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Extended Abstract

Fully Printed Flexible Chemiresistors with Tunable Selectivity Based on Gold Nanoparticle Composites †

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Functional composite nanomaterials are promising candidates for the fabrication of wearable, flexible chemiresistive sensors which can be used, e.g., in food analysis, healthcare and for medical diagnosis [1–3]. Among various nanomaterials, gold nanoparticles (GNP) have been studied intensively during the past two decades as they are especially suited for the design of highly responsive chemiresistive gas and vapor sensors [4,5]. Major advantages of GNPs in sensing applications are their tunable surface characteristics via well-established thiol-gold chemistry as well as the perturbation sensitive charge transport mechanism of GNP assemblies. Furthermore, GNPs are easily synthesized via wet chemical protocols and, after appropriate stabilization, GNP solutions can be used for different ink-based patterning and substrate deposition approaches. However, it is still a challenging task to pattern GNP-based nanomaterials onto flexible substrates and to integrate them into complex electronic circuits.

In this study, we present two-step printed chemiresistive vapor sensors consisting of gold nanoparticles (GNPs) embedded in different organic thiol matrices. First, interdigitated silver paste electrode structures are printed via dispenser printing onto polyimide (PI) foil. Second, thin films of interconnected GNPs are inkjet-printed onto these electrodes. As depicted in Figure 1a, the GNP and thiol inks are printed as alternating layers to obtain a cross-linked chemically selective sensing material. The thiol matrix contains nonanedithiol (9DT) as cross-linking agent and a functionalized monothiol to tune the selectivity of respective chemiresistor. Due to the inkjet printing technique, quite homogenous films (Figure 1b) with defined geometries were obtained. Several sensors with different chemical selectivity were fabricated this way and combined to form a sensor array. As shown by the radar plot in Figure 1c, this sensor array was able to discern different analyte vapors. The tunable selectivity of individual sensors is attributed to the incorporation of differently concentrated hydrophilic sorption sites, i.e., hydroxyl groups and carboxylic acid groups.

In summary, our approach enables the facile on demand patterning of GNP layers via inkjet-printing on dispenser-printed silver electrodes. The GNP layers are cross-linked with 9DT and their chemical selectivity is controlled by adding functionalized monothiols. The technique is well-suited for the fabrication of chemiresistive sensor arrays with prospective applications in electronic nose devices.

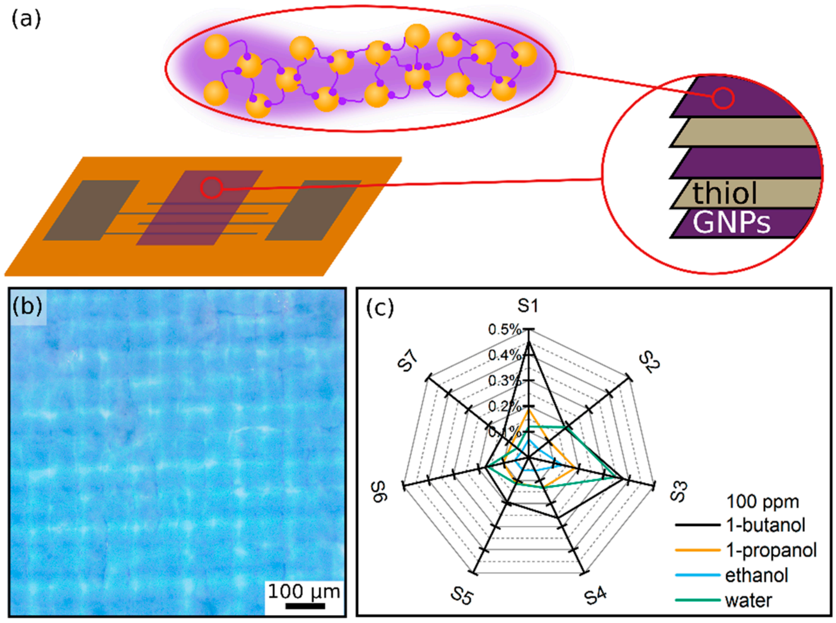

Figure 1. (**a**) Schematic zoom of a layer-by-layer inkjet-printed flexible chemiresistor on polyimide (PI) foil. (**b**) Optical micrograph of an inkjet-printed sensitive nanoparticle layer on glass. (**c**) Radar plot showing the responses of seven sensors with tuned selectivity to various analytes.

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