Synthesis of Carbon Nanotubes by Arc Discharge and Chemical Vapor Deposition

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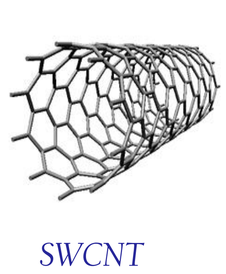
Introduction

Synthesis of carbon nanotubes in arc-discharge (AD) and chemical vapor deposition (CVD) reactor, is presented. In our work, the classical anodic electric arc discharge method has been implemented and refined into the fully automatic system. By proper choice of experimental conditions, both single (SWCNT)- and multi (MWCNT)-walled carbon nanotubes have been successfully produced. In case of CVD process the thermal decomposition of hydrocarbon is achieved in the presence of metal catalysts on the surface of substrate. The pretreatment and synthesis conditions, as well as morphology and structure of catalytic nanoparticles play an important role on quality and crystallinity of carbon nanotubes.

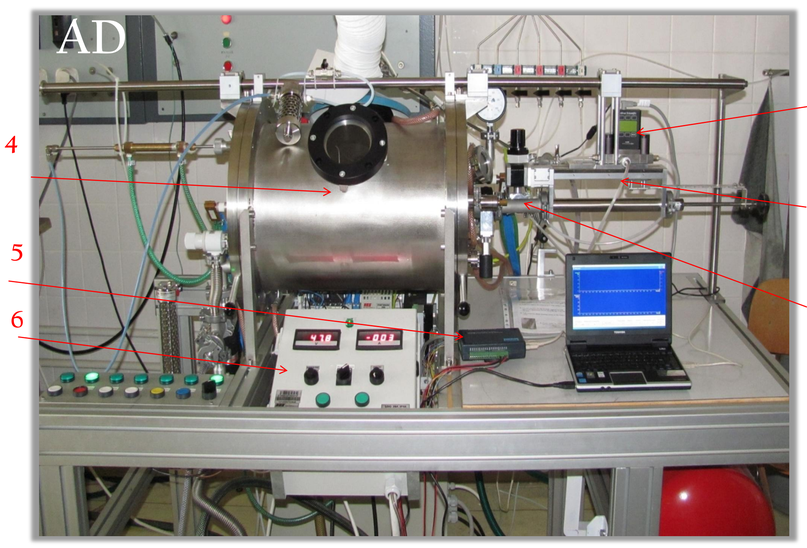


SWCNT *MWCNT*

Molecular structures of carbon nanotubes

Experimental apparatus – Arc discharge and CVD reactors

Image of AD reactor



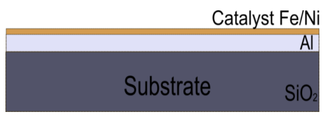
1 – Dual valve pressure controller, 2 – Linear movement of electrode, 3 – Electrodes replacement system, 4 –Double wall water jacket, 7 – Power source/electrode movement panel, 8 – Main control panel

Experimental conditions

Anode/SWCNT	**94 at% C, 4 at% Ni, 1 at% Y**
Anode/MWCNT	**100 at% C**
Pressure of inert gas	He 500 – 800 mbar
Current	60 – 100 A
Voltage	20 – 30 V

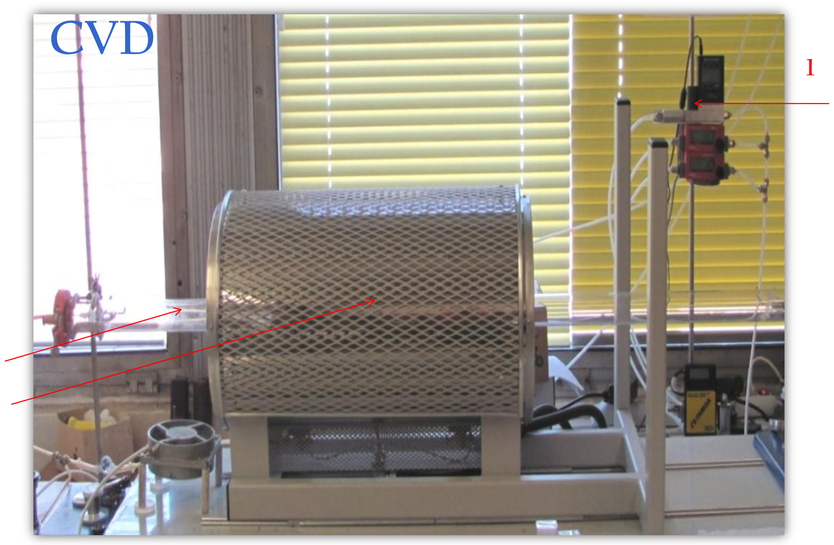
Electrodes arrangement (cathode – left, anode – right)

