
CHEMICALLY DERIVED GRAPHENE FOR SUB-ppm NITROGEN DIOXIDE DETECTION

**T. Polichetti^{a*}, E. Massera^a, M. L. Miglietta^a
I. Nasti^a, F. Ricciardella^a, S. Romano^a
G. Di Francia^a**

^a ENEA-UTTP-MDB Laboratory for Materials and Devices Basic research
p.le E. Fermi, 1, Portici (Na), I-80055, Italy
^{a*} Corresponding author: tiziana.polichetti@enea.it

The manifold and astonishing potential applications of graphene have aroused extraordinary efforts of the scientific community to fully explore them. The exceptionally high surface to area ratio of this 2D material pushes into investigating its potential in the gas sensing field and, actually, it has been already proven that a graphene flake has the ability to detect the presence even of a single interacting molecule [1]. However, until now the fabrication of the single graphene flake based chemical sensor is still challenging due to the complexity of the entire process, starting from the graphene synthesis and/or isolation up to the introduction into the proper device architecture. To date, indeed, several works report on the fabrication of gas sensor devices that employ, as sensing layers, a much more easily manageable material such as the reduced graphene oxide sheets [2,3,4]. Herein, the simple fabrication process and characterization of a chemiresistor device, based on chemically exfoliated graphite, is described. Relying on the exfoliation method exposed by the Geim's group [5], a suspension of graphitic platelets in N,N-dimethylformamide (DMF) was prepared and the film formed by drop-casting the dispersion onto a transducer was investigated as sensing material. The final dispersion is a stable suspension of graphitic platelets which mean size ranges between 124 and 160 nm (as measured by the Dynamic Light Scattering technique). This result is also confirmed by SEM images of the graphene films (see fig. 1a). Raman spectrum (inset fig. 1a) of the sample shows the typical 2D band profile of a graphitic material devoid of stacking order along the c axis, usually named turbostratic graphite [6], that is considered a two dimensional material [7].

So prepared devices show an ohmic behaviour with electrical resistance ranging from 10^1 to 10^2 k Ω . Graphene films, biased at 10V DC, were exposed to a gas flow of dry nitrogen containing 350 ppb of NO₂ at room temperature for 10 minutes (see fig. 1b). The conductance response is highly reproducible and fast. The very high signal to noise ratio of the sensor response suggests the feasibility to achieve detection levels as low as few ppb. The capacity to achieve such a sensitivity levels can be only ascribed to the nanometric thickness of the sensing layer. As usual for solid state chemical sensors working at room temperature, and as already reported for graphene based chemical sensor, the conductance exhibits a slow recover to the initial value after the exposure. In our case, a complete conductance recovery was observed within an hour by simply switching-off the applied voltage. The sensor device was tested towards several other analytes (namely: NH₃, H₂, CO, SO₂, CH₃CN) showing a very interesting behaviour with acetonitrile vapours.

We have shown that a graphene based chemical sensor can be easily fabricated from chemically exfoliated graphite. The graphene films are sensitive to NO_2 and CH_3CN and show, besides, fast response times at room temperature. The response and recovery features can help in throwing a light on the interaction mechanism of such a material with the environment, allowing further improvements of the device [8].

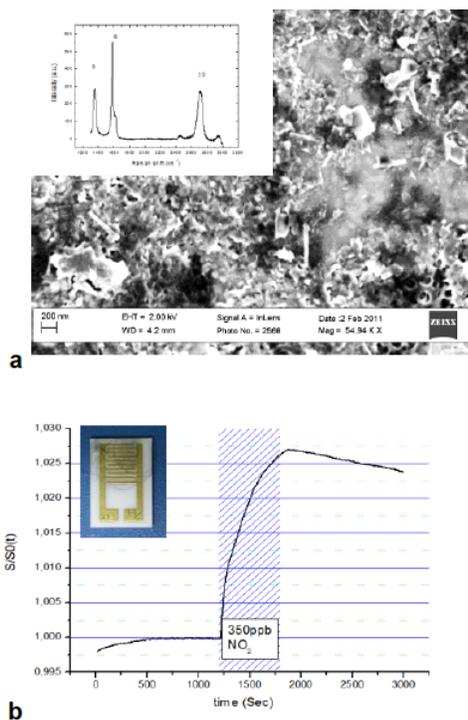


Figure 1: Graphene films characterization and device performance: a) SEM image of a graphene film, the inset shows its Raman spectrum; b) conductance response (S/S_0) kinetics of the chemiresistor upon exposure to 350 ppb of NO_2 in dry nitrogen; the inset shows the final device with a transducer realized by an interdigitated Cr/Au structure on alumina substrate, with a distance of $500 \mu\text{m}$ between two adjacent fingers.

References

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