Growth of vertically oriented nanotubes on clusters, made by nanoimprint lithography

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It's well known today, that properties and structure of catalytic particles determine key features of nanotubes growth and their properties. Catalytic particles engineering hereby determine further formation of carbon nanotube based nanostructures and this is why it is actual scientific problem. Nanoimprint lithography is a promising method of creation structured catalytic particles about 50 nm over [1].

100 nm thick PMMA layer was spun onto silicon substrate. Nanoimprint stamp and substrate were heated up to 180°C and then stamp was pressed into polymer. After releasing, substrate was cooled and polymer layer was etched in O_2 plasma. If time of etching is 35 seconds the remaining thickness of polymer is 40 nm. 6 nm of nickel was deposited by thermal evaporation and lift-off in warm dimethyl formamide. Finally there are Ni islands on the substrate with diameter of 50 nm.

CNT synthesis performed with CVDomna unit by catalytic pyrolysis of ethanol. Temperature of process is 600°C and ethanol vapour pressure is 10 kPa. Heated clusters tend to minimize their surface energy and relax to spherical form. When ethanol vapours get into the chamber, they decompose into carbon monoxide. Catalytic particles adsorb this monoxide. Disproportionation of CO molecules takes place on their surface. Products of this reaction are CO_2 and carbon dissolving in catalytic particles. Carbon nanotubes grow from these particles and according to existing models nanotube diameter must be determined by radius of curvature of catalytic cluster. Our results are in full accordance with this fact. Diameter of our nanotubes is about 30 nm (see Fig.), what corresponds with dimension of sphere, whose volume equal to the volume of cluster.

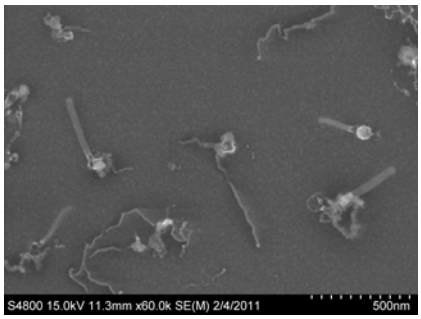

Figure: vertically oriented carbon nanotubes.

[1] S. Zankovych, T. Hoffmann, J. Seekamp, J.-U. Bruch, C.M. Sotomayor Torres, *Nanotechnology* **12**, 91 (2001).