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Spectroscopy insight in the nickel catalyst state in carbon nanotube growth inside metallic single-walled carbon nanotubes

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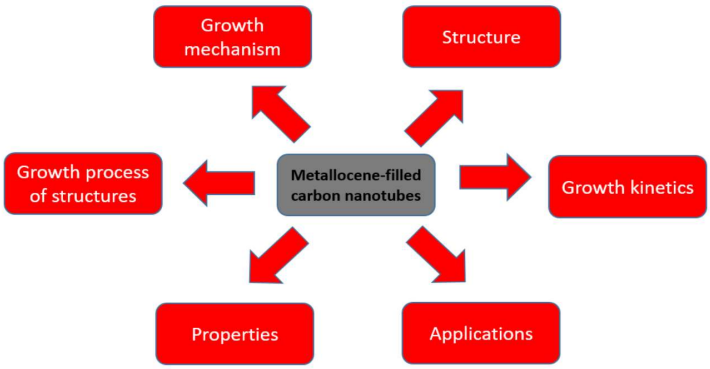
INTRODUCTION & AIM

The catalyst state in carbon nanotube growth can be caused by metal or metal carbide. The applications of carbon nanotubes (CNTs) require detailed investigations of the structures and properties of catalysts. A novel factor 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.

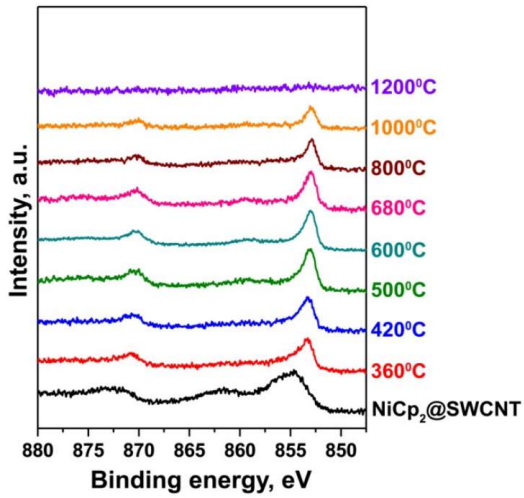
METHOD

The growth of carbon nanotubes was monitored in the outer template metallic SWCNTs where metallocenes served as catalysts and sources of carbon . 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).

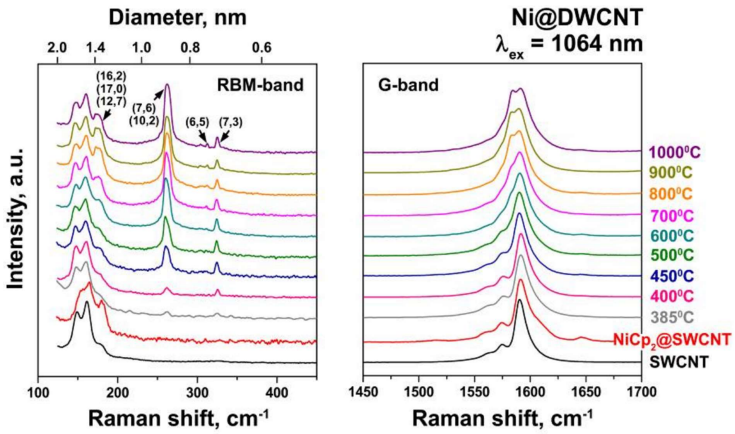
RESULTS & DISCUSSION



The investigations of metallocene-filled SWCNTs [1]. Copyright 2023 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license.



The Ni 2p XPS spectra of the annealed metallic nickelocene-filled SWCNTs [3]. Copyright 2021 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license.



The growth dynamics of inner SWCNTs inside nickelocene-filled SWCNTs [2]. Copyright 2021 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license.

CONCLUSIONS

It was found that chemical reactions of molecules, metal carbides, and metals occurred 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.

FUTURE WORK / REFERENCES

[1] Kharlamova M.V. et al. Nanomaterials 2023, 13, 774.
[2] Kharlamova M.V. et al. Nanomaterials 2021, 11, 2984.
[3] Kharlamova M.V. et al. Nanomaterials 2021, 11, 2500.