MM 38: Nanostructured Materials II

Time: Thursday 10:15–11:45 Location: IFW B

MM 38.1 Thu 10:15 IFW B

Electrical and mass transport in filled multi-wall carbon nanotubes — •Markus Löffler, Uhland Weissker, Thomas Mühl, Thomas Gemming, Rüdiger Klingeler, and Bernd Büchner — IFW Dresden, (P.O. box 270116, 01171 Dresden,) Germany

Electrical and concomitant mass transport in multi-wall carbon nanotubes (MWCNT) has been studied in a transmission electron microscope using the tip of an in-situ scanning tunnelling microscope. The mass transport has been found to be driven by electromigration and it has been studied in different regimes. Especially, fully reversible mass transport inside a MWCNT as well as current-induced directed MWCNT growth has been observed. The knowledge of the measured electromechanical properties of filled carbon nanotubes presents a starting point for the understanding of growth dynamics as well as for future applications in nanoelectromechanical systems (NEMS).

MM 38.2 Thu 10:30 IFW B

Quantitative composition of a single-walled carbon nanotube sample: Raman scattering vs. Photoluminescence — •Sebastian Heeg, Cinzia Casiraghi, and Stephanie Reich — Freie Universität Berlin, Berlin, Deutschland

The growth processes of Carbon Nanotubes (CNTs) yield samples containing tubes with a large variety of different chiralities. The qualitative composition of the CNTs product has been revealed by Raman scattering [1] and by Photoluminescence Emission (PLE) measurements [2]. The quantitative composition, however, remains a task in CNT characterization. We adress this problem by comparing the relative PLE intensities of two families of nanotubes with the relative intensities of the according Radial Breathing Modes obtained by Raman scattering. The PLE measurements were performed by dissolving the HiPCO grown nanotubes in aqueous solution using sodium dodecylbenzene sulfonate as surfactant. Raman Spectroscopy was performed by depositing the tubes from the solution on a silicon substrate by spin-coating. The presence of the CNTs was confirmed by atomic force microscopy. We show that the two methods yield significantly different ratios and we compare the results with theoretical predictions.

[1] J. Maultsch *et al.* Radial breathing mode of single-walled carbon nanotubes: Optical transition energies and chiral index assignment. *Phys. Rev B*, 72:205438, 2005.

[2] S.M. Bachilo *et al.* Structure-assigned optical spectra of single-walled carbon nanotubes.*Science*, 298:2361, 2002.

MM 38.3 Thu 10:45 IFW B

Mechanical properties of iron-filled CNTs — •Uhland Weissker, Markus Löffler, Franziska Wolny, Thomas Mühl, Siegfried Menzel, Albrecht Leonhardt, and Bernd Büchner — IFW Dresden, (PF 270116, 01171

Iron-filled carbon nanotubes (CNTs) are promising nanoscale probes for magnetic force microscopy. To achieve high lateral magnetic as well as topographic resolution, a high stiffness of the nanotube is one of the requirements. Iron-filled CNTs combine several advantages. The filling creates a more localized and harder magnetic moment than common coated cantilevers. The CNT shells protect the filling from oxidation and also ensure high mechanical stability. In this work we performed mechanical investigations on iron-filled CNTs by dynamic and static bending. In the dynamic method a high frequency electric field is applied to the CNT in order to excite a resonant oscillation. In the static method a Lorentz force acts on a current-carrying CNT in the presence of a strong magnetic field (2 Tesla), which is provided by the lens system of a transmission electron microscope (TEM). The CNT mounting is carefully considered; it can be modeled as a torsion spring and provides a correction to the calculated Young's modulus. Depending on the CNT diameter, we found a wide variation in the Young's modulus of iron-filled CNTs.

