATES AT LOW TEMPERATURE

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Energy storage is a major challenge for the next years, with the development of renewable energy, mobile devices (smartphones, tablets, computers,...) and electric vehicles. Supercapacitors have a great potential, with performance located between the capacitors and batteries. Their principle is based on rapid ion charge / discharge cycles, using the common activated carbon based electrodes. However, these systems have limitations in terms of energy density and cost which involves the development of new electrode materials.

During the last five years, a strong interest has been devoted to electrodes based on vertically aligned carbon nanotubes (VACNT) thanks to their large specific surface area developed, their anisotropy and good electrical conductivity. In this context, our first results obtained in collaboration with the Universities of Cergy Pontoise and Tours have demonstrated a high increase of capacitance due to the implementation, in ionic liquid, of electrodes based on VACNT covered with conducting polymers and standing on Si substrates [1]. The development of ultra-capacitor by NawaTechnologies Company is based on this VACNT-based technology. One of the challenge to penetrate the market is to replace the silicon collector by a conductive and inexpensive substrate.

In this context, the aim of this collaborative work is to develop the growth of VACNT on aluminum foil by aerosol assisted Chemical Vapor Deposition (CVD). This method is well controlled on substrates such as stainless steel or quartz for synthesis temperatures between 800 and 850°C [2, 3 and 4]. Taking into account the aluminum melting temperature of about 660°C, the synthesis of VACNT on aluminum requires a significant lowering of VACNT growth temperature.

At low temperatures, the decomposition of catalytic and carbon precursors commonly used is insufficient. To overcome this problem, the nature of the gas phase has been changed in terms of both carbonaceous precursor and carrier gas. Indeed, the decomposition of the catalyst precursor at low temperatures and thus the synthesis yield are increased by the addition of hydrogen in the atmosphere [3]. Moreover, in order to limit the decrease in growth rate it is necessary to use precursors with a catalytic and thermal decomposition more favorable around 600 ° C, such as acetylene recently reported for CVD growth on aluminum [5]. Therefore, the approach in this work is first to identify the most relevant synthesis parameters to reach VACNT growth at such a low temperature by varying them and analyzing subsequently the products obtained with SEM, TEM, Raman, ATG, to have information on CNT length, density, diameter,… The first results obtained on pure aluminum, without any surface pretreatment show that growth in VACNT is strongly influenced by the flow of the reactive gas phase, composition and the synthesis temperature as represented on *figure 1*. Moreover, attention is paid on study of Al surface before growth or during the initial steps of VACNT growth, and of CNT / Al interface with various analysis technics: SEM, TEM, XPS, AFM… in order to understand VACNT formation mechanisms at lower temperatures which has a direct link towards the optimization of VACNT synthesis process.

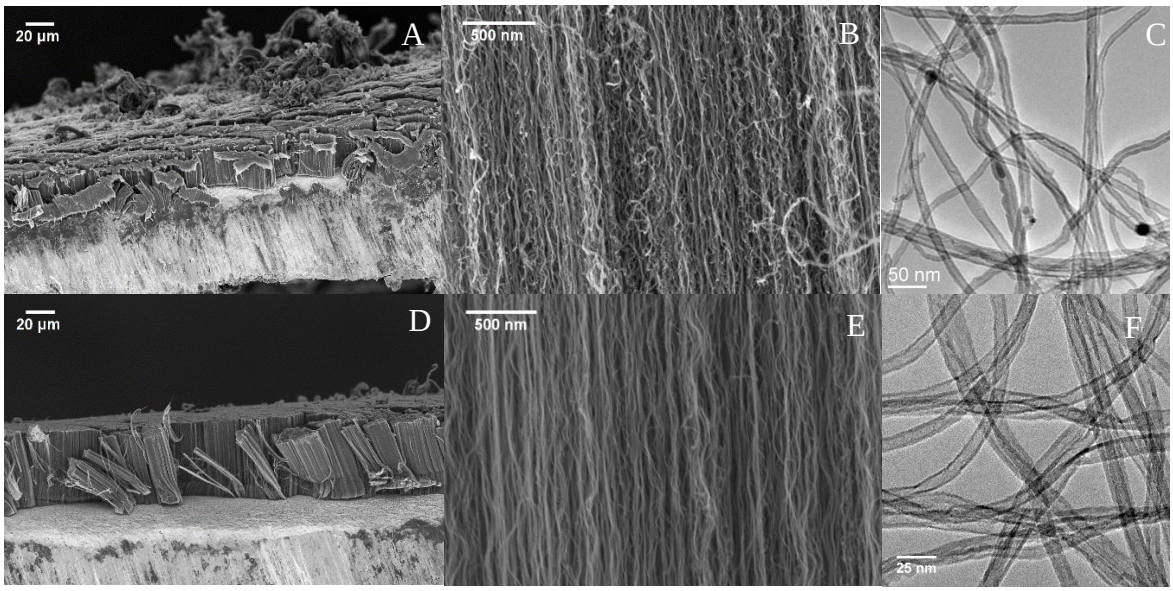

Fig. 1. Up: SEM (A,B) and TEM (C) images of VACNT morphology obtained on pure Al through aerosol CVD in the presence of hydrogen and acetylene; Down: SEM (D,E) and TEM (F) images of VACNT obtained with optimized synthesis parameter showing a better alignment and cleanness of the CNT.

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