Catalyst SWCNT	**Al/Ni ~8nm/2nm**
Catalyst MWCNT	**Al/Fe ~8nm/2nm**
Ar	200 sccm
H_2	30 sccm
CH_4	80 sccm



Substrate composition

Image of CVD reactor

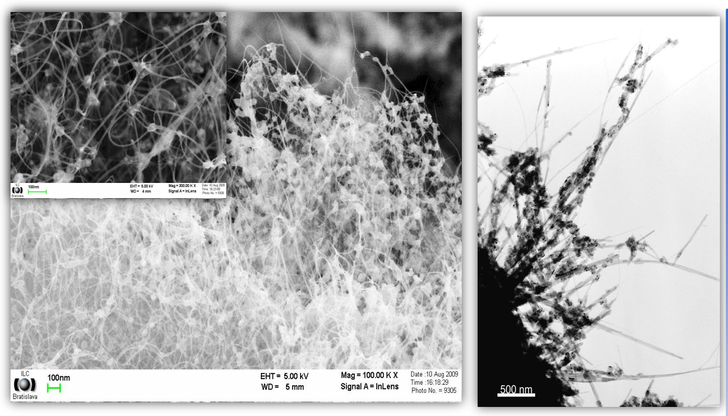


1 – Set of flow controllers , 2 – Quartz tube, 3 – Furnace

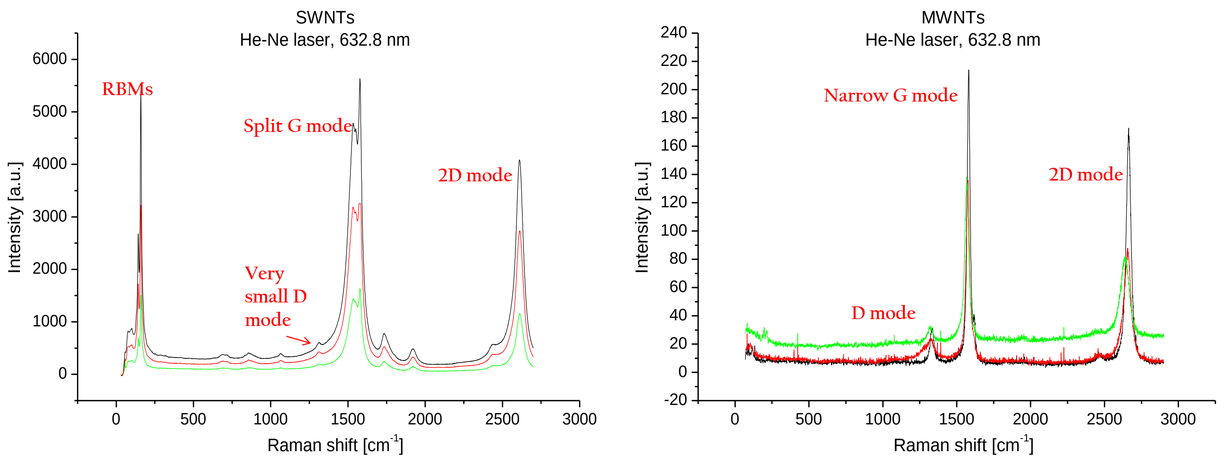
Experiments & Results AD CVD

AD reactor after experiment

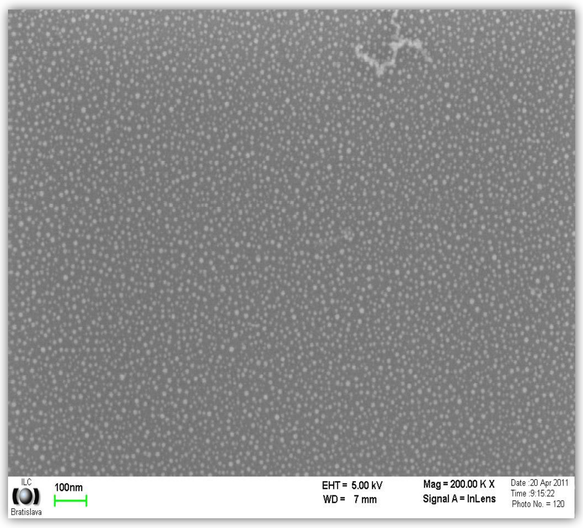
