Optimization of CVD synthesis parameters for growth of long carbon nanotubes array

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This work directed to study of influence of parameters of CVD synthesis (time of synthesis, flow rate of gas-carrier, location of substrates in the reactor and structure of a reactionary mixture) for growth of array of carbon nanotube (CNT). The synthesis of oriented CNT's array in was realized on square 10×10 mm^2 silicon substrate (100). The rinsing of the substrates in ethanol has been made before synthesis of CNT's. The silicon substrates were located on quartz boat in the central zone of the reactor. The 2%- solutions of ferrocene $Fe(C_5H_5)_2$ in toluene and acetonitrile were used for formation of perpendicularly oriented CNT's arrays. The spraying of catalytic solution in the reactor was carried out through injector located in a zone with temperature 200 ± 10°C. The vapor of reactionary mixture were transferred to a zone of thermal decomposition of mixture due to gas-carrier fpow. The flow rate of reactionary mixture was 0.14 ml/min and controlled by spraying controller. The grown samples were investigated by SEM, X-ray-electron spectroscopy and X-ray diffraction. The increase of synthesis time (t) leads to increase CNT's length (L) in CNT's array. If t = 1 hour, then L = 1 mm, but, if t = 3 hours, then L = 3 mm. The growth rate of CNT's arrays was investigated for different flow rate of gas-carrier. It was found out that optimal flow rate is 200 ml/min. The change flow rate of gas-carrier leads to variation of the gradient of concentration of reactionary mixture in the reactor. In turn, it leads to change of a thickness of CNT's arrays. The thickness of CNT's arrays depends on location of the substrates in the reactor. If flow rate of gas-carrier is 200 ml/min, then maximum of array thickness is observed in the center of reactor. The change of reaction mixture composition from acetonitrile to toluene leads to significant growth of a thickness of CNT's arrays. It should be concerned with lower content of carbon in acetonitrile in comparison with carbon presence in toluene.