The state of catalyst in carbon nanotube growth can be metal, or metal carbide. It is important to investigate the chemical state of catalyst. The applications of carbon nanotubes (CNTs) require detailed investigation of structures, and properties of catalysts. The novelty of this work is that the chemical, and physical properties of nickel catalysts in the growth of single-walled carbon nanotubes (SWCNTs) inside metallic SWCNTs were investigated. The difference to other works is that here metallicity-sorted metallic SWCNTs were used as templates. The growth of carbon nanotubes was performed in the outer template metallic SWCNTs where metallocenes served as catalysts, and carbon source. This system provided as best as possible control over the synthesis conditions, and the processes of metallocene catalyst decomposition, and metal carbide/metal formation were traced by X-ray photoelectron spectroscopy (XPS). The contribution of this paper is that the positions of Ni 2p XPS were tracked upon heating of metallocene-filled metallic SWCNTs. All states of nickel were studied in detail with increasing annealing temperature. It was found that there are the chemical reactions of molecules, metal carbides, and metals inside metallic SWCNTs upon heating. First, at low annealing temperatures, metastable nickel carbides were formed. Second, at higher annealing temperatures, nickel carbides were transited into metallic nickel. Third, at high annealing temperatures, nickel was removed from SWCNTs.