



ACS Applied Materials &
Interfaces

2019, Vol. 11, Issue. 28, pag. 25508-25515

3D-Printed Chemiresistive Sensor Array on Nanowire CuO/Cu₂O/Cu Heterojunction Nets

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<https://doi.org/10.1021/acsami.9b04385>

Abstract

In this work, the one-step three-dimensional (3D) printing of 20 nm nanowire (NW)-covered CuO/Cu₂O/Cu microparticles (MPs) with diameters of 15–25 μm on the surface of the glass substrate forming an ordered net is successfully reported for the first time. 3D-printed Cu MP-based stripes formed nonplanar CuO/Cu₂O/Cu heterojunctions after thermal annealing at 425 °C for 2 h in air and were fully covered with a 20 nm NW net bridging MPs with external Au contacts. The morphological, vibrational, chemical, and structural investigations were performed in detail, showing the high crystallinity of the NWs and 3D-printed CuO/Cu₂O/Cu heterojunction lines, as well as the growth of CuO NWs on the surface of MPs. The gas-sensing measurements showed excellent selectivity to acetone vapor at an operating temperature of 350 °C with a high gas response about 150% to 100 ppm. The combination of the possibility of fast acetone vapor detection, low power consumption, and controllable size and geometry makes these 3D-printed devices ideal candidates for fast detection, as well as for acetone vapor monitoring (down to 100 ppm). This 3D-printing approach will pave a new way for many different devices through the simplicity and versatility of the fabrication method for the exact detection of acetone vapors in various atmospheres.