Synthesis and investigation of iron-filled carbon nanotubes as probes for magnetic force microscopy — •Ulland Weisser, Thomas Möhl, Albrecht Leonhardt, Christine Taschner, Siegfried Menzel, Franceska Wolny, Christian Müller, and Bernd Büchner — Leibniz Institute for Solid State and Material Research IFW, Dresden

Magnetic force microscopy is a powerful method for imaging magnetic stray fields of magnetic surfaces with high spatial resolution. For magnetic force microscopy a conventional atomic force microscope tapping mode cantilever is coated with a magnetic layer that interacts with the sample stray field. Using this kind of probes the rather complicated pyramid shape of the probe influences the measurement results. Because of that, a straightforward quantitative interpretation of MFM data is hardly possible. On the other hand, quasi one-dimensional ferromagnetic wire-shaped probes should allow quantitative stray field measurements.

One promising solution is the use of iron-filled carbon nanotubes as scanning tip. The filled nanotubes offer a high aspect ratio, good mechanical properties and are magnetic. We report a chemical vapour deposition method (CVD) for fabrication of in-situ filled carbon nanotubes, which exhibit a long continuous iron-filling of several microns. The nanotube structure is investigated by SEM and TEM, whereas the filling is examined by AGM, XRD and EELS.

Scratching Multilayer Graphene with an Atomic Force Microscope — •Patrick Barthold, Thomas Lüdtke, and Rolf J. Haug — Institut für Festkörperphysik, Universität Hannover, D-30167 Hannover

The atomic force microscope (AFM) is a well known tool used for structuring devices on different materials. Besides others, one way is to scratch the surface and thus create insulating lines. We used this technique on thin graphite films. In situ measurements of the resistance while the sample was mounted and electrically contacted in the AFM show an astonishing reversible change in the resistance when the sample was scratched with a diamond coated tip. After moving the tip several times across the sample the resistance changes permanently. We contribute the reversible effect to induced and then moving defects in the graphite, whereas the irreversible change indicates that different layers have been cut through.

Ab initio calculation of the lattice dynamics of graphene nanoribbons — •Roland Gillen, Marcel Möhr, Janina Maultzsch, and Christian Thomsen — Institut für Festkörperphysik, Technische Universität Berlin, Hardenbergstraße 36, 10623 Berlin

During the past decades, graphite-related materials of nanoscale, such as fullerenes and nanotubes, have been subject to scientific interest. Their remarkable optical and electronic properties make them promising for use in future nanotechnology. Recently, another type of nanoscale materials, narrow stripes of graphene (single layer graphite) have been fabricated and were investigated regarding their electrical transport properties. These graphene nanoribbons are, depending on the direction of their edges, classified into armchair (AGNR), zig-zag (ZGNR) and chiral nanoribbons (CGNR). They correspond to "unrolled" carbon nanotubes, i.e. the model system used in zone-folding calculations of carbon nanotube properties. We use DFT calculations to obtain the band structure and phonon dispersion of various AGNR and ZGNR. Group theory was applied to classify the resulting phonon modes. We show that most of the phonon modes can be interpreted as "overtones" of a few fundamental modes. These overtone frequencies can be understood from zone folding the phonon dispersion of graphene. Shape and size dependences of the phonon frequencies of the nanoribbons are found. Similarities between nanoribbons and carbon nanotubes will be discussed.
Picotubes are ring-shaped hydrocarbons closely related to very short carbon nanotubes. They seem to be a promising starting point for the specific synthesis of nanotubes, which is one of the great goals in nanotube research. We identified the symmetries of all main modes in the Raman spectrum of semitrimer picotubes by performing polarization-dependent Raman measurements on crystalline samples. Furthermore, the semitrimer molecule has been subject to ab initio calculations, the results of which agree excellently to the experimental data. By comparing experiment and theory, we can assign phonon eigenvectors to all main Raman peaks.

The intermediate frequency modes in the carbon nanotube Raman spectra — • Martin Weiss¹, Hagen Telg¹, Janina Maultzsch¹, Viera Skáklová², and Christian Thomsen¹ — ¹Institut für Festkörperphysik, Technische Universität Berlin, Hardenbergstr. 36, 10623 Berlin, Germany — ²Max Planck Institut for Solid State Research, Heisenbergstr. 1, 70569 Stuttgart, Germany

The carbon nanotube Raman spectrum as it is commonly referred to consists of three features, the radial breathing mode (RBM), the high energy modes and the defect induced D mode. These modes are used to gain information on the diameter distribution, the presence of metallic tubes, the defect density and even the precise chiral indices \((n_1, n_2)\) of the tubes in a nanotube sample. However, apart from these three modes the nanotube Raman spectrum contains features in the intermediate frequency range of which the scattering mechanism is not yet consistently understood. These modes in part result from second-order scattering and resemble the phonon density of states. Therefore, they can give information on the phonon dispersion of nanotubes and on Raman inactive modes. We performed resonant Raman measurements of the intermediate frequency modes (IFM) located between \(\sim 400\) and \(\sim 1000\) cm\(^{-1}\). By comparing the resonance conditions of the IFMs and RBMs we assign the IFMs to certain groups of nanotubes \((n_1, n_2)\). Furthermore we discuss the dependence of the IFMs on excitation energy and their lineshapes with respect to the calculated phonon density of states.