Effects of MWCNTs/graphene nanoflakes/MXene addition to TiO2 thick film on hydrogen gas sensing

ABSTRACT

Various doping materials, such as MWCNTs, graphene nanoflakes and MXene, have been doped into TiO2 and the hydrogen sensing properties investigated. Using a similar volume, MWCNTs (5 wt.%) and graphene nanoflakes (5 wt.%) and MXene (10 wt.%) were added to TiO2 and prepared in a paste form by mixing the sensing material with the organic binder. The sensing film was deposited on an alumina substrate using a screen-printing technique and annealed at 500 °C for 30 min in ambient air. The crystallinity of TiO2 and the doped material in the sensing film after the annealing treatment were verified using FESEM, EDX, XRD and Raman Spectroscopy. By depositing an interdigitated electrode at the bottom of the sensing film, the thick film gas sensors (TiO2/MWCNT, TiO2/Gr, TiO2/MXene) were exposed to 100–1000 ppm of hydrogen at an operating temperature of 100–250 °C. The responses showed that the addition of MWCNTs and MXene to TiO2 reduced the operating temperature of the TiO2 gas sensor from 150 °C to 100 °C, while the addition of graphene nanoflakes did not affect the operating temperature of the TiO2 gas sensor. The TiO2/MWCNT gas sensor showed linear sensitivity as hydrogen concentrations increased for operating temperatures of 100–250 °C. The optimal operating temperature for TiO2/MXene occurred at 100 °C, while the optimal operating temperature for the TiO2/Gr gas sensor occurred at 200 °C. The highest sensitivity for 100–500 ppm hydrogen was generated by the TiO2/MXene gas sensor, and for 600–1000 ppm hydrogen was generated by the TiO2/MWCNT gas sensor at an operating temperature of 250 °C. The TiO2/MWCNT gas sensor produced the highest sensitivity to hydrogen at the operating temperature of 250 °C with sensitivity values of approximately 6.36, 33.61, 67.64, 102.23 and 159.07 for 100, 300, 500, 700 ppm and 1000 ppm of hydrogen, respectively.

Keyword: MWCNTs; Graphene nanoflakes; Ti3C2Tx MXene; TiO2 hydrogen gas sensor; Screen-printing; Thick film