Probing the Persistent Photoresponse in WS_2 using Kelvin Probe Force Microscopy

S. Chen,[1,#] W. Behn,[1] Z. Jiang,[1] W. Fu,[2] C. P. Y. Wong,[2] K. E. J. Goh,[2] and P. Grutter[1]

[1] *Department of Physics, McGill University, Montreal, H3A2T8, Canada*
[2] *Institute of Materials Research and Engineering, Singapore, 138634*
Presenting author's e-mail: sean.chen3@mail.mcgill.ca

Persistent photoconductivity is a light-induced phenomenon observed in a wide variety of materials and it is characterized by a slow drop in conductivity after illumination is terminated. Monolayer transition metal dichalcogenides are direct bandgap semiconductors [1] that have garnered widespread scientific attention for novel optoelectronic applications. However, the response time of optoelectronic devices fabricated from transition metal dichalcogenides is often limited by persistent photoconductivity with rise times and fall times ranging from milliseconds to days [2, 3, 8]. Thus, it is essential to elucidate the mechanisms responsible for persistent photoconductivity in two-dimensional transition metal dichalcogenides and understand how to tune its properties. Some proposed mechanisms for persistent photoconductivity include charge trapping in adsorbed molecules [3, 6, 7], trapping in SiO_2 [2,5] and trapping from defects in the flake itself [7]. Yet, there is no consensus on the relative importance of these mechanisms in realizing persistent photoconductivity. In this study, we use Kelvin probe force microscopy to visualize the slow reshuffling of charge upon illumination and termination of illumination in mechanically-exfoliated and chemical vapor-grown monolayer WS_2 on silicon dioxide substrates. We aim to study how illumination intensity, illumination wavelength, doping level, and sample thickness influence the characteristics of persistent photoconductivity. Source and drain electrodes are patterned onto WS_2 flakes for photocurrent measurements. Time-resolved surface potential and source-drain photocurrent measurements are compared to reveal the mechanisms responsible for persistent photoconductivity in two-dimensional transition metal dichalcogenides. Initial measurements demonstrate that different mechanically exfoliated samples exhibit drastically different surface potential photoresponse, and surface photovoltage and photocurrent seemingly saturate at different illumination intensity.

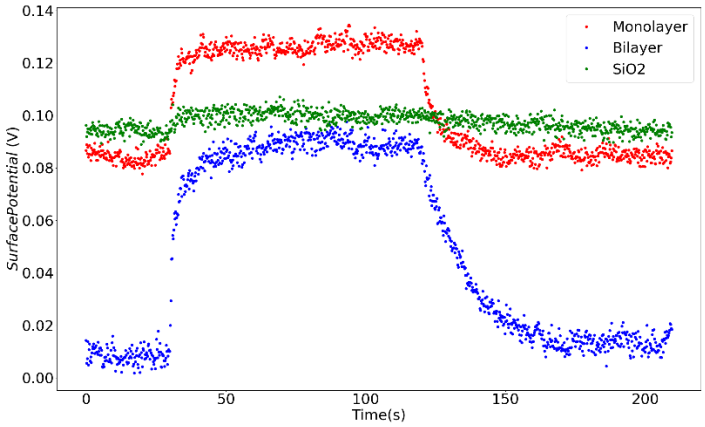

Fig. 1: Surface potential of mechanically exfoliated monolayer WS_2, bilayer WS_2, and SiO_2 substrate plotted vs time. The sample was illuminated with 565 nm LED light at t = 30 s and the light was turned off at t = 120 s. Surface photovoltage on the SiO_2 substrate was measured to keep track of possible tip changes.

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