MM 38.4 Thu 11:00 IFW B

Liquid surface model for carbon nanotube energetic — •Ilia Solov'yov, Maneesh Mathew, Andrey Solov'yov, and Walter Greiner — Frankfurt Institute for Advanced Studies, Goethe University, Frankfurt am Main, Germany

We have developed a model [1] for calculating the energy of single wall carbon nanotubes of arbitrary chirality. This model, which we call as the liquid surface model, predicts the energy of a nanotube with relative error less than one percent once its chirality and the total number of atoms are known. The parameters of the liquid surface model and its potential applications are discussed. The model has been suggested for open end and capped nanotubes. The influence of the catalytic nanoparticle, atop which nanotubes grow, on the nanotube stability is also discussed.

The suggested model gives an important insight in the energetics and stability of nanotubes of different chirality and might be important for the understanding of nanotube growth process. For the computations we use empirical Brenner and Tersoff potentials and discuss their applicability to the study of carbon nanotubes. From the calculated energies we determine the elastic properties of the single wall carbon nanotubes (Young modulus, curvature constant) and perform a comparison with available experimental measurements and earlier theoretical predictions.

[1] Ilia A. Solov'yov, Maneesh Mathew, Andrey V. Solov'yov and Walter Greiner, Phys. Rev. E 78, 051601-(1-13) (2008)

MM 38.5 Thu 11:15 IFW B

Clean production of N-doped Singled-walled Carbon Nanotubes by CDV — •Jessica Walkenhorst[1], José M. Romo Herrera[2], Ana Laura Elias[3], Humberto Terrones[3], Mauricio Terrones[3], and Martin E. Garcia[1] — [1]Theoretische Physik, Fachbereich Naturwissenschaften, Universität Kassel, Heinrich-Plett-Str. 40, 34132 Kassel, Germany — [2]Colloid Chemistry Group at Phisico-Chemistry Department & CSIC Associated Unit in Universidad de Vigo, Vigo, Spain — [3]Advanced Materials Department, IPICYT, San Luis Potosí, México

We synthesized pristine and N-doped Single-Wall-Carbon-Nanotubes (SWCNTs) by the CVD technique, involving the spray pyrolysis of a ferrocene solution in ethanol in an Ar atmosphere. When synthesizing N-doped SWCNTs, the solution also contained benzylamine. The aerosol containing the precursors is guided using a quartz tube into a furnace operating at 950 (965) °C; synthesis times of 30-50 min. After the system cooled down the nanotube material was extracted and characterized. We used modified exprimental setups to increase the quality and quantities of the nanotubes produced. In one case, the gas flow upon cooling continues passing through the aerosol generator. In the other case, it passes directly into the quartz tube, thus bypassing the aerosol generator. The different SWCNT materials were mainly characterized using SEM, TGA and Raman spectroscopy. We observed clear differences in the D/G-band ratios, suggesting an increase in the sample's quality where the carrier gas (upon cooling) was directed straight into the tube, bypassing the aerosol generator.

MM 38.6 Thu 11:30 IFW B

Optimization of PECVD growth of individual vertical carbon nanotubes for field emission applications — •Ronny Löffler, Michael Häffner, Helmut Weigand, Monika Fleischer, and Dieter P. Kern — Institute of Applied Physics, University of Tübingen, Auf der Morgenstelle 10, 72076 Tübingen, Germany

Carbon nanotubes (CNTs) are interesting for many new applications due to their excellent electrical and mechanical properties, e.g. in the form of vertical CNTs used as field emitters. A promising way to produce uniform vertically aligned CNTs is the growth by plasma enhanced chemical vapor deposition (PECVD). This process is mainly affected by catalyst material and size, gas mixture and flow, deposition temperature, applied power and growth time. The effect of these parameters on the growth of CNT forests has already been reported by others. We present a variation of parameters focused on the growth of individual CNTs, which react much more sensitively to changes in the deposition process. By systematic variation, optimal growth parameters have been identified for the PECVD growth of individual vertical CNTs to be used as field emitters. The growth process has been integrated into the lithographical fabrication of an electrically controlled test structure for I-V-measurements in a UHV chamber.