Multifunctional Optoelectronic Platform using Two-Dimensional Lateral Heterostructures

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Two-dimensional (2D) transition metal dichalcogenide (TMDs) based heterostructures hold great promise for future VLSI technology with sub-nm nodes due to their distinct optical and electrical properties[1]. In this context, 2D lateral heterostructures (LHS) with spatially separated domains and 1D heterointerfaces can provide unique device engineering with controlled charge carriers and gate electrostatic transport, promising for low-power, high-speed, and energy-efficient applications[1–6] Over the years, numerous proof-of-principle 2D heterostructure devices have been fabricated via chemical and physical transfer processes. However, scalable, controlled, and electronic-grade synthesis of 2D TMDs and associated heterostructures remains a challenge. Among the different synthesis processes, chemical vapour deposition (CVD) is a potentially viable and cost-effective technology for fabricating a wide variety of 2D LHS. In this context, we use the water-assisted one-pot CVD method, a scalable, reliable, and reproducible approach for the sequential growth of $MoSe_2$-WSe_2 multijunction LHS with controlled layer numbers and domain sizes[1,2]. The as-synthesized 2D LHSs are characterized using Raman and photoluminescence spectroscopy to evaluate their crystallinity, chemical composition, and optical quality. LHS-based FETs were fabricated to evaluate their electrical transport characteristics and crucial figure-of-merits. The output transfer characteristics reveal the n-type and p-type dopings for $MoSe_2$ and WSe_2, respectively. The drain current as a function of drain voltage across the interface exhibits diode-like characteristics, confirming the formation of a P-N junction. Furthermore, we have demonstrated bipolar junction transistors and electroluminescent devices that can be further fine-tuned as a function of external gate bias. The results seem promising for the realization of all 2D in-plane opto-electronic devices.

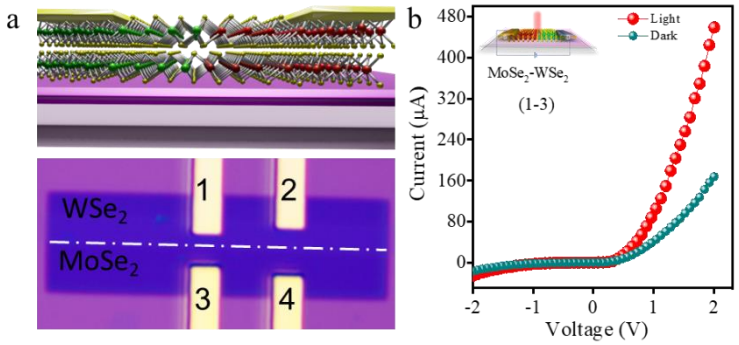

Figure 1a. schematical representation and optical microscopic image of $MoSe_2$-WSe_2 lateral heterostructure devices and
b. comparison of the photo response characteristics of under dark and light conditions.

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