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Ultra-lightweight pressure sensor based on graphene aerogel decorated with piezoelectric nanocrystalline films

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Abstract

In this paper, we report on a pressure sensor based on graphene aerogel functionalized with SnO_2 or GaN thin films deposited by magnetron sputtering. Decoration by nanocrystalline SnO_2 or GaN was found to enhance the piezoresistive response of the bare aerogel. The responsivity and pressure sensing range (from 1–5 atm) of the sensor are shown to be higher than those inherent in pressure sensors based on graphene membranes.

Keywords: graphene aerogel, pressure sensor, piezoelectric nanomaterials, functionalization

(Some figures may appear in colour only in the online journal)

1. Introduction

Graphene aerogel is an extra porous (degree of porosity >99%) 3D ultra-lightweight material formed from randomly-distributed graphene networks with a very low density (0.2 g cm^{-3} < ρ < 3 g cm^{-3}), which is able to absorb oil in a quantity exceeding its own weight by two to three orders of magnitude. Graphene aerogels are fabricated by freeze-drying aqueous solutions of large graphene oxide sheets followed by chemical reduction in graphene with hydrazine vapor [1]. Graphene aerogel is deformable at an applied mechanical stress, displaying a compression factor of 90% [2], can be printed for flexible electronics [3] and can be doped with Fe_3O_4 nanoparticles, in cases in which it is deformable via magnetic forces [4]. Graphene aerogels are also highly conductive [5].

The applications of graphene aerogels, based on the above-mentioned physical properties, are oriented towards low-pressure sensors, batteries, and biomedical scaffolds. Another interesting application is electromagnetic shielding for the aeronautic and automotive industry [6], with the ultralight graphene aerogels replacing the heavy metals commonly used for shielding. Moreover, sensors show enhanced performance when graphene aerogels are used, eventually in combination with carbon nanotubes or nanoparticles [7, 8].

In this paper, we demonstrate a high-pressure (>100 kPa) sensor based on graphene aerogel functionalized with SnO_2 or GaN thin films. The aerogel is highly compressible, while SnO_2 or GaN thin films formed from aggregated nanoparticles are piezoelectric, so that their combination could constitute a good pressure sensor. The physical properties of

