

Synthesis, characterization and applications of multi-wall carbon nanotubes

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An overview of experimental researches on carbon nanotubes carried out in CCS-UNICAMP will be presented. Practical aspects of synthesis, characterization and applications of carbon nanotubes are considered, with the main focus on multi-wall nanotubes, MWNT. Two alternative approaches for fabrication of nanotubes based devices (controlled synthesis and controlled deposition using ac di-electrophoresis) are compared.

For controlled synthesis, better understanding of basic mechanisms of nanotube nucleation and growth is required. New mechanism of MWNT nucleation in a catalytic chemical vapor deposition is presented. Based on experimental investigations, the nucleation is explained as a specific surface instability which can be developed under certain conditions in a catalyst nanoparticle supersaturated with carbon, starting as a well-known Millins-Sekerka instability. This finding opens the way for optimization and control of MWNT synthesis for various applications.

Electrical characterization of nanotubes was performed using 2 and 4 terminals methods employing FIB. Analysis of the MWNT resistance dependence on nanotube length allows to separate the contributions of external and internal walls, as well as intershell conductance. This kind of analysis is shown to be important for optimization of MWNTs based devices or components, such as sensors or interconnects.

Among numerous potential applications in microelectronics, utilization of nanotubes for gas sensing with very low power consumption will be considered in more detail. MWNTs, both pristine and decorated by metal/metal oxide nanoparticles, were utilized here for gas sensing in configuration of chemical resistor. Selectivity of sensing can be provided by using different metals. Thermoelectric effect (dependence of the MWNT resistance on temperature) is shown to be responsible for non-selective sensing of gases, so that both pressure and gas sensors can be fabricated using the same configuration.