Abstract

Carbon nanotubes are unique nanostructure with remarkable electronic, mechanical and thermal properties, some stemming from the close relation between carbon nanotubes and graphite, and some from their one-dimensional structure. Since their exceptional and suitable properties (high thermal and electrical conductivity, high thermal stability, relevant mechanical and field emission properties) they have soon attracted great attention.

Graphene is the first two-dimensional (2D) atomic crystal available to us. Since its discovery in 2004, graphene has captured the attention and the imagination of worldwide researchers thank to its supreme properties.

Carbon nanotubes and graphene are considered today the building blocks of nanotechnology.

In such light, this thesis work has been focused to develop industrial scalable processes, starting from research at lab scale on carbon nanotubes and graphene formation, to explore their potentialities for electrical and thermal applications, e.g. microelectronic devices.

In particular, graphene has been obtained at atmospheric pressure and low temperature on exhausted activated carbon-derived SiC nanoparticles (Chapter II). The graphene's growth, traced by online analyzers, has been obtained from an external source of carbon, in particular by methane/hydrogen chemical vapor deposition (CVD). Recycled SiC has been chosen as growth substrate to carry out a convenient process and to increase the added value of the recycled, combining the favorable properties of different substances. Therefore, the SiC powder and the composite material obtained have been carefully characterized by the combined use of different techniques and tested for energy storage applications, e.g. due to their "fine pitch" for microsupercapacitor. The results show a very high capacitances up to 114.7 F/g for SiC alone and three times higher in the presence of graphene with an excellent cycle stability

Moreover, few layer graphene/SiO_2/SiC (G/SiO_2/SiC) core-layers-sheath nano-heterojunctions were obtained (Chapter II) by a new easy and cheap designed procedure by thermal annealing at atmospheric pressure and low temperature on the SiC powder. The advanced materials obtained were carefully characterized by the combining use of different techniques: transmission electron microscopy (TEM) with EDAX probe, scanning electron microscopy (SEM), X-ray diffraction analysis, Raman spectroscopy, thermogravimetric analysis coupled with quadrupole mass detector (TG-DTG-MASS).

Finally, in Chapter III an experimental, modelling and theoretical study of CNT growth and connection on a chip device with a flip chip configuration used to improve thermal management performances, in order to elaborate board design analysis, was reported. CNTs growth was obtained for the first time on AlN substrate typically used in high power electronic. An innovative technique was developed to measure thermal conductivity, of 1698,5 W/mK, for an isolated CNT. Moreover, the aim of the work was to study the role of the design parameters to mitigate the effects of a non-correct thermal management obtained with the help of high thermal conductive CNT connections bumps.

With the support of a COMSOL MULTIPHYSICS simulator we evaluated thermal performances to help in a preliminary phase the board design. We worked on a configuration that would allow the direct integration into flip-chip devices in order to reduce the thermal contact resistance at interfaces from the die through the heat spreader and the junction temperature and thermal crosstalk.