Alkali halide promoter induced synthesis of crystalline quasi-1D MoS_2 nanoribbons from PLD grown MoO_x precursor

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Abstract

The large-scale and quality growth of semiconducting thin films form the basis of modern-day optoelectronic devices. Atomic-scale growth of traditional semiconductors is always a challenge for the growth community. To overcome this transition, metal dichalcogenides (TMDs) form a stable atomic-scale structure that provides the ideal platform. The large-scale growth of TMDs on various insulating substrates would open a promising way to explore the use of these materials. Among all the TMDs family, molybdenum disulfide (MoS_2) is a promising candidate for power electronics due to its sizeable direct bandgap and other electronic properties. Pulsed laser deposition (PLD) is one of the ways to synthesize MoS_2 monolayers, demonstrating its potential for 2D materials synthesis via both direct growth and a two-step process. In this work, we present a two-step process of synthesizing quasi-one-dimensional (1D) MoS_2 nanoribbons. In the first step, the precursor film of oxygen-deficient molybdenum oxide films is grown by PLD on sapphire, followed by sulfurization process at the desired temperature. The vapor-liquid-solid (VLS) growth of quasi-1D-MoS_2 nanoribbons gives highly anisotropic crystalline structure with a height of few nm, several microns in length, and a few hundred nm width. The VLS growth happens due to the reaction between MoOx precursors and sodium fluoride (NaF) as a promotor forming liquid droplets. An epitaxial growth of quasi-1D nanoribbons was analyzed by SEM, AFM, and Raman spectroscopy. The structural properties of the nanoribbons possess highly anisotropic crystalline structure with predominantly 3R-stacking, which was confirmed by STEM, polarization-dependent Raman spectroscopy, second harmonic generation microscopy, and terahertz spectroscopy. The electrical measurement on the nanoribbons demonstrates reasonable value of photocurrent. All the experimental results reveal the growth of high-quality quasi 1D-MoS_2 nanoribbons and their potential use in future optoelectronic applications. Details will be presented.

Figure

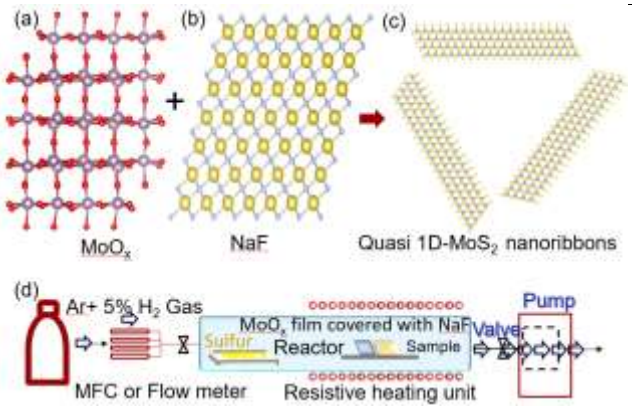

Figure 1. Schematic illustration of the sample preparation process. The schematics from a-d displayed the complete steps of fabricating the nanoribbons from oxide precursors.