Reversing of humidity response of MoS_2- and WS_2-based sensors with metal coatings

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Abstract

Two-dimensional materials, such as transition metal dichalcogenides, have been identified as attractive candidates for sensing applications due to their high surface-to-volume ratio, chemically active edges and good electrical performance. However, their electrical response to humidity is still under debate and the experimental reports still remain inconclusive. For instance, the impedance of the MoS_2-based sensors decreases or increases with increasing humidity, compromising the use of MoS_2 for humidity sensing. In this work we focus on understanding the interaction between water and the transition metal dichalcogenides. We fabricated and studied humidity sensors based on MoS_2 and WS_2 coated with copper and silver metals. The devices exhibited high chemical stability and excellent humidity sensing performance in relative humidity between 4 and 80%, with response and recovery times of 2 and 40 seconds, respectively. We have systematically investigated the humidity response of the materials as a function of the type and amount of metal coating and observed the reverse action of sensing mechanisms. This phenomenon is explained based on a detailed structural analysis of the samples considering the Grotthuss mechanism in the presence of charge trapping, which was verified by simulations of an appropriate lumped-element model. Our findings open up a possibility for tuning of the electrical response in a facile manner and without compromising the high performance of our sensor.