Electrically gated TMD heterostructures as a tool to achieve 1D excitonic states and study charge carriers

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Due to their layered crystal structure, Transition Metal Dichalcogenides (TMDs) are an excellent platform to study behaviour of free electric carriers in a 2D regime, especially optical properties caused by emergence of different excitonic states. However, to study more intricate states, such as charged excitons, a sophisticated multilayer structures are required. Process used to fabricate such structures must ensure high accuracy in placement of subsequent layers as well as reasonably high success rate. In this work we present such method, which uses a PDMS stamp covered in polycarbonate film. As a proof of concept, an electrically gated WSe_2 structure encapsulated in hBN was prepared and its photoluminescence and reflectivity were measured as a function of applied voltage.

The goal of the ongoing research is twofold. The first one is to study excitons confined in a 1D space due to local lowering of exciton binding energy in nonuniform electric field. Such confinement is possible to obtain in a structure similar to the already fabricated one by proper electrode positioning [1]. The second goal is to study charge carriers unstability in high magnetic field by measurement of X^-' resonance achieved in highly electron-doped regime [2].

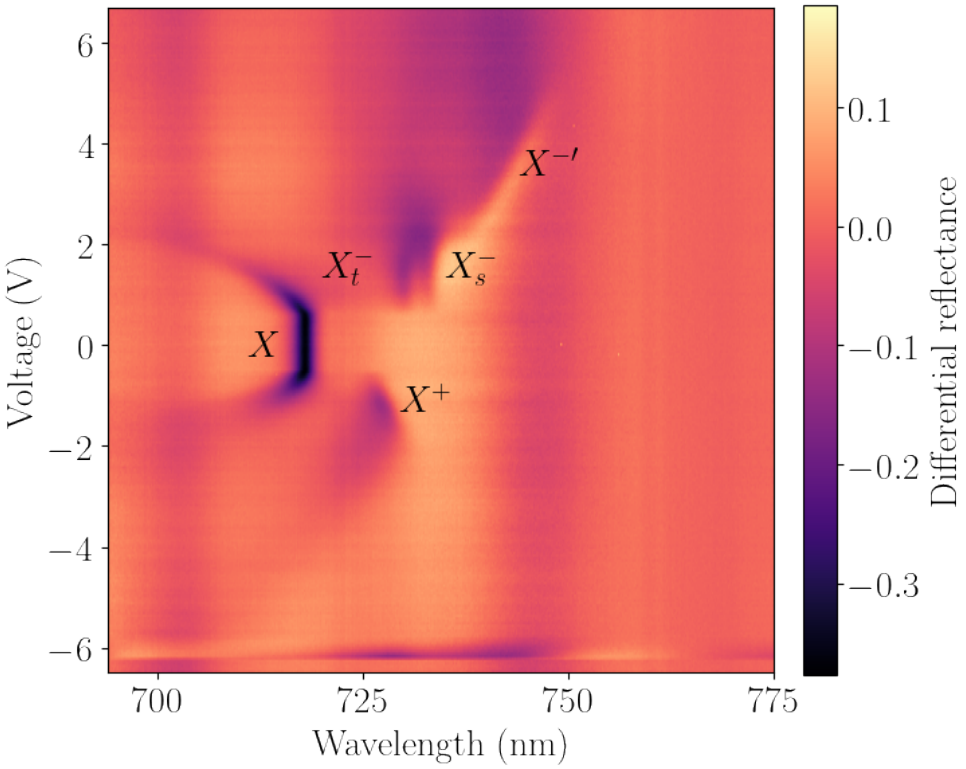

Figure 1: Reflectance of the fabricated sample as a function of applied voltage. Signatures of several different excitonic states are clearly visible.

[1]D. Thureja, A. Imamoglu, T. Smoleński *et al. Nature* **606**, 298-304 (2022),
[2]J. Li, M. Goryca, J. Choi, X. Xu, S. A. Crooker *Nano Letters* **22** (1), 426-432 (2022).