

Advanced Electron Microscopy Study of GdX₃@WS₂ Nanotubes

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Abstract

Nanotubes including those of carbon, BN and WS₂ are widely investigated as templates for nanomaterial synthesis as well as for filling of foreign atoms or compounds to obtain heterostructures with improved functionalities like quantum confinement in semiconductors and reduced dimensionality.¹ The well-defined cavities result in the formation of size and shape confined structures including nanotubes, nanorods/wires or atom chains.² Solution synthesis, electrochemical methods, vapor phase filling and capillary filling are mainly employed to obtain filled nanotubes. The morphology and concentration of the filling varies with the synthesis conditions. Many of these materials are being widely studied for biomedical applications. For example, Gd³⁺@ultra-short carbon nanotubes are studied as MRI contrast agent and CNT functionalized with Eu complexes for its luminescent properties.³ In this work, capillary filling is employed for the synthesis of GdX₃ (X – I, Cl, Br) filled WS₂ nanotubes. The precise determination of the structure and composition is essential for its further application. In the present study, the morphology, structure and chemical composition of the synthesized GdX₃@WS₂ nanotubes is investigated using aberration corrected scanning/transmission electron microscopy and spectroscopy (Energy Dispersive X-ray Spectroscopy and Electron Energy Loss Spectroscopy). The three-dimensional morphology is investigated using STEM tomography. EDS tomography- a novel and less explored technique of tomography, is employed in the present study to map the three dimensional chemical composition.⁴ In order to reduce the beam induced damage effects on the specimen, tomography experiments were carried out at 80 kV in the present case.

References

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Figures

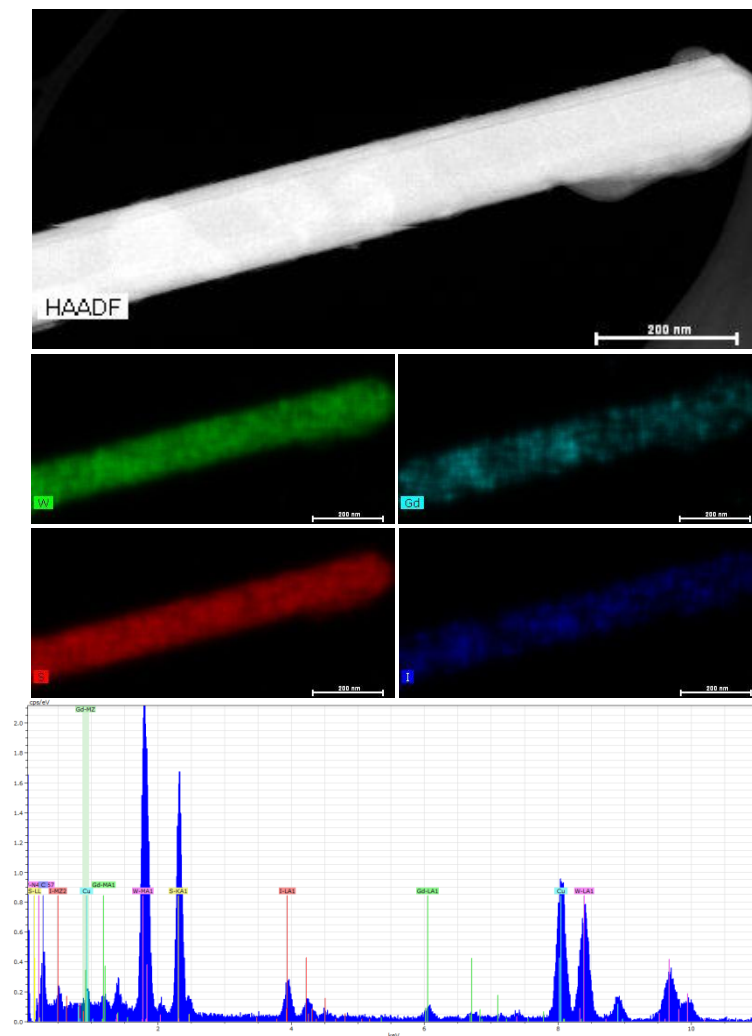


Figure 1. HAADF-STEM image, elemental maps and EDS spectrum of GdI₃ filled WS₂ nanotube