Kenjiro Hayashi[1,2]
Masako Kataoka[1], Hideyuki Jippo[1,2], Mari Ohfuchi[1,2] and Shintaro Sato[1,2]
[1]Fujitsu Laboratories Ltd., Atsugi, Kanagawa, Japan and [2]Fujitsu Limited, Kawasaki, Kanagawa, Japan

hayashi.kenjiro@fujitsu.com

Rotationally-oriented MoS_2 grown by Mo-film sulfurization and its application to NO_2 detection

Abstract
Two-dimensional molybdenum disulphide (MoS_2) film has been synthesized by thermal vapour sulfurization of thin Mo film. Figure 1(a) shows transmission electron microscopy (TEM) image of the MoS_2 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 MoS_2 domains in the film. The film was found to consist of 4~5 layers. The MoS_2 film was also characterized by Raman spectroscopy. As shown in Figure 2(a), the two Raman modes E^1_{2g} and A_{1g} are observed at a separation of about 25 cm^{-1}, indicating multilayer formation [1]. MoS_2-channel Field-effect-transistor (FET) fabricated on a SiO_2/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 $cm^2V^{-1}s^{-1}$ at room temperature which is larger than previously reported values of TVS-grown MoS_2 [4, 5]. The FET-based sensor was found to detect NO_2 with concentrations as low as 7 ppb in N_2 and exhibited resistivity change by an order of magnitude, as shown in Figure 2(c). Therefore, NO_2 with concentration of several hundreds of ppt or lower would probably be detectable.
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References

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Figures

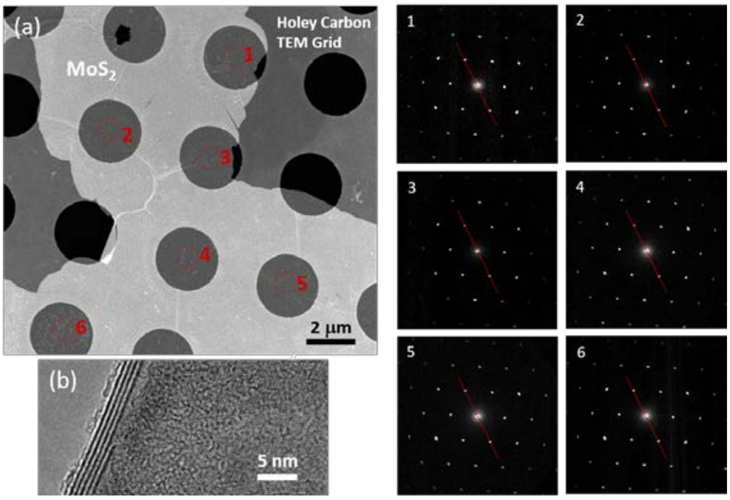

Figure 1: (a) TEM image of MoS_2 (bright region) and SAED patterns taken from the correspond-ing areas labelled in the image. (b) TEM image of a folded MoS_2 film.

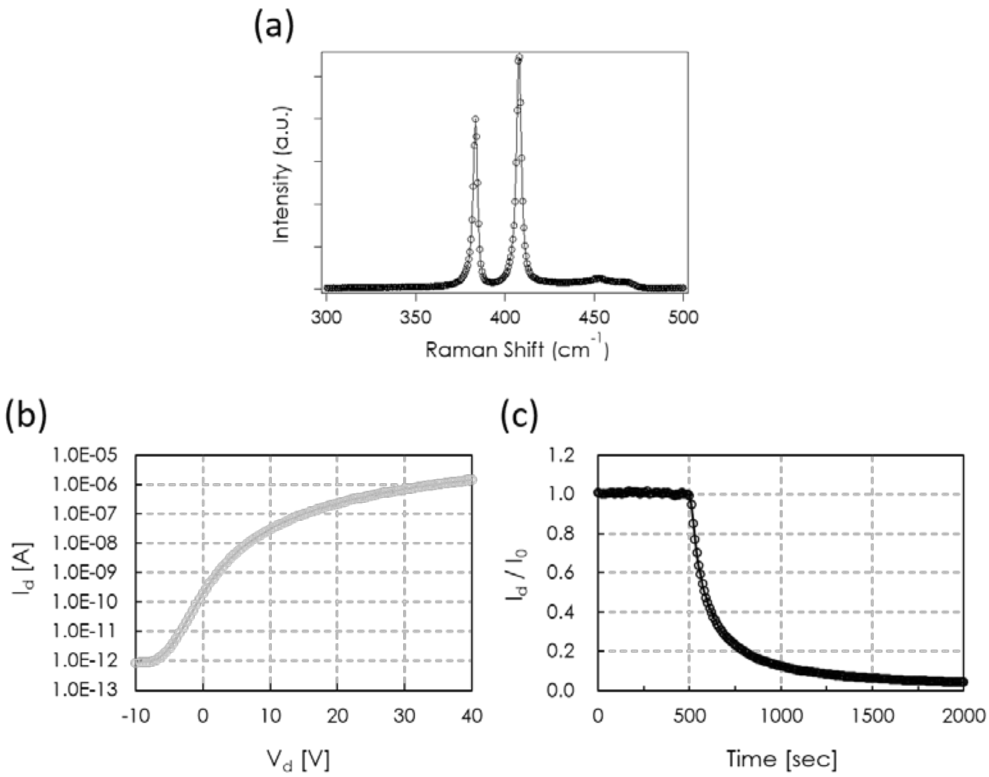

Figure 2: (a) Raman spectrum of the MoS2 film. (b) Drain current, I_d, as a function of back-gate voltage, V_g, of a MoS_2-FET. (c) Drain current (I_d) normalized by the initial drain current (I_{d0}) of the MoS_2 sensor when exposed to 7 ppb of NO_2 in N_2 atmosphere.