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Review Article

On the Low-Temperature Response of Semiconductor Gas Sensors

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Abstract

The present paper compares three different kinds of semiconductor gas sensing materials: metal oxides (MOX), hydrogen-terminated diamond (HD), and hydrogenated amorphous silicon (a-Si:H). Whereas in MOX materials oxygen is the chemically reactive surface species, HD and a-Si:H are covalently bonded semiconductors with hydrogenterminated surfaces. We demonstrate that these dissimilar semiconductor materials exhibit the same kind of low-temperature gas response. This low-temperature response-mechanism is mediated by a thin layer of adsorbed water with the semiconductor materials themselves acting as pH sensors. In this adsorbate-limited state the gas sensitivity is limited to molecular species that can easily dissolve in H2O and subsequently undergo electrolytic dissociation. At higher temperatures, where a closed layer of adsorbed water can no longer exist, the gas response is limited by direct molecule-semiconductor interactions. In this latter mode of operation, MOX gas sensors respond to adsorbed gases according to their different oxidising or reducing properties. Hydrogenated amorphous silicon (a-Si:H), on the other hand, exhibits a significantly different cross sensitivity profile, revealing that gas-surface interactions may largely be restricted to analyte molecules with lone-pair and electron-deficient three-centre orbitals.