Abstract

Transition metal dichalcogenides are fascinating materials that can be used in various applications like electrochemistry, catalytic reactions, optoelectronics, sensing applications and many more. They have unique tunable layer-dependent properties that can be exploited in those applications. Amongst the various transition metal dichalcogenides, MoS_2 is probably the most sought-after material due to its abundance and ease of production. MoS_2 and its composites are excellent materials for resistive sensing applications. Resistive sensors are easy to fabricate. Cost-effective and CMOS compatible. MoS_2 and its composite-based resistive sensors can monitor various environmental parameters such as humidity and heavy metal ion concentrations in drinking water. These parameters are critical as specific values can cause serious health hazards.

MoS_2 and its biocomposites, such as bovine serum albumin, acted as a low-power humidity sensor with an operating voltage of 0.5 V. It has a response and recovery time of 1.03 seconds and 2.09 seconds at 70% relative humidity. A current calibration model was developed to understand the carrier interaction with humidity and the channel material. However, this material suffers a drawback as the biocomposite degrades over 45^0C. An amine-functionalised MoS_2 was prepared to mitigate the temperature issue. It was exfoliated via a low-temperature water-based exfoliation technique. The sensor has low hysteresis and can sense up to 10% relative humidity. The operating temperature of the sensor can be reached up to 65^0C. The low humidity response of the sensor was thoroughly analysed. A pseudo electron injection model was put forward, where a relation between humidity, band bending, carrier concentration and the system's response has been modelled.

Thioglycolic acid-modified MoS_2 has been prepared to sense toxic metal ions from drinking water. The sensor showed a cross-sensitivity between cadmium and mercury ion. The problem was solved by introducing a mixed-response model, where mercury and cadmium are injected simultaneously into the channel. The model dictates that cadmium loses its selectivity in the presence of mercury. The kinetics of the adsorption was also studied. Finally, the band-bending and carrier concentration of the device was analysed with and without mercury.

In the last work, a flexible inter-digitised electrode-based reduced graphene oxide-MoS_2 nanojunction aggregate device was fabricated to sense mercury ions in an aqueous medium selectively. The system's response was analytically investigated and matched with the experimental values. The p-n junction played a pivotal role in the overall response.

All the devices are made by standard CMOS process and can be integrated into any IoT platform.

Keywords: MoS_2, exfoliation, humidity sensor, heavy metal sensor, resistive sensors.