Ionic Glass Gated 2D Material Based Field Effect Transistor and Phototransistor: $MoSe_2$ over LaF_3 as case study.

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Abstract : Modulating the carrier density of two dimensional ('2D') materials is pivotal to tailor their electrical properties, with novel physical phenomena expected to occur at higher doping level. Here, the use of ionic glass as a high capacitance gate is explored to develop 2D material based phototransistor operated for the first time with higher carrier concentration up to $5x10^{13}$ cm^{-2}, using $MoSe_2$ over LaF_3 as archetypal system [1]. Ion glass gating allows low operating biases, then circumventing the possible electrical breakdown of conventional dielectric gating, while preserving low temperature operation which is not possible using electrolytes gating. It reveals to be a powerful technique combining the high carrier density of electrolyte gating methods while enabling direct optical addressability impeded with usual electrolyte technology. The $LaF_3/MoSe_2$ phototransistors demonstrate I_{ON}/I_{OFF} ratio exceeding 5 decades and photoresponse times down to 200 µs, up to two decades faster than $MoSe_2$ phototransistors reported so far. Careful phototransport analysis unveils that ionic glass gating of 2D materials allows tuning the nature of the carrier recombination processes, while annihilating completely the traps contribution in electron injection regime. This remarkable property results in photoresponse that can be modulated electrostatically by more than two orders of magnitude, while at the same time increasing the gain bandwidth product. This study demonstrates the potential of ionic glass gating to explore novel photoconduction processes and alternative architectures of devices. Finally, this approach reveals to be a promising technology to develop 0D based phototransistor for IR detection. [2].

References

[1] <u>Ulrich N. Noumbé</u> et al, Adv Funct Mat. 2019, 29 (33), 1902723
[2] Charlie Gréboval, <u>Ulrich Noumbé</u> et al, Nano Lett. 2019, 19, 6, 3981-3986.

Figure

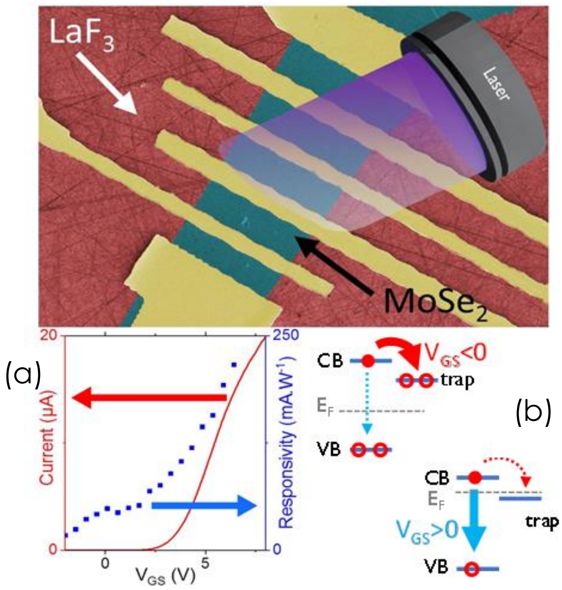

Figure: (a) Transfer curve in red and responsivity gate dependent in blue; (b) Schemes illustrate relaxation mechanisms for negative biases (top) and for positive biases (bottom