Wearable Gas sensors based on functionalized transition metal dichalcogenide nanosheets for the detection of NO_x and CO

Air pollution is undeniably one of the major issues in our contemporary world, it was labelled as ‘the largest environmental hazard’ and according to research by the EU's environmental protection agency, roughly 400 000 death are related to air pollution in the EU in 2021 [1]. Air pollution is monitored by measuring concentrations of various pollutants using very accurate and expensive instrumentations. The gold standard for monitoring air pollution is spectroscopy-based techniques such as gas chromatography, infrared absorption spectroscopy, and mass spectrometry. All these analytical systems show a high sensitivity, down to the low concentrations. However, such equipment is stationary, costly, bulky, requires strict maintenance routines and qualified training personals [2]. This has led to increased demand for portable, low-power consuming, customizable gas sensors capable of performing the detection of toxic gases and their quantification with high sensitivity, specificity and speed, without additional sample pretreatment. Chemiresistive gas-sensors have clear attractive advantages over other family of gas sensors, because they are easier to integrate with conventional microelectronics technology for implementation into portable devices. Metal oxides Semiconductors (MOS) are the most investigated sensing materials for resistive sensors. However, they suffer from a high working temperature (200–450°C) in order to induce the oxidation reaction on their surface, low sensitivity (can detect only in the sub-parts-per-million (ppm)), a slow response at low concentrations of analytes, and a poor selectivity [3]. To resolve these limitations, two-dimensional (2D) layered materials, such as graphene, transition metal dichalcogenides (TMDs) and MXenes are a promising alternative; they have ability to sense gases at room temperature (RT), with a good sensitivity, a fast response/recovery time and a moderate selectivity due to their large surface area, which facilitates surface reactions via physisorption or chemisorption [4].

In the framework of the internship we will develop new wearable gas sensors based on functionalized 2D materials and their heterostructures that will be able to detect sub-ppm-level NO_2, CO, and CO_2 pollutants, in a highly selective manner, in urban environments. The sensing layers will be produced by a solution-processable method for cost effective reason and its compatibility at large-scale manufacturing. To improve the sensitivity, selectivity,

stability and time response/recovery of the sensor, its surface will be chemically functionalized and engineered by specific molecules that selectively bind to the target gas analyte.

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