# Ambipolar Molybdenum Diselenide Field-Effect Transistors: Field-Effect and Hall Mobilities

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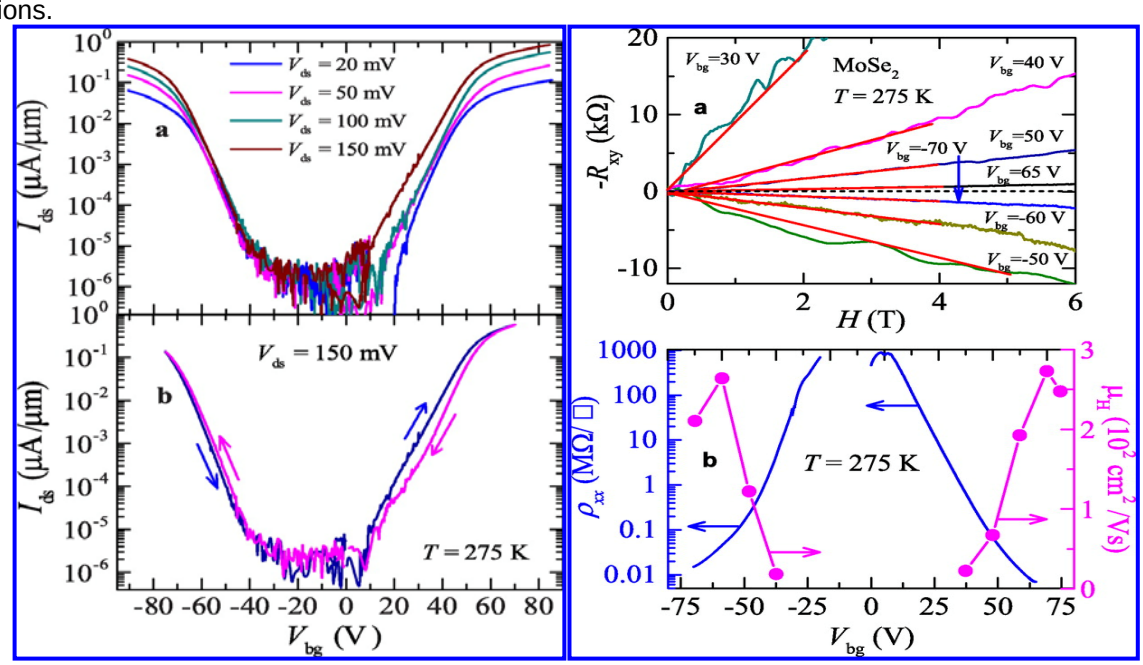
## Introduction

High mobility ambipolar conduction within a Field-effect transistor (FET) device is the key requirement for complementary logic technology, such as low power consumption, robust operation, and ease of circuit design. Here we investigated the electrical transport properties of few-layer $MoSe_2$ FET at room temperature, grown by chemical vapor transport technique. FET fabricated with Ti/Au contacts on $MoSe_2$ shows current ON/OFF ratios up to $10^6$ for both hole and electron channels when applying a small excitation voltage. A rather small hysteresis is observed when sweeping the back gate voltage between positive and negative values. indicating the near absence of charge puddles. For both type of conduction, Hall effect indicates Hall mobilities $\mu_H$ = 250cm$^2$/Vs, which are comparable to the corresponding field-effect mobilites, i.e., $\mu_{FE}$ = 150 to 200 cm$^2$/Vs evaluated through the conventional two-terminal field-effect configuration. Therefore, our results suggested that the $MoSe_2$ could be promising candidate for *p-n* junctions composed of a single atomic layer for low-power, complementary logic applications.




**Left Panel**: (**a**) Electrical current $I_{ds}$ flowing through the drain-source contacts normalized by the width of the channel as a function of the back gate voltage $V_{bg}$ for several values of excitation voltage $V_{ds}$. (**b**) $I_{ds}$ as a function of both increasing (blue line) and decreasing (magenta line) values of $V_{bg}$. Notice that for both electrons ($V_{bg}$>0) and hole ($V_{bg}$ <0) the ratio between the transistor current ON/OFF ratio is $10^6$.

**Right Panel**: (**a**) Raw Hall resistance $R_{xy}$ as a function of the magnetic field H for several values of back gate voltages $V_{bg}$. Red lines are linear fits from hose slope we extract the Hall constant $R_H = 1/ne$ where $n$ is the number of carriers. (**b**) Four terminal resistivity (blue lines) and Hall mobility $\mu_H = R_H/\rho_{xx}$ as a function of $V_{bg}$. Notice that the maximum mobilities for both electrons (positive gate voltage) and holes negative gate voltage) approaches ~250cm$^2$/Vs.

## Conclusions

$MoSe_2$ FET grown on vapor transport technique shows an ambipolar semiconductor behavior. The hall mobilities for both electron and dholes are ~250 cm$^2$/Vs. Therefore, our results indicate that $MoSe_2$ is an excellent candidate, for not only complementary logic electronics, but also for *p–n* junctions based on a single to few atomic layers on $SiO_2$ substrate.

## Acknowledgements:

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## References:

[1] N. R. Pradhan, D. Rhodes, Y. Xin, S. Memaran, L. Bhaskaran, M. Siddiq, S. Hill, P. M. Ajayan and L. Balicas, ***ACS Nano*** 8, 7923 - 7929 (**2014**)