Unravelling the Mechanism of the Large Photocurrent Enhancement in 2D Transition Metal Dichalcogenides by Plasma Treatment

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The recent attention given to applications such as optoelectronic memories[1] or artificial optical synapses[2] resulted in the emergence of the two-dimensional (2D) transition metal dichalcogenides (TMDs) as the perfect candidates for these types of devices. TMDs under illumination frequently exhibit the effect of persistent photoconductivity (PPC)[3], which allows the storage of electrical information in the device's channel for an extended period after the light is removed. Increasing the signal strength and elongating PPC duration would be very beneficial to developing such applications.

In this communication, we report an over 150-fold increase in the photocurrent signal while simultaneously elongating the response time of the tungsten disulphide and molybdenum disulphide electronic devices by oxygen-argon plasma treatment. The enhancing effect also depends on the applied gate voltage and measurement environment, leading to intriguing differences between the measurements in air and vacuum. This on-chip successful modification method changes the material's structure, introducing structural defects such as atomic vacancies or transition metal oxides. We explain that the enhancement effect is a combined result of introducing the specific trap states in the 2D materials and a favourable choice of wavelength in the experiment.

We believe that our study contributes to paving the way for tuneable 2D TMDs optoelectronic applications.

References

[1] F. Zhou et al., Nature Nanotechnology, 14 (2019), 776–782
[2] M. M. Islam, et al., Scientific Reports, 10 (2020), 1
[3] A. George et al., npj 2D Materials and Applications (2021), 5

Figures

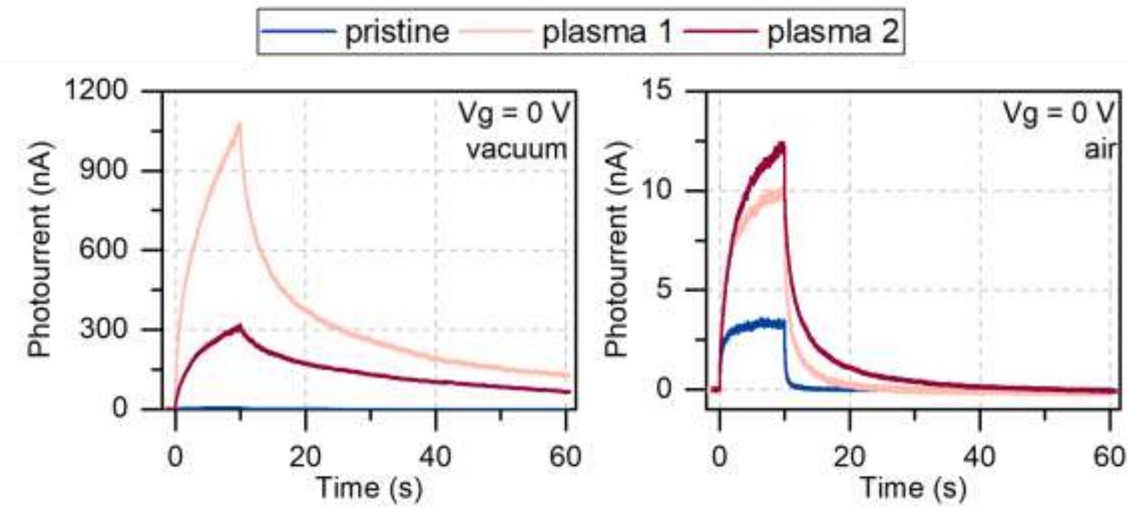

Figure 1: Photocurrent obtained before and after plasma treatment for samples in the vacuum (left) and air (right) at zero gate bias. The signal shows environmental dependence and the photocurrent enhancement reaches over 150 times in vacuum for sample after one plasma treatment.