Analysis of rearranged organic/inorganic hybrid 2D tincone film via molecular layer deposition

Session: Emerging Materials / EM2: Organic-Inorganic Hybrid Materials

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Abstract text

In recent years, research on monolayer and two-dimensional (2D)-based family materials developed, starting with well-known graphene which has emerged an innovative research topic[1]. Through atomic-level thickness control of ultra-thin 2D materials, the design and fusion of electronic devices are possible, enabling applications in various fields as well as in optoelectronics and semiconductors. Organic/inorganic hybrid tincone films were deposited by molecular layer deposition (MLD) using N,N′-tert-butyl-1,1-dimethylethylenediamine stannylene(II) as a precursor and hydroquinone (HQ) as organic reactants. When combined with HQ having a bi-functional hydroxyl group, SnO-based 2D hybrid tincone can be produced. In this study of tincone fabricated with a divalent precursor after a vacuum post-annealing process, the structural rearrangement of the SnO and the benzene ring bonds proceeded to form a SnO-based hybrid 2D structure. The rearrangement of the resulting structure occurred through π-π stacking (without pyrolysis) of the benzene ring. To understand the mechanism of fabrication of 2D hybrid tincone by π-π stacking of the benzene ring, and the strengthening of the crystallinity of SnO after the annealing process, the structural rearrangement was observed using X-ray photoelectron spectroscopy (XPS), grazing incidence X-ray diffraction (GIXRD), grazing-incidence wide-angle X-ray scattering (GIWAXS), and Raman spectra.

As seen in the analyses, the as-deposited tincone originally had weak SnO nano-crystallinity without a specific crystal orientation. One hour after the annealing process at 400 ℃, individual benzene ring bonds were combined with the SnO layer in a repeated arrangement of tincone monomer [-Sn-O-C_6H_4-O-]n. In the visible region (380–750 nm), high transparency (>85%) enabled optical device application through a hybrid layer with the SnO.

Reference

[1] K. S. Novoselov, A. K. Geim, S. V. Morozov, D.-e. Jiang, Y. Zhang, S. V. Dubonos, I. V. Grigorieva and A. A. Firsov, science, 2004, 306, 666-669.

Supplemental Document

An unique 2D structure was formed with the repeated tincone monomers that were rearranged by annealing process. After the annealing process of the tincone film at 400 ℃, individual benzene ring bonds were combined with the SnO layer in a repeated arrangement of tincone monomer [-Sn-O-C_6H_4-O-]n.

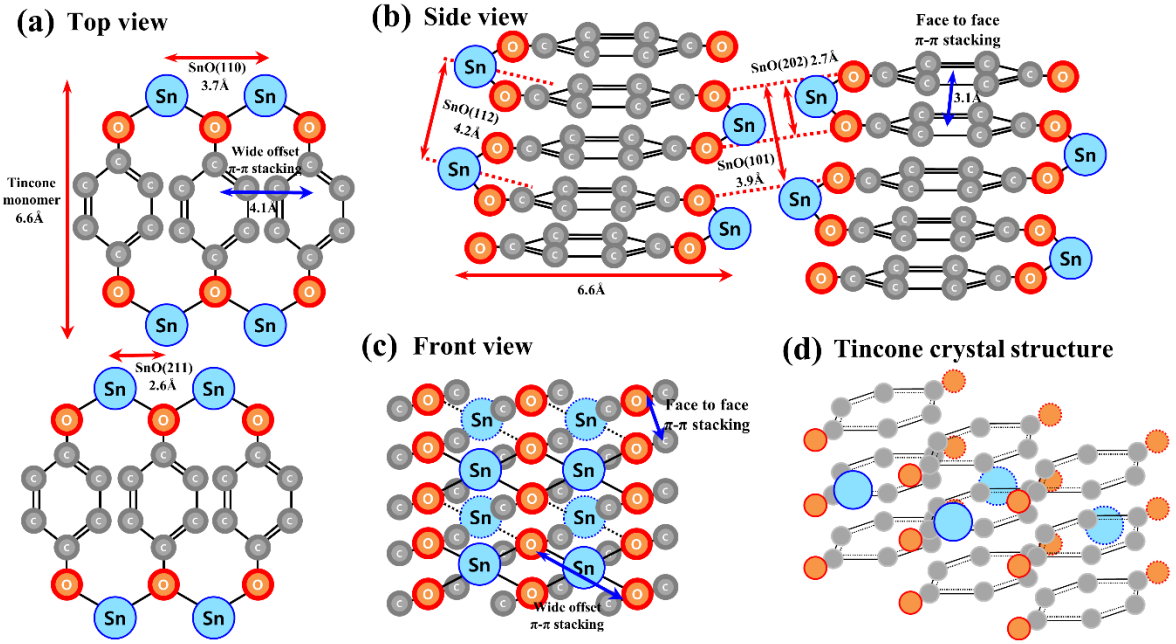

Fig. 1. Schematic of 400 ℃ rearranged tincone crystal structure: (a) top, (b) side, (c) front view, and (d) repeated tincone crystal structure.