Dress them with molecules! Elevating 2D materials to a new dimension

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The already exceptional properties of 2D semiconductors can be further tuned, enriched and enhanced by interfacing them with ad hoc molecular switches, by mastering principles of supramolecular chemistry. By taking full advantage of the almost unlimited variety of molecular switches that can be designed and synthesized with functionalities at will, one can engineer 2D semiconducting hybrid materials exhibiting dynamic physical and chemical properties, tailored-made for applications in electronics beyond CMOS through the functional diversification following a “more than Moore” strategy. [1]
In my lecture I will present our recent findings on the covalent and non-covalent functionalization of 2D materials to engineer hybrid systems. This has been accomplished via the controlled interfacing of its two surfaces either in a symmetric or asymmetric fashion with molecular switches, thereby imparting additional properties to MoS_2, back phosphorous or WSe2, rendering 2D material-based transistors capable to respond to as many as four different independent stimuli.[2] Such a strategy enables to execute complex function thereby emulating neuromorphic-based cognitive processes.[3] Physical sensors for medical diagnosis and health monitoring were also realized, upon use of active materials with sensitivities in the low-pressure or medium-pressure range. Example of flexible piezoresistive pressure sensors compatible with wearable technologies for digital healthcare, human-machine interfaces and robotics will be provided. [4]
The presented modular strategies provide a glimpse on the chemist’s toolbox to generate multifunctional 2D materials -based hybrids with ad-hoc properties to address key global challenges in electronics, sensing and energy applications.

References

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[2] (a) *Nat. Commun.* **2018**, *9*, 2661. (b) *Nat. Commun.* **2017**, *8*, 14767. (c) *ACS Nano*, **2019**, *13*, 4814–4825. (d) *Adv. Mater.* **2019**, *31*, 1903402. (e) *Adv. Mater.* **2020**, 32, 1907903. (f) *ACS Nano* **2021**, *15*, 10668–10677. (g) *Adv. Funct. Mater.*, **2021** *31*, 2102721
[3] *Adv. Mater.*, **2024**, *36*, 2307359.
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Figure

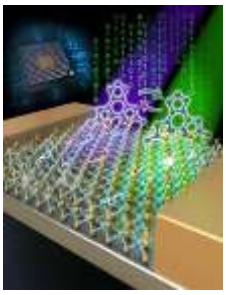

Figure 1. Figure 1: Optically switchable multilevel high-mobility FETs based on few-layer ambipolar WSe_2.