IPID4all Doctorate Research Exchange with Stevens Institute of Technology.
Feedback report

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Investigation of TMDC materials for solar cells

Introduction

I participated in a two-month research exchange with the NanoPhotonics Lab at Stevens Institute of Technology. I completed a preliminary investigation on the use of transition metal dichalcogenide (TMDC) monolayers in thin-film solar cells. This included learning different exfoliation and stamping techniques for the TMDCs in order to create and investigate rudimentary structures. The goals for this two month exchange are as follows: 1) To learn about and study the stamping set up at Stevens Institute of Technology in order to A) make simple stacked layers of TMDC materials and B) build a similar setup at our institute in the future. 2) Investigate different cleaning methods and substrate materials. 3) Measure the photoluminescence of samples created.

Research Undertaken

A short literature review was conducted in order to gain a basic understanding of TMDC materials characteristics and functions, along with recent developments in the field. The literature review focused on the use of TMDCs in photovoltaic devices. Different fabrication methods for TMDCs were also studied to some degree, with an emphasis on exfoliation and dry stamping.

Before creating TMDC heterostructures, appropriate cleaning methods for the substrates had to be determined. Many methods where tested including cleaning with acids, bases, and alcohols. It was decided that cleaning with an alcohol and rinsing in DI water was the easiest and safest method to use, with no detrimental effects to the stamping process.

The next step was to learn about the stamping setup at Stevens Institute of Technology NanoPhotonics Lab. This setup is based on the paper by Castellanos-Gomez et.al. (2D Materials, 2014) and is an all-dry viscoelastic stamping method. After an introduction to the stamping setup and a lot of practicing exfoliating and stamping TMDCs, rudimentary heterostructures were made. The structures consisted of an insulator (hBN) on a conductive or semiconducting substrate and a TMDC material (MoS_2) partly on top of the insulator and the substrate. Figure 1a shows a sketch of this simple heterostructure, while Figure 1b shows MoS2 and hBN stamped on to a substrate (yellow box indicates the MoS_2 monolayer). Once several of these heterostructures were created preliminary photoluminescence measurements were carried out. One of these measurements can be seen in Figure 1c. All the photoluminescence measurements show that we get a photoluminescence signal when the MoS2 is on the insulating hBN and that we get a weaker or no signal when the MoS_2 is on the substrate. We expected to see a quenching of the signal on the substrate and further investigation will let us know more about the nature of this interaction.

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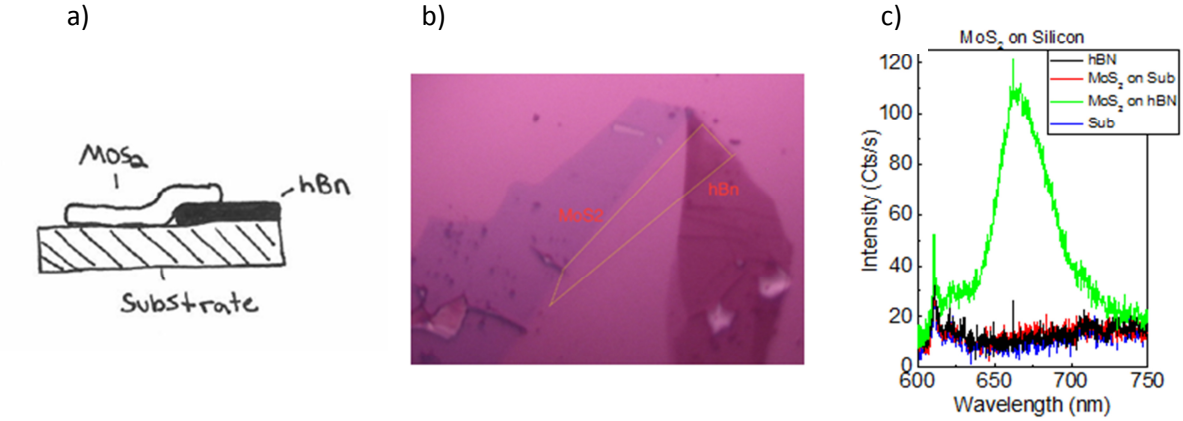

Figure 1: a) Sketch of heterostructure, b) actual heterostructure, and c) preliminary photoluminescence measurement.

Personal Experience

I got to explore a new topic and cutting-edge materials: I expanded my knowledge of TMDCs from the perspective of material scientists and physicists that work with nano photonics instead of the perspective of scientists who work solely with solar technology. I really gained a lot of insight in to my research project by looking at it with people who have different scientific backgrounds. I now have a good foundation to start my PhD research in this field.

Other experiences include: getting to experience the difference between working and researching at a research institute in Germany verse a university in the USA, learning about photoluminescence and how to measure it, and exploring the city and enjoying my time in New York City/Hoboken.

Conclusions

Overall it was a great experience and an amazing start to my PhD project. I was able to complete all of my goals and we produced promising preliminary results. We will further investigate these results by having another student measure photoluminescence at low temperatures, and then continue to explore the possibility of using TMDCs for photovoltaics.

Outlook

The research I did during this exchange was very preliminary so no publications are planned as of yet. However, we hope to further expand our relationship with Stevens Institute of Technology. We have already sent another student to continue with work that was started as a part of this exchange. The goal is to refine the preliminary experiments that I have carried out and we strongly believe that we will be able to publish the results in the future.

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