SEM and TEM images of SWCNT (left) and MWCNT (right)



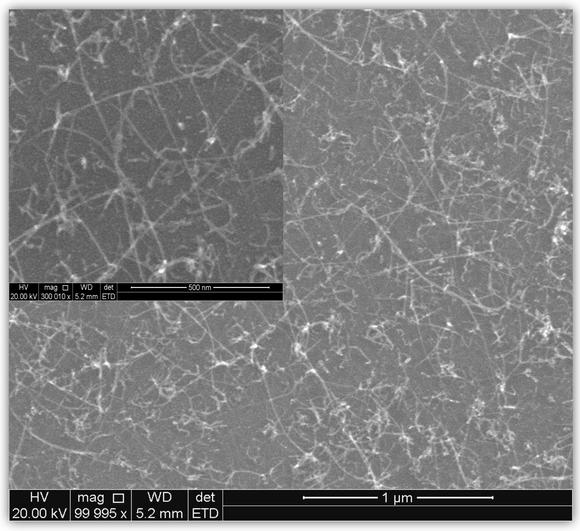
Raman spectra of SWNT (left) and MWNT (right)



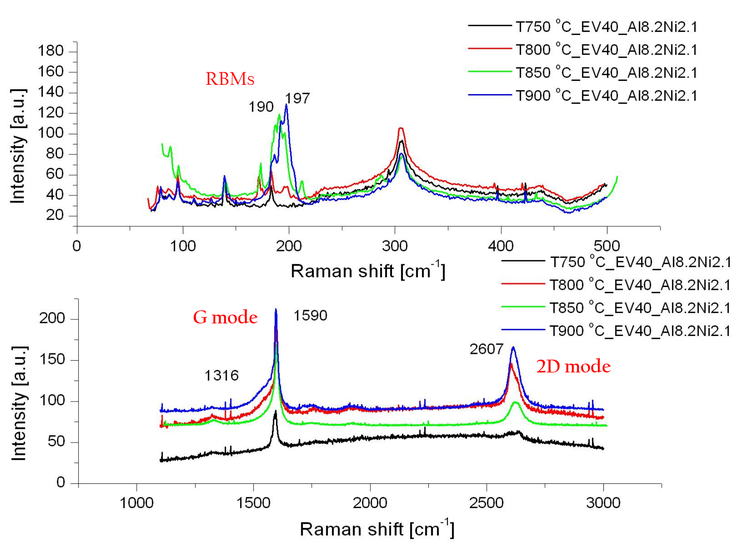
Substrate after annealing



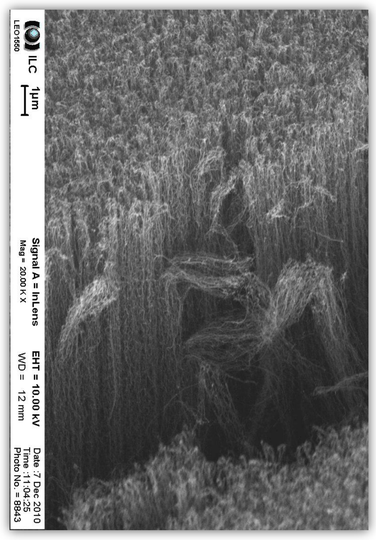
SEM image of SWCNT network



Raman spectra of SWNT for different growth temperature



SEM image of MWCNT forest



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