Can the Recent FAB Progress in 2D Transistors Serve 2D Photodetectors?

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The tremendous amount of research on photodetectors with 2D channels has recently resulted in creation of a big zoo of prototypes with different layouts and operation principles [1]. This makes it complicated to select the most suitable 2D photodetector technology and move towards further integration, as finding the optimum trade-off between the technology-related aspects and performance characteristics remains complicated.

In this work we suggest to complement the recent advances of the optoelectronics community with what we have achieved working on 2D field-effect transistors (FETs) which are already being explored by the semiconductor industry [2,3]. First, back-gated FET-like 2D photodetectors, which in our opinion is the optimum way to go, would give an extra degree of freedom to modulate the device performance as compared to two-terminal devices (Fig.1a). However, currently available FET-like 2D photodetectors are impractical due to the use of thick oxides and resulting high operation voltages up to 70V [4]. Thus, scalable crystalline insulators such as CaF_2 [5] and Bi_2SeO_5 [6] previously used in 2D FETs should be very beneficial for 2D photodetectors as they would enable stable performance within CMOS-compatible few Volts operation range (Fig.1b), thereby also lowering power consumption. Next we will have to take into account that the use of a single 2D material as an active layer in photodetectors is typically not sufficient to achieve all desired performance parameters at once [7]. Thus, our recent results on CdS_xSe_{1-x}/PbI_2 heterostructures which enable photodetectors with simultaneously high photoresponsivity and fast time response (Fig.1c) will have to be considered. Finally, for CMOS circuits a buried back gate [4] is required for individual control of each particular device on the chip. Combining all these findings will bring us to the desired structure of a future 2D photodetector shown in Fig.1d.

In summary, we believe that future FET-like photodetectors employing scalable gate insulators, heterostructure channels and local back gates would be very attractive for future integrated circuits as they should simultaneously have superior performance and facile CMOS-friendly processing technology.

References

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Figures

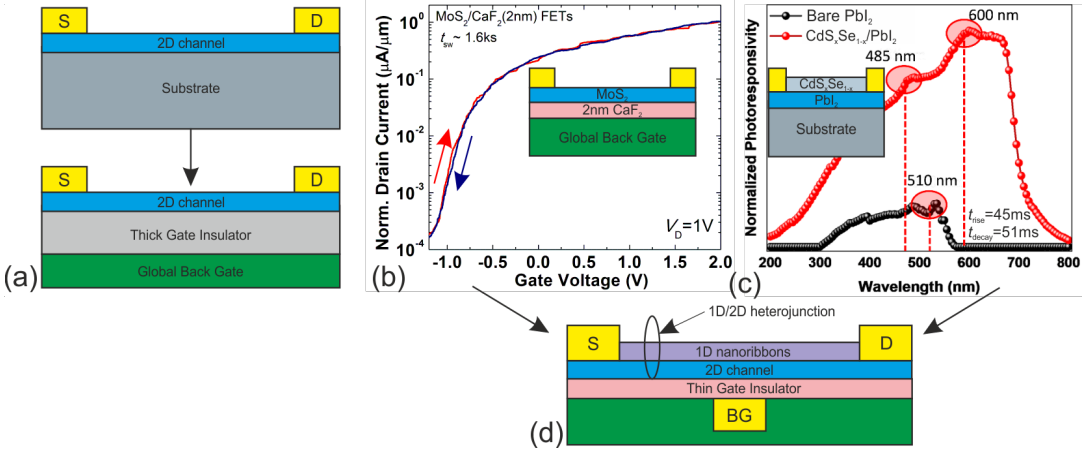

Figure 1: (a) Schematics of a two-terminal 2D photodetector (top) and a FET-like device with global back gate (bottom). (b) Back-gated MoS_2 FETs with 2nm CaF_2 insulators offer stable operation within few Volts bias range. (c) Photodetectors based on 1D CdS_xSe_{1-x}/2D PbI_2 heterojunctions exhibit fast photoresponse in a broad spectrum range. (d) Schematics of FET-like 1D/2D heterostructure photodetector with thin insulator and local back gate which could combine our advances made in scalable 2D FETs and heterojunction photodetectors.