Fabrication via Contact Printing: Chemical and Physical Sensors from Cross-Linked Nanoparticles

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Layered nanocomposites based on graphene, carbon nanotubes, or noble metal nanoparticles are excellently suited for the fabrication of various types of healthcare sensors. For example, layered nanocomposites deposited onto polymeric substrates can be employed as epidermal pulse wave sensors or for monitoring of muscle activity [1,2]. Further, thin films of gold nanoparticles (GNPs) can be used as highly sensitive chemiresistors [3], rendering them interesting for the detection of volatile compounds transpired from skin or contained in exhaled breath. Thus, these sensors can be used for medical diagnosis [2].
However, the development of robust and cost-efficient fabrication schemes for such sensors remains extremely challenging. Here, we present a simple and versatile method for printing physical and chemical sensors based on layered nanocomposites.
In particular, we show how thin films of cross-linked GNPs can be transferred onto various substrates via contact printing to produce different types of sensors. In one approach, spin-coated GNP films are peeled off with a PDMS stamp and transferred via contact printing onto flexible or rigid substrates equipped with suitable electrodes. For example, we present the fabrication of very sensitive and robust strain gauges by stamping GNP films onto flexible polyimide substrates. When taped onto the skin, these sensors can be employed to monitor muscle movements. Further, such sensors can also be applied as flexible chemiresistors, which are interesting for the design of wearable gas sensors. In another example, we printed GNP-films onto 3D-structured substrates to produce freestanding GNP membranes. These microelectromechanical systems (MEMS) can be employed as resistive pressure sensors [4] (see Fig. 1a), or as electrostatically driven resonators [5], which can also be used as gas sensors [6].
Finally, using a modified approach, we prepared an all-printed, highly flexible pulse wave sensor. First, a PDMS sheet is furnished with silver paste electrodes via dispenser printing. The PDMS sheet is then used to peel off the spin-coated GNP film. After taping the thus fabricated all-printed strain sensor onto the skin above the radial artery, well-resolved pulse wave signals could be recorded, enabling a clear discrimination of diagnostically valuable waveform components (see Fig. 1b).

References

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Figures

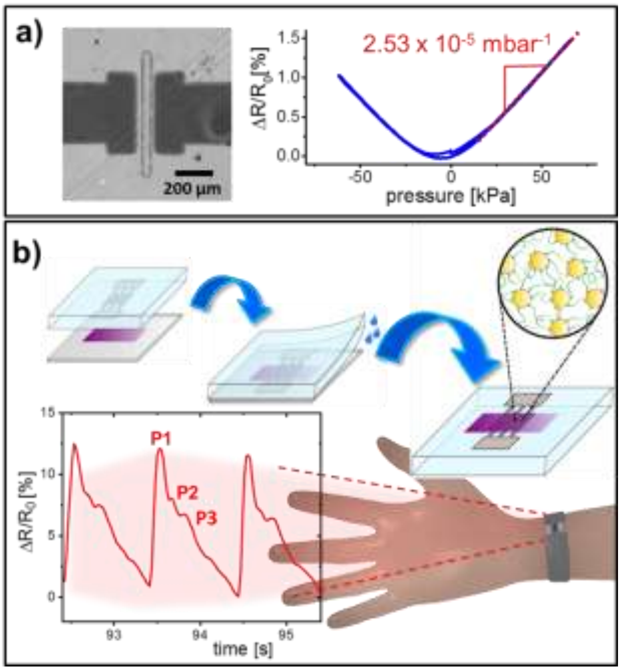

Figure 1. a) Micrograph of printed barometric pressure sensor based on a GNP membrane (left); transfer function (right). b) Scheme for the fabrication a GNP based pulse wave sensor with measured transients.