SYNTHESIS OF TUBULAR VAN DER WAALS HETEROSTRUCTURES BY CARBON NANOTUBE TEMPLATE ASSISTED GROWTH OF SINGLE-LAYERED INORGANIC NANOTUBES.

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Abstract

The unique properties of two-dimensional (2D) layered nanomaterials make them highly attractive for a wide range of applications. Their electronic and optical properties allow the miniaturization of nanoelectronic and optoelectronic devices in a competitive manner. Even larger opportunities arise when two or more layers of different materials are combined. As a consequence, several top-down and bottom up approaches are being explored to isolate or synthesize single-layers of 2D materials. Using a molten phase capillary approach, we have been able to synthesize a wide range of tubular van der Waals heterostructures by growing single-layered inorganic nanotubes, namely, PbI_2, CeI_3, $CeCl_3$, $TbCl_3$, ZnI_2, $GdCl_3$ and $SmCl_3$ within MWCNTs. Once confined, the metal halides can adopt different structures, the formation of inorganic nanotubes being greatly enhanced by increasing the temperature of synthesis.[1, 2] We also report on an ultrafast energy efficient strategy, using laser irradiation, which allows bulk synthesis of crystalline single-layered metal halides in the cavities of CNTs. In contrast to the conventional thermal approach this strategy is highly selective toward the growth of monolayers forming tubular van der Waals heterostructures, the present study proposing a simple, versatile, ultrafast and energy efficient strategy for their tailored synthesis. In case of PbI_2-NT@MWCNTs, the irradiated bulk material bearing the nanotubes reveals a decrease of the resistivity as well as a significant increase in the current flow upon illumination. Both effects are attributed to the presence of single-walled lead iodide nanotubes in the cavities of carbon nanotubes, which dominate the properties of the whole matrix.[3]

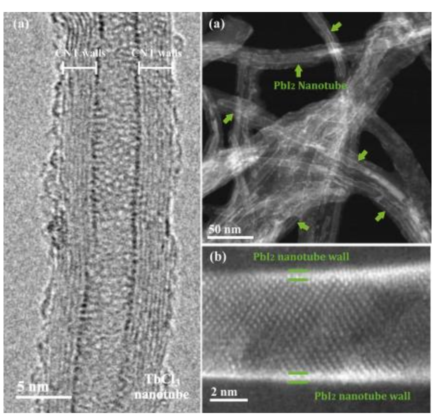

Figure 1. (a) $TbCl_3$-NT@MWCNT prepared by molten phase capillary wetting (thermal approach). (b) HAADF-STEM and (c) high resolution aberration corrected HAADF-STEM images of PbI_2-NT@MWCNTs synthesized by laser assisted approach.

References

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