Noble TMDs heterostructures based devices

M. Perucchini, D. Marian, E. G. Marin, G. Iannaccone, G. Fiori
Dip. di Ingegneria dell’Informazione, Università di Pisa, via Girolamo Caruso 16, 56122, Pisa, Italy
gfiori@mercurio.iet.unipi.it

The possibility of combining different materials to obtain a tailor-made ultra-thin heterostructure is a peculiarity and an advantage of two-dimensional (2D) materials. Among them, the so called noble-transition-metal dichalcogenides (TMDs) stand out for their exceptionally bandgap dependence on stacking order, which can also lead to a change of fundamental electronic properties (from metal to semiconductor) [1]. Recently, some of these materials have been synthesized in mono- and few-layers and exploited in the realizations of Field Effect Transistors (FETs) [2-4]. By means of multi-scale simulations, we explore the potential of new device concepts based on PdS$_2$, PtS$_2$ and NiS$_2$ lateral heterostructures (LH), which operate either as Schottky Barrier (SB) or as standard FETs. We will show that PdS$_2$ and PtS$_2$ based devices show a very promising behaviour, compliant with industry requirements for low power and high-performance applications.

References

Figure 1: Electronic band-structure for mono-layer and bilayer PtS$_2$ and PdS$_2$ as calculated with Density functional theory (circles) and with Maximally Localized Wannier Functions (lines). On top: 1T-crystal structure, lateral and top view.

Figure 2: Transfer characteristic (semi-logarithmic scale) for LH-FETs with channel lengths ranging from 5 nm up to 10 nm made of PdS$_2$ (a), NiS$_2$ (b) and PtS$_2$ (c). The drain-to-source voltage $V_{DS}$ is 0.5 V.