I3S 2021

sciforum

Abstract

Palladium Nanoparticles Decorated Electrostatically-Formed Nanowire Sensor for High Performance Hydrogen Gas Detection †

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† Presented at the 8th International Symposium on Sensor Science, 17–26 May 2021; Available online: https://i3s2021dresden.sciforum.net/.

Published: date

Abstract: CMOS based Electrostatically-Formed Nanowire (EFN) sensor is based on a silicon nanowire field-effect transistor (FET) with a nanowire that is electrostatically formed and controlled by post fabrication. The EFN-FET is composed of doped silicon region surrounded by three gates: bottom gate and two lateral junction gates. Appropriate biasing at the gates induces depletion regions at the gate-silicon interfaces and an un-depleted silicon region which is electrostatically shaped into a wire of several nm in diameter is now available for conduction. Target gas molecules get adsorbed on the SiO_2 surface and via field-effect modifies the current conduction through the nanowire. Further, surface functionalization of these EFN sensors by metal nanoparticles could be an effective approach to achieve selectivity towards gases. For example, Pd nanoparticles (1 nm) decorated EFN (Pd-EFN) sensor shows promising results towards hydrogen gas. It shows excellent sensor responses at all concentrations ranging from 0.2 to 2.56% with quick response and recovery times. Also, the responses are linear over the entire concentration range and shows good repeatability. A low detection limit of 200 ppm (with a sensor response of 500%) is achieved which is much lower than the lower explosive limit of hydrogen gas which is 4%. The sensor retains good performances even in humid conditions with 80% RH. The sensor performances can further be tuned through application of different gate biases. A comparison of the performance metrics with the state of the art hydrogen sensors show that Pd-EFN proves to be a promising hydrogen sensor.

Keywords: hydrogen gas sensor; CMOS based sensor; nanowire FET; palladium nanoparticles decoration