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Facile fabrication of semiconducting oxide nanostructures by direct ink writing of readily available metal microparticles and their application as low power acetone gas sensors

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Abstract

In this work, a facile two-step fabrication and characterization of printed acetone sensors based on mixed semiconducting metal oxides is introduced. The devices are fabricated by Direct Ink Writing metal microparticle (MP) stripes of commercially available pure iron and copper particles onto the surface of a glass substrate, forming a bridging multi-phase semiconducting oxide net by subsequent thermal annealing. The open, highly porous bridging structures consist of heterojunctions which are interconnected via non-planar CuO/Cu2O/Cu nanowires and Fe2O3/Fe nanospikes. Morphological, vibrational, chemical and structural studies were performed to investigate the contact-forming Fe2O3–CuO nanostructures on the surface of the MPs. The power consumption and the gas sensing properties showed selectivity to acetone vapor at an operating temperature of around 300 °C with a high gas response of about 50% and the lowest operating power of around 0.26 µW to a concentration of 100 ppm of acetone vapor. The combination of the possibility of acetone vapor detection, the controllable size and geometry and their low power make these printed structures important candidates for next developments of accessible detection devices, as well as acetone vapor monitoring (even below 1 ppm). The printing of MPs in general paves the way for a new generation of printed different devices, even in "home-made" conditions, for a manifold of applications tailored by the composition and geometry of the printed MP stripes, enabled through the simplicity and versatility of the fabrication method.