Abstract
Selective Detection of Toxic Gases by Arrays of Single-Layer Graphene Sensors Functionalized with Nanolayers of Different Oxides †

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Abstract: Graphene provides an ideal platform for chemiresistive gas sensors as the material is fully exposed to the surrounding environment. For practical use in an ambient atmosphere, its sensitivity and selectivity should be evoked by functionalization by defects and dopants or by decoration with nanophases of metals or metal oxides. Here, we demonstrate a few successful cases of selectivity enhancement by functionalizing the graphene with different oxide layers and applying machine learning to the resulting sensor array.

Keywords: graphene; gas sensor; laser deposition; functionalization; sensor array; electronic nose

1. Introduction
Chemiresistive graphene gas sensors are appealing for e-nose applications where their easy production and miniaturization potential can be exploited. Relevant use cases include monitoring indoor and outdoor air quality, performing medical self-diagnosis by breath analysis, and controlling industrial processes. However, for effective use in practical sensors, the sensing properties of graphene have to be improved and controllably modified. We have shown nearly a 100 times enhancement of graphene’s gas sensitivity as well as improved selectivity through functionalization by pulsed laser deposition [1,2]. In this work, we demonstrate the modification of graphene with different metal oxides to controllably induce partial selectivity toward the harmful gases NH3, H2S, NO2, and O3. Selected combinations of these sensors were integrated into arrays, whereby machine learning applied to the output signal pattern of each array allowed the successful differentiation of various gases and their mixtures.

2. Materials and Methods
Chemically vapor-deposited single-layer graphene was transferred onto Si/SiO2 electrode substrates (inset in Figure 1) or special CMOS sensor substrates with built-in microheaters. A KrF excimer laser was used to deposit thin oxide layers on top of the graphene from respective ceramic targets [1]. The substrate temperature, background gas type and pressure, and the thickness of the functionalizing layer were optimized for the best performance of the sensors.
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References


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