Growth of High-Crystalline Bulk $MoSe_2$ Using Chemical Vapor Deposition

Na Liu
Soo Ho Choo, Jeong Hun Kim, Naqi Siddiqi, and Sunkook Kim

School of Advanced Materials Science & Engineering, Sungkyunkwan University, 300, Chunchun-dong, Jangan-gu, Suwon, Republic of Korea

Contact@E-mail (naliufit9@gmail.com)

Abstract

Layered semiconductors based on transition metal dichalcogenides (TMDs) exhibit many distinctive characteristics, including wide band gap (E_g > 1 eV), high carrier mobility (>100 cm^2/Vs), large photoresponsivity (~500 A/W). It has been reported that $MoSe_2$ shows a higher photoresponsivity compared to MoS_2 because of the quantum confinement effect during the bad gap transition. On the other hand, multilayer TMDs provide a wider spectral response and higher photoresponsivity than monolayer TMDs. Additionally, FETs based on multilayer TMDs offer a relatively high performance, which are expected to be more suitable for commercial fabrication process than monolayer TMDs. In this study, a highly crystalline multilayer $MoSe_2$ film was grown by CVD method directly onto SiO_2 substrates. Firstly, we used a relatively high pressure (>760 Torr) to form multiple nuclei during the CVD growth, resulting in multilayer $MoSe_2$ film. The fabricated multilayer $MoSe_2$ thin-film transistors (TFTs) exhibit ambipolar behaviors with reasonably large field-effect mobility (~10 cm^2/Vs) and high photoresponsivity (93.7 A/W). Secondly, large-grain multilayer $MoSe_2$ was synthesized using a modified CVD method. Polycrystalline compounds of $MoSe_2$ as precursor were directly vaporized onto Mo-coated SiO_2 substrates. The multilayer $MoSe_2$ has a relatively large grain size of several hundred micrometers. Transistors based on such $MoSe_2$ single grains show *n*-type characteristics with field-effect mobility up to 121 cm^2/Vs and on/off current ratio higher than 10^4 on Si wafers or plastic polyimide films. The overall results of CVD-grown multilayer $MoSe_2$ offers high speed, highly photoresponsive transistor for high-performance flexible/stretchable electronics.

References

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[2] Chulseung Jung, Seung Min Kim, Hyunseong Moon, Gyuchull Han, Junyeon Kwon, Young Ki Hong, Inturu Omkaram, Youngki Yoon, Sunkook Kim and Jozeph Park, Scientific Reports, 5 (2015) 15313.

Figures

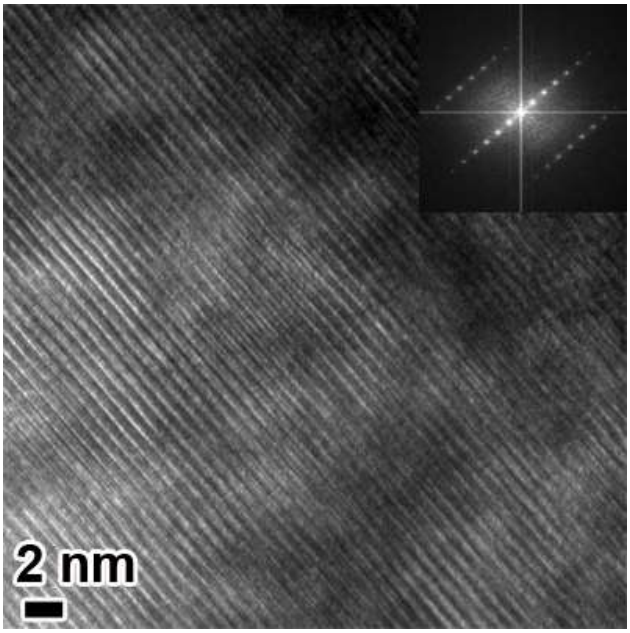

Figure 1: High-resolution TEM image of cross-sectional MoS_2 film.