ANALYZING THE GROWTH PROCESS OF SINGLE-WALLED CARBON NANOTUBES BY X-RAY SPECTROMETRY

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Carbon Nanotubes (CNTs) are very promising objects in the technologic development of modern nanoelectronic devices and circuits. Consisting of sp^2 hybridized graphene sheets rolled up into a cylindrical shape, CNT may be composed of one (i.e., single walled CNTs – SWNTs) or several concentrically nested arranged cylinders, i.e., multi-walled carbon nanotubes - MWNTs. The properties of CNTs are strongly correlated to their arrangement. Only SWNTs with certain chirality, i.e., the way the graphene sheet is rolled up are semiconducting, the required property to be used as active part in nanoelectronic devices such as field-effect transistors). For this reason, it is necessary to understand the growth mechanism for SWNTs and to identify the crucial factors in the production process in order to be able to grow semiconducting SWNTs selectively.

In general, a catalyst is required for the growth of CNTs. Its properties such as roughness, thickness, chemical binding and in a further step the cluster size significantly influences the kind of CNTs [3]. Different X-ray spectrometry methods have been developed for various characterization tasks: reference-free X-Ray Fluorescence analysis (XRF) for measuring the mass deposition, XRF in Grazing Incidence geometry (GIXRF) for elemental depth profiling and high resolution X-Ray Absorption Spectroscopy (XAS) for determining the chemical species. As sample systems, silicon wafers at different processing steps were investigated in the present work. They were entirely processed in the clean room facilities of ISTN. CNTs were grown in situ, i.e., directly at their final place, on silicon substrate covered by SiO_2, aluminum and nickel, by means of CVD (chemical vapor deposition) from a methane feedstock at 900°C.

The X-ray spectrometric investigations were carried out in the PTB laboratory at the electron storage ring BESSY II employing monochromatized undulator radiation and calibrated instrumentation [1, 2]. The catalytic layers consist of Al and Ni, whereas the Ni layer is converted in clusters during further processing step and the Al is oxidized [4-5]. Initial results of GIXRF and XAFS measurements show that XRS methods can substantially contribute to the analysis of the growth processes of carbon nanostructures.

References

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