CALIFORNIA STATE SCIENCE FAIR
2017 PROJECT SUMMARY

Name(s)

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Project Number

S0614

Project Title

Characterization of 2D Molybdenum Disulfide Crystal Growth for Nano-Optics and the Extension of Moore's Law

Abstract

Objectives/Goals

The objective of this research is to optimize the Chemical Vapor Deposition synthesis method of 2D Molybdenum Disulfide by analyzing the effect of Molybdenum Oxide to Sulfur Precursor on crystal thickness. Currently, 2D MoS2 is a very new material in an early R&D phase. With the optimization of CVD growth conditions, a larger database of MoS2 crystallization can be generated for large scale production of MoS2.

Methods/Materials

Molybdenum oxide (MoO3) and sulfur in varying molar ratios were prepared onto glass boats. The prepared SiO2 wafer was put on top of the molybdenum oxide and the two boats of MoO3 and S were placed inside the CVD furnace at specified locations based off the heat distribution. The furnace settings and the argon gas flow were modulated where the CVD would heat up to 650° C then cool back down to 100° C, where crystals were extracted. The crystals were analyzed at the 100 micrometer level with a Horiba LabRAM. Photoluminescence (PL) spectra and Raman spectra were taken for analysis of monolayer, bilayer, trilayer, or bulk crystal growth.

Results

Through the analysis of the PL and Raman Spectra, a higher molar ratio of MoO3 to Sulfur was correlated with more monolayer crystal growths. Specifically, ratios 0.252 to 0.332 had the most prominent single layer crystals. Samples 1 and 2, which had lower ratios, grew in trilayers and bilayers respectively. Additionally, sample 5 showed anomalous wire-structured MoS2 growths and an abnormally high and near-single wavelength photoluminescence. Further analysis showed that a water impurity caused the odd crystals to grow.

Conclusions/Discussion

From this data, multiple conditions with higher precursor molar ratios in MoS2 CVD synthesis were shown in effect to their crystallization. By showing which ratios of MoO3 to Sulfur precursors allowed for monolayer and multilayer crystals, the CVD synthesis can be exactly tailored to specific crystals required in Van Der Waal heterostructures, which are composed of multiple stacked 2D materials. Because multilayer MoS2 materials have different band gaps, the data gathered in this experiment can be used to grow MoS2 crystals specific for optoelectronic devices that emit or detect specific wavelengths of light. In addition, exact ratios for monolayer growths are crucial in the advancement of MoS2 MOSFETs for the extension of Moore's Law beyond silicon's 5nm gate limit.

Summary Statement

I varied the ratios of MoO3 to sulfur precursor in a CVD synthesis method and analyzed the effects on growth of monolayer/multilayer MoS2 crystals.

Help Received

I conducted the research at the Zhang lab at Berkeley. Mervin Zhao, a graduate student, taught me how to use the CVD furnace. In addition, he guided me through the process of how to take Raman and photoluminescence spectra using the Horiba LabRAM.