Ambipolar transistor operation in WSe_2 epitaxial thin films grown by molecular-beam epitaxy

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【Abstract】 Since the discovery of graphene, emerging properties of 2D materials at monolayer limit have attracted considerable attention both from fundamental and applied viewpoints. Among various 2D materials, monolayer semiconducting transition-metal dichalcogenides (TMDC) such as MoX_2 and WX_2 (X = S, Se) are of particular interest due to its unique physical properties originating from direct band gap with broken inversion symmetry and strong spin-orbit coupling, providing a platform for basic researches as well as for practical device applications. We have been developing a growth process of high quality TMDC thin films by molecular-beam epitaxy (MBE), and recently succeeded in establishing a versatile route to layer-by-layer epitaxial growth of millimeter-scale TMDC thin films on commercially-available insulating sapphire substrate by MBE. In the presentation, we will introduce our growth recipe, together with ambipolar transistor operation in WSe_2 epitaxial thin films grown by our MBE system.

【Results】 WSe_2 epitaxial thin films were grown on sapphire with the layer-by-layer mode confirmed by reflection high energy electron diffraction (RHEED) with the intensity oscillation enabling precise control of a layer number. Film crystallinity was evaluated by x-ray diffraction measurements both for out-of-plane and in-plane directions, proving epitaxial growth of single-crystalline WSe_2 thin films. The obtained WSe_2 epitaxial thin films exhibited ambipolar transistor operation upon electrolyte gating with clear Hall signals for hole-accumulation regime with the maximum mobility of about 3 cm^2/Vs at T = 150 K, which was in the highest level reported for the first-generation CVD-grown MoS_2 thin films.

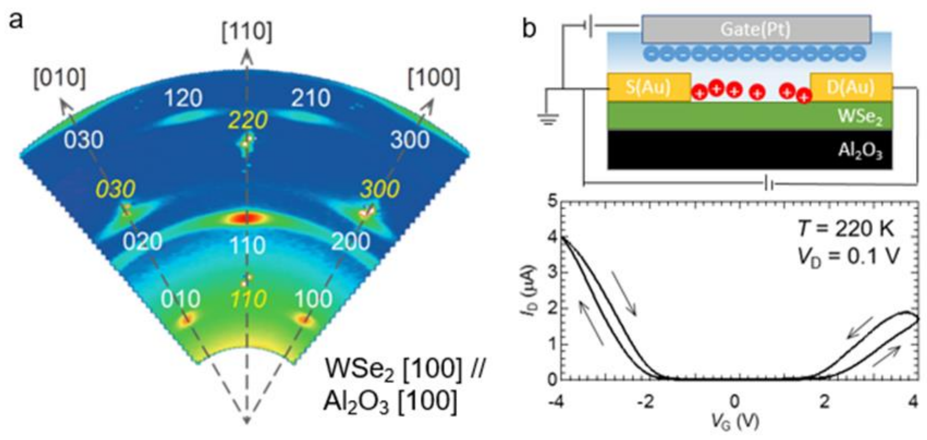

Figure 1: **a**, The reciprocal space map of the x-ray diffraction measurement within the (hk0) plane. **b**, (top) A schematic device structure using electrolyte as a gate dielectric, and (bottom) the drain current (I_D) as a function of gate voltage (V_G) taken at T = 220 K.