
Contents

1	Introduction	1
2	Basic properties of carbon nanotubes	7
2.1	Atomic structure	7
2.2	Electronic structure	10
2.3	Trigonal warping effect	13
2.4	Curvature effect	14
2.5	Bundling effect	16
2.6	Multi-walled carbon nanotubes	17
2.7	Peapods	18
2.8	Summary	20
3	Experimental methods	23
3.1	Atomic force microscopy (AFM)	23
3.2	Electron microscopy	25
3.2.1	Scanning electron microscopy (SEM)	25
3.2.2	Transmission electron microscopy (TEM)	27
3.3	Raman spectroscopy	31
3.3.1	Confocal Raman spectroscopy	33
3.3.2	Fourier transform Raman spectroscopy	34
3.3.3	Raman spectroscopy of CNTs	36
3.4	Comparison of the methods used	46
4	Growth of carbon nanotubes	49
4.1	Synthesis of carbon nanotubes using CVD	50
4.2	Substrates	51
4.3	Growth mechanism	52
4.4	Fe:Mo alloy catalysts	53
4.5	Influence of the growth temperature	56
4.6	Summary	58

5	Frequency-dependent Raman spectroscopy	61
5.1	Diameter Assignment of a separated bundle of CNTs	61
5.2	Chirality Assignment	65
5.3	Summary	71
6	Phonon coupling in carbon nanotubes	73
6.1	Phonon modes of an individual MWCNT	73
6.1.1	Numeric model of phonon coupling in MWCNTs	74
6.2	Phonon modes in nanotubes bundles	79
6.3	Summary	81
7	Synthesis and characterization of peapods	83
7.1	Opening of carbon nanotubes	84
7.1.1	Acid treatment	84
7.1.2	Heating in air	90
7.2	Filling CNTs with C ₆₀ molecules	95
7.3	Summary	103
8	Conclusions and Outlook	105
	Bibliography	111