A Study of Novel Van der Waals Heterostructures

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Low-dimensional structures, because of their novel quantum properties, have recently attracted much interest. In addition to conventional 2D quantum wells, which have been at the heart of research, van der Waals crystals such as graphite and transition metal dichalcogenides (TMDs) have been found to be capable of being cleaved into monolayers, thus providing an ideal platform for research of low-dimensional physics. As many characteristic electronic and optical properties have already been measured for graphene and monolayer TMDs, many researchers are beginning to refocus themselves onto new heterostructures such as graphene/hexagonal boron nitride interfaces, twisted graphene systems, and heterostructures of different TMDs. Here, we report the fabrication and optical and/or electrical measurement of new van der Waals heterostructures. By using gold-mediated mechanical exfoliation and transfer techniques, we fabricated two new van der Waals heterostructures on SiO_2 substrates: one, WSe_2 on top of phosphorous, and the other, MoS_2 on top of ReS_2. We study the optical and electronic properties of these new interfaces, and report our findings.

A Search for Novel Van der Waals Heterostructures

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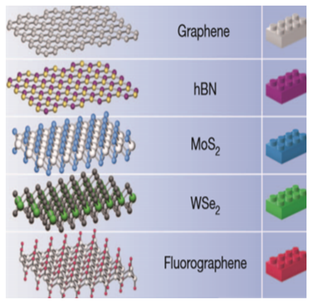
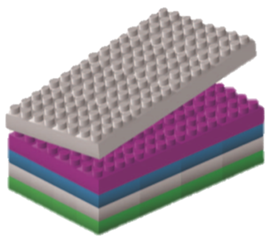
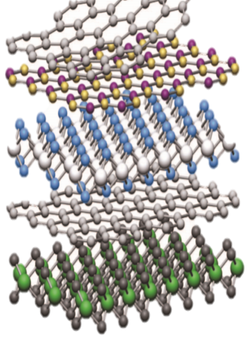
Introduction to van der Waals Heterostructures

- **Van der Waals heterostructures** with crystal layers of different structure have recently been realized
- Monolayer transition metal dichalcogenides **(TMDs)** hold potential as building blocks due to their monolayer stabilities and their characteristic electrical and optical properties
- **WSe_2** is especially interesting for its graphene-like structure, direct band gap, and optical properties
- Although not a TMD, **phosphorene** (single layer black phosphorus) has recently attracted interest due to its own unique optical properties



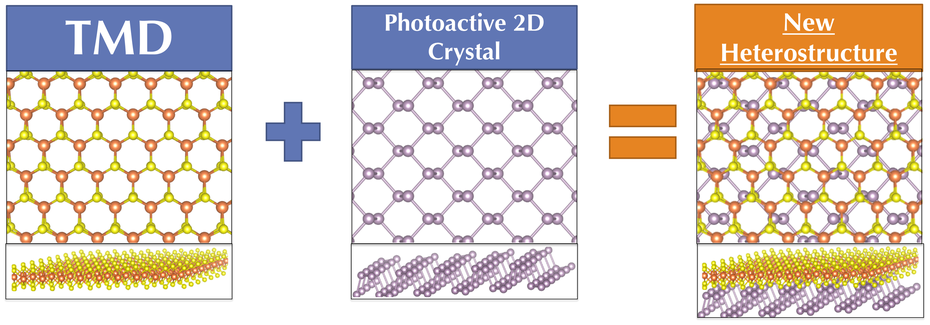


[1]*Van der Waals heterostructures* by Geim, A. K. and Grigorieva, I. V. Nature. dx.doi.org/10.1038/nature123852



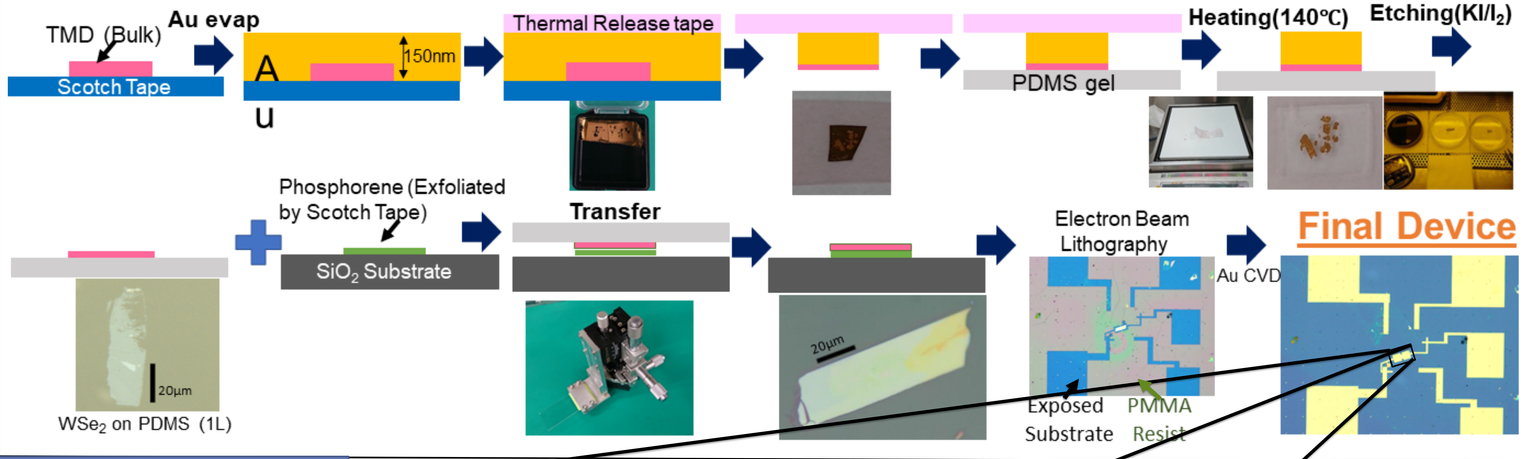
Motivation

- Expand the library of materials by creating new heterostructures with never-before-seen properties
- Explore the properties of these newly formed materials

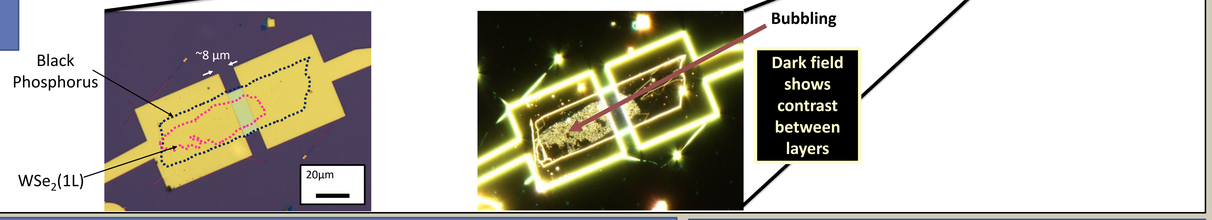


Goal: Create a new van der Waals heterostructure and characterize its optical and electrical properties for application

Device Fabrication

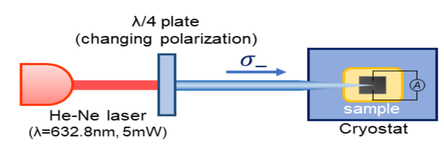


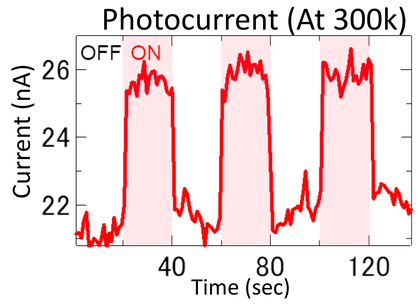
Detailed View



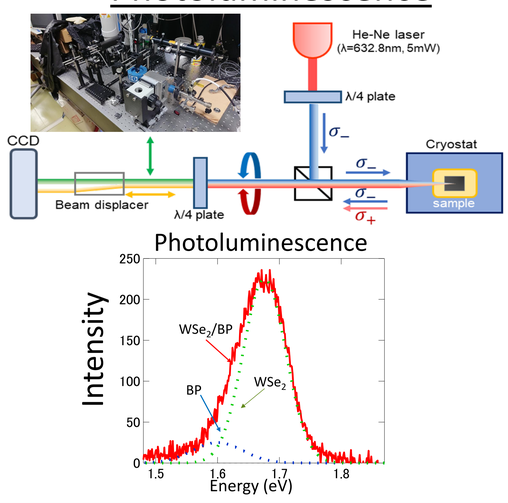
Optical Setups and Measurements

Photocurrent





Photoluminescence



Analysis

- Device capable of producing about 4 nA when struck by laser
- Photoluminescence profile of device appears to be summation of layers

Conclusion

- Photocurrent suggests TMD heterostructures show promise for photovoltaic cells and similar devices
- Photoluminescence data shows no special interaction

Future Work

- Resolve interlayer bubbling
- Find applications in electronics
- Explore similar interfaces

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