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Rotationally-oriented MoS2 grown by Mo-film sulfuration and its application to NO2 detection

Abstract
Two-dimensional molybdenum disulphide (MoS2) film has been synthesized by thermal vapour sulfurization of thin Mo film. Figure 1(a) shows transmission electron microscopy (TEM) image of the MoS2 film transferred on a TEM grid. Selected area electron diffraction (SAED) patterns taken from different spots identified in (a) exhibited nearly identical crystallographic orientations, revealing the rotational alignment of the MoS2 domains in the film. The film was found to consist of 4–5 layers. The MoS2 film was also characterized by Raman spectroscopy. As shown in Figure 2(a), the two Raman modes E1g and A1g are observed at a separation of about 25 cm⁻¹, indicating multilayer formation [1]. MoS2-channel Field-effect-transistor (FET) fabricated on a SiO₂/Si substrate exhibits n-type semiconducting behaviour (Figure 2(b)), which is consistent with previous reports [2, 3]. Two-terminal FETs exhibited electron mobility ranged from 0.1 to 2.9 cm²V⁻¹s⁻¹ at room temperature which is larger than previously reported values of TVS-grown MoS₂ [4, 5]. The FET-based sensor was found to detect NO₂ with concentrations as low as 7 ppb in N₂ and exhibited resistivity change by an order of magnitude, as shown in Figure 2(c). Therefore, NO₂ with concentration of several hundreds of ppt or lower would probably be detectable.

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References

Figure 1: (a) TEM image of MoS$_2$ (bright region) and SAED patterns taken from the corresponding areas labelled in the image. (b) TEM image of a folded MoS$_2$ film.

Figure 2: (a) Raman spectrum of the MoS$_2$ film. (b) Drain current, $I_d$, as a function of back-gate voltage, $V_g$, of a MoS$_2$-FET. (c) Drain current ($I_d$) normalized by the initial drain current ($I_{d0}$) of the MoS$_2$ sensor when exposed to 7 ppb of NO$_2$ in N$_2$ atmosphere.