High energy spectroscopy on rare-earth nanowires inside the hollow core of Carbon Nanotubes

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Single wall carbon nanotubes (SWCNTs) are archetypical 1D systems with peculiar electronic properties which can be modified in a controlled manner by various methods. One of these methods takes advantage of the tubular space inside the SWCNTs, which can encapsulate 1D crystals or tiny molecular structures. We aim at explaining how applying thermo-chemical reactions in ultra high vacuum, it is possible to obtain elemental rare earth nanowires still encapsulated in the CNTs. As first example, the case of Er nanowires obtained from the transformation of ErCl3 will be addressed [1]. A second example considers the filling of the hollow core of SWCNTs with Gd@C_{82} metallofullerenes and how subsequent modifications can be induced utilizing the nanotube hollow space as a nano-reactor [2].

The work to be presented focuses on controlling the effective hybridization and charge transfer of rare earths inside the SWCNT nanoreactor. This has been monitored by a combined high resolution photoemission and x-ray absorption study [3]. The hybridization degree and the effective charge changes were directly accessed by across the 4d and 3d edges of Er in the corresponding case. Here, it is found that Er is trivalent but the effective valence is reduced for Er filled tubes. This strongly suggests an increased hybridization between the nanotube π states and the Er 5d orbitals. In the metallofullerene-filling case, from a detailed analysis of the Gd 3d, 4d, and C1s responses, as well as the valence band resonant photoemission, we have been able to elucidate the changes in the bonding environment and charge transfer in these 1D systems. This particular case is very interesting because we observe a clear modification of the low energy electronic properties of the SWCNT transformed partly into double walled tubular structures with encapsulated Gd nanowires.

These results have significant implications for the 1D electronic and magnetic properties of these and similar rare earth nanowire hybrids.

References

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