Accessing the electronic and optical properties of metallicity-selected and functionalized single-walled carbon nanotubes

Paola Ayala[1], Yasumitsu Miyata[2], Hidetsugu Shiozawa[3], Christian Kramberger[1], Ryo Kitaura[2], Hiromichi Kitaura[4], Thomas Pichler[1]

[1] University of Vienna, AUSTRIA
[2] University of Nagoya, JAPAN
[3] University of Surrey, UK
[4] AIST, Tsukuba, JAPAN

Single-walled carbon nanotubes (SWCNTs) exhibit unique one-dimensional electronic and optical properties related to their peculiar local arrangement of sp2 hybridised carbon atoms. Especially the feasibility to have different semiconducting and metallic structures from the same species, appraise their related research. Furthermore the possibility to modify these properties in a controlled manner is particularly appealing. In this framework, hybrid structures can be thought-out based on the inevitable interactions of nanotubes in a bundle or via different doping routes.

In this presentation we first review how the properties of these structures are usually determined by their interaction in a nanotube solid. High energy spectroscopy, as well as optical and Raman spectroscopy have been shown to be very effective key tool to analyse the details in modifications of the underlying basic correlation effects, in the bonding environment, the charge transfer between functionalized nanotubes and the doping in nanotubes. It will also be emphasized how these studies provide a solid basis for a detailed insight into the influence of doping, chemical interactions on the electronic ground state and the transport properties of SWCNTs. This includes the three alternative doping routes: substitution, intercalation and endohedral doping. For metallic functionalized nanotubes, doping induced changes will be discussed in the framework of a dimensionality crossover, which causes a change from a one-dimensional metal to a normal Fermi liquid.

Finally we will deal with the recent great progress regarding metallicity-selected bulk nanotube samples. SWNTs bulk samples of as-synthesized material are mixtures of all sorts of chiralities and have different metallicity but a successful separation of such samples has been achieved by novel methods, for instance density gradient ultracentrifugation. We will show that this opens a new research field as it allows addressing these properties for nanotubes with known metallicity in unprecedented detail. We present here our recent progress on bulk properties of pristine and intercalated metallicity-separated carbon nanotubes using photoemission and x-ray absorption spectroscopy in analysing the changes in the site selective valence and conduction band electronic structure in metallicity-selected nanotubes.