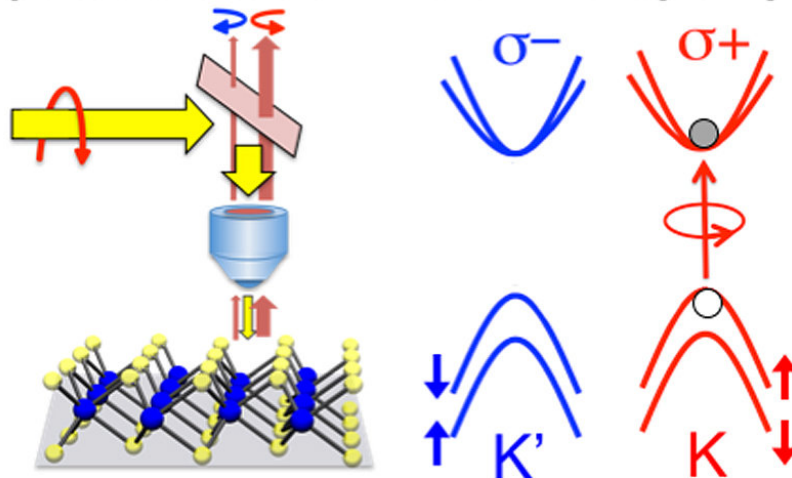


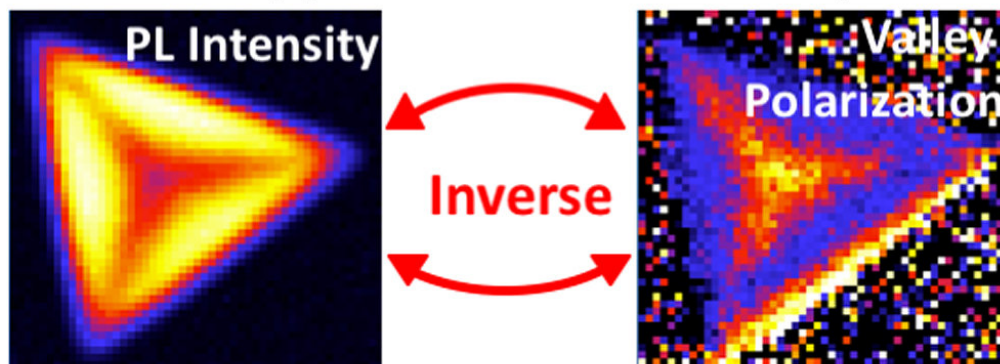
Team clarifies valley polarization for electronic and optoelectronic technologies

October 19 2017, by Daniel Parry

Optical excitation in the K valley only



PL and valley polarization are inversely related



Upper Panel: schematic of optical excitation in the K valley of WS2 monolayers.
 Lower Panel: Photoluminescence (PL) intensity map of a triangular monolayer

island of WS₂ and the associated valley polarization map demonstrate the clear inverse relationship. Each map covers a 46 x 43 micron area. The regions exhibiting smallest PL intensity and lowest quality are found at the center of the flake and radiate outward toward the three corners. These regions correspond to the highest valley polarization. Credit: US Naval Research Laboratory

An interdisciplinary team of scientists at the U.S. Naval Research Laboratory (NRL) has uncovered a direct link between sample quality and the degree of valley polarization in monolayer transition metal dichalcogenides (TMDs). In contrast with graphene, many monolayer TMDs are semiconductors and show promise for future applications in electronic and optoelectronic technologies.

In this sense, a 'valley' refers to the region in an [electronic band structure](#) where both electrons and holes are localized, and 'valley polarization' refers to the ratio of valley populations—an important metric applied in valleytronics research.

"A high degree of valley polarization has been theoretically predicted in TMDs yet experimental values are often low and vary widely," said Kathleen McCreary, Ph.D., lead author of the study. "It is extremely important to determine the origin of these variations in order to further our basic understanding of TMDs as well as advance the field of valleytronics."

Many of today's technologies (i.e. [solid state lighting](#), transistors in computer chips, and batteries in cell phones) rely simply on the charge of the electron and how it moves through the material. However, in certain materials such as the monolayer TMDs, electrons can be selectively placed into a chosen electronic valley using optical excitation.

"The development of TMD materials and hybrid 2D/3D heterostructures promises enhanced functionality relevant to future Department of Defense missions," said Berend Jonker, Ph.D., principal investigator of the program. "These include ultra-low power electronics, non-volatile optical memory, and quantum computation applications in information processing and sensing."

The growing fields of spintronics and valleytronics aim to use the spin or valley population, rather than only charge, to store information and perform logic operations. Progress in these developing fields has attracted the attention of industry leaders, and has already resulted in products such as magnetic [random access memory](#) that improve upon the existing charge-based technologies.

The team focused on TMD monolayers such as WS₂ and WSe₂, which have high optical responsivity, and found that samples exhibiting low photoluminescence (PL) intensity exhibited a high degree of valley polarization. These findings suggest a means to engineer [valley](#) polarization via controlled introduction of defects and nonradiative recombination sites

"Truly understanding the reason for sample-to-sample variation is the first step towards valleytronic control," McCreary said. "In the near future, we may be able to accurately increase polarization by adding defect sites or reduce [polarization](#) by passivation of defects."

Results of this research are reported in the August 2017 edition of the *ACS Nano*.

More information: Kathleen M. McCreary et al. Understanding Variations in Circularly Polarized Photoluminescence in Monolayer Transition Metal Dichalcogenides, *ACS Nano* (2017). [DOI: 10.1021/acsnano.7b02554](#)

Provided by Naval Research Laboratory

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