**Wafer scale quasi single crystalline (SC) MoS₂ realized by epitaxial phase conversion**

**Recent Technological Demands:**

- The fabrication of large-scale, single-crystalline, silicon wafers has enabled the modern electronics industry.
- Wafer-scale, single-crystalline 2D graphene was first fabricated in 2014.
- Until now, wafer scale MoS₂ film has been realized, but all with polycrystalline structure, which limit the reliability of MoS₂ based integrated circuit devices.
- Develop a new fabrication process for fabricating single crystalline MoS₂ film at wafer scale is significant and necessary.

**Reason for two step fabrication**

- Thickness control
- Wafer scale fabrication
- However, low-quality film hence worse performance

**Theory of MoOₓ epitaxial film**

C-cut sapphire [(001)Al₂O₃] substrate is suitable candidate for grow epitaxy MoOₓ film. Lattice mismatch is small:

- MoO₂[(010)/Al₂O₃{120}]: (0.572-0.5628)/0.572=1.6% (compressive strain)
- MoO₂[(010)/Al₂O₃{100}]: (0.4856-0.4762)/0.4762=2.0% (tensile strain)

**Experiment and Characterization of epitaxial MoOₓ film**

**Typical epitaxial phase conversion process**

- MoO₂ + S, 900 °C, 1 hr

**Outcomes**

- We realized the quasi single crystalline structure of MoS₂ film at wafer scale by sulfuration of epitaxial MoO₂ film.
- Quasi single crystalline MoS₂ film has a field effect mobility 35 times higher than the polycrystalline MoS₂ film.
- The wafer-scale MoS₂ film we made could be uniformly transferred onto different substrates to realize their various applications, such as Si-based, transparent or flexible electronics.
- The discoveries reported herein bring up a new research topic in the area of two-step fabrication process of wafer-scale 2D materials: influences of the structure of precursor film on the structures and properties of 2D materials. TFT devices based on MoS₂ film with this structure have the mobility up to 10 cm² V⁻¹ s⁻